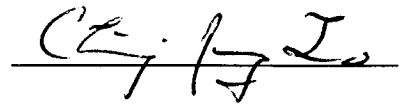


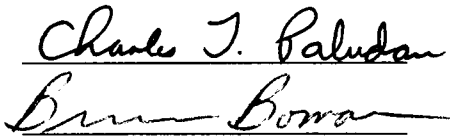
To the Graduate Council:

I am submitting herewith a thesis written by D. Trent Loman entitled "Improving Post-Test Data Reduction and Analysis for Dynamic Drop Testing of Store Models." 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 Engineering Science.



Dr. Ching-Fang Lo, Major Professor

We have read this thesis and
recommend its acceptance:



Accepted for the Council:



Associate Vice Chancellor and

Dean of The Graduate School

**IMPROVING
POST-TEST DATA REDUCTION AND ANALYSIS
FOR
DYNAMIC DROP TESTING
OF STORE MODELS**

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

D. Trent Loman
August, 1996

DEDICATION

This is dedicated to my grandparents

Mrs. Mildred Miller

and

Mr. Charley Miller.

ACKNOWLEDGMENTS

There are many people to whom I am grateful for making my time at the University of Tennessee so rewarding. I have benefited greatly from knowing several members of faculty in many different departments over the last few years. I am particularly grateful to Dr. Bruce Whitehead for advice and guidance during the early years. I am also grateful to my Thesis Committee, Dr. Ching Lo, Dr. Ted Paludan, and Dr. Bruce Bomar.

I would like to express my gratitude to Jeff Amacher, whose help on both the original Free-Drop software and the intricacies of Microsoft Word[®] was extremely appreciated. There are a number of other people whose assistance should be recognized. I would like to thank Doyle Veazey, Dave Anderson, and Scott Keen for invaluable inputs to my research. I would also like to thank David Rollins for his help in tracking down instructions and procedures pertaining to AEDC related thesis topics. I would also like to thank Danna Pemberton for providing ADS support.

Lastly, the greatest debt is owed to my wife, Christie. Without her help and strong encouragement I would never have reached this moment.

ABSTRACT

Dynamic Drop testing is a method of trajectory simulation whereby store models which are both geometrically and dynamically scaled are released in the wind tunnel air stream. The resulting trajectories are then mapped photographically onto film. Drop testing is often necessary when captive trajectory testing is not feasible or for final trajectory verification prior to actual flight tests (Allee, 1980).

During drops, data are acquired by means of high-speed motion picture cameras mounted in the test section. Data acquisition is controlled by a sequencer which is programmed to automatically actuate the lighting and cameras and to release the stores at the proper time intervals.

Once the film is obtained, it is analyzed manually post-test by the use of a machine called the film-reader. Each frame of the film is projected onto a screen from which reference points are input into an interactive program which stores the data into a file. The data are then processed through software which will store the coordinates into data files. The files are then transferred to a working directory where additional software is executed to validate the data and to finally achieve full-scale trajectory data.

The current method of achieving final data is time consuming and often a concern of the users. In this study, the complete process was examined and inefficiencies described. This process was streamlined and improved. Since most of the software was outdated, the post-test analysis software was selected as the area of improvement. The improvements cover two phases. The first phase covers conversion from the Amdahl Computer System to the Facility Computer System VAX 8650. The second phase consists of creating a Graphical User Interface (GUI) for

these processes. Other areas with inefficiencies or possible improvement have been listed and suggested as a future project.

PREFACE

For several years while working at the Propulsion Wind Tunnel Facility Complex, the author prepared software for several Dynamic Drop tests. This was when he began realizing the awkwardness, complexity, and lack of user-friendliness of the post-test data reduction and analysis. He also realized that the processes could be improved significantly. Many people with Dynamic Drop testing experience have departed AEDC (Arnold Engineering Development Center); therefore, a more detailed description of the testing process is presented. The research included reviews of technical reports and software as well as many interviews with users of the software and utilities.

The first few chapters of the thesis are dedicated to the testing process. Chapter One provides a brief introduction to Dynamic Drop testing. It describes the need and benefits of this type of testing. Chapter Two describes the three wind tunnels currently capable of executing drop tests at the AEDC and lists their essential capabilities. Chapter Three covers the models used in Dynamic Drop testing: the parent model and the store model. The Fourth Chapter covers the Data Acquisition process. It discusses the cameras and film along with the sequencer, which coordinates the timing activities of Dynamic Drop testing. The film-reader analyzer is also covered in Chapter Four.

The next few chapters deal with the software. Chapter Five gives an overview of the software and divides it into two sections: the film-reader software and the post-test analysis software. Chapter Six details the software processes and the first improvement phase: the conversion of the post-test analysis software from the Amdahl computer to the VAX 8650. All files and software programs (both existing and new) are listed along with the modifications

required. Chapter Seven details the second improvement phase: the creation of a user-friendly Graphical User Interface (GUI). The design and layout of the interface screens as well as the software modifications are discussed. Chapter Eight provides a complete example from the film-reader through to the data reduction. This example shows the improvements made and validates the results.

Chapter Nine summarizes the research and the work accomplished through the two improvement phases. Suggested areas of improvement are also listed in this chapter.

TABLE OF CONTENTS

CHAPTER	PAGE
I. Introduction	1
The Need for Dynamic Drop Testing	2
Background	2
II. Test Facilities	4
PWT 4-Foot Aerodynamic Wind Tunnel	4
PWT 16-Foot Transonic Wind Tunnel	5
VKF Supersonic Wind Tunnel A	6
III. Models	7
Aircraft Model Support	8
Store Model Scaling	10
Store Model Release	11
Store Model Recovery	12
IV. Data Acquisition	14
Camera/Film	14
Sequencer	16
Film-Reader	16
V. Software	18
Film-Reader Software	18
Post-Test Analysis Software	22
VI. Improvement Phase I	23
<i>FDCON</i>	23
<i>FDCHK</i>	29
<i>FDROP</i>	34
<i>COMPARE</i>	36
VII. Improvement Phase II	39
Screen Design	39
Screen Layouts	40
Software Modification	43

CHAPTER	PAGE
VIII. Validation Results	49
IX. Summary	60
Improvements	60
Future Improvement Areas	61
BIBLIOGRAPHY	63
Vita	65

LIST OF TABLES

TABLE	PAGE
1. Capabilities of the Propulsion Wind Tunnels	5
2. Capabilities of the Von Karman Facility Wind Tunnels	6
3. Grid Board Calibration File	20
4. Constant Work File Structure	21
5. Free-Drop Constant Set File Structure	27
6. Comparison File Parameters	36

LIST OF FIGURES

FIGURE	PAGE
1. Typical Sting Mount Installation	8
2. Typical Strut Mount Installation	9
3. Recorded Film with Identification Markings	15
4. Store Reference Points on Film	17
5. Film-Reader Workstation	19
6. Overview of Free-Drop Post-Test Processes	24
7. Free-Drop Constant Manager Options	28
8. <i>FDCHK</i> Process	30
9. Sample <i>FDCHK</i> Print	31
10. Sample Raw Data Print	33
11. Sample <i>COMPARE</i> Print	38
12. Free-Drop Main Menu Screen	41
13. Free-Drop Raw Data Menu Screen	42
14. Free-Drop Constant Menu and EUD Menu Screens	43
15. Free-Drop <i>FDCON</i> Menu and <i>FDROP</i> Menu Screens	44
16. Drop Log Listing	50
17. Constant Box Configuration	51
18. <i>FDROP</i> Summary 1 Print - Run 2	53
19. <i>FDROP</i> Summary 1 Print - Run 6	55
20. Compare Print - Run 2 and Run 6	57

FIGURE	PAGE
21. ADS Plot - Run 2 Flight Axis	58
22. ADS Plot - Run 6 Pylon Axis	59

NOMENCLATURE

16T	16-Foot Propulsion Wind Tunnel
4T	4-Foot Aerodynamic Wind Tunnel
ADS	Analysis and Display System (Graphics Software)
AEDC	Arnold Engineering Development Center
AMAPS	Automated Model Attitude Positioning System
Amdahl®	Large-Scale Amdahl 580/5860 Mainframe Computer System
C	Software Programming Language
CMS	Code Management System (Software Library)
<i>COMPARE</i>	The Comparison Process (A step in the Free-Drop Data Reduction)
CTS	Captive Trajectory Support
DataViews®	Graphical Software Package by V.I. Corporation
DEC™	Digital Equipment Corporation
DECterm™	DEC Window Terminal
DoD	Department of Defense
EUD	Engineering Units Data
<i>FDCHK</i>	Free-Drop Check Process
<i>FDCON</i>	Free-Drop Constant Generation Process
<i>FDGRID</i>	Free-Drop Grid Calibration Process
<i>FDGRID_PRT</i>	Free-Drop Grid Calibration Print Process
<i>FDROP</i>	Free-Drop Process
FORTRAN	FORmula TRANslation (Scientific Software Programming Language)

GUI	Graphical User Interface
HCI	Human-Computer Interface
HYPERchannel	NSC's Data Routing Lines
IBM	International Business Machine Corporation
IDS	Independent Drive System
JCL	Job Control Language
LFWC	Lockheed Ft. Worth Company - formerly General Dynamics
<i>MKCON</i>	Make Constants (FDCON subroutine)
MVS/XA	Multiple Virtual Storage/Extended Architecture Operating System
NSC	Network System Corporation
PES	Plenum Evacuation System
PWT	Propulsion Wind Tunnel
SMG	Screen Management Utilities
VAX 8650	DEC Computer VAX 8650
VKF	Von Karman Facility
VMS	Virtual Memory System (Operating System)
X-Designer	Software Design Product by V.I. Corporation

CHAPTER I

INTRODUCTION

As part of its development, an aircraft is subjected to many hours of wind tunnel testing. Precisely-scaled models of the aircraft or certain critical parts are attached to a support which holds the model in the wind tunnel. Air is then blown over the model at controlled velocities to simulate aircraft flight. The support system moves the model to simulate the angles that the actual aircraft will encounter in flight. Forces, moments, and pressures are some of the commonly measured parameters used to determine how the aircraft will perform. Special types of tests are performed to determine whether a fighter or bomber aircraft will be able to successfully release the bombs or missiles it carries.

At transonic speeds, and at certain attitudes or maneuver conditions, an aircraft's stores (bombs, missiles or fuel tanks carried externally) may veer upward when released, and collide with the aircraft. Dynamic Drop, commonly called "Free-Drop", is a method of trajectory testing whereby a scale model of a store is separated from the aircraft and released in the wind tunnel air stream. The resulting path is recorded photographically by two or more high-speed cameras. In addition to being geometrically scaled, the store models must be dynamically scaled to represent the mass, moment of inertia, and center of gravity characteristics of the full-scale article (Allee, 1980).

The Need for Dynamic Drop Testing

Generally, Free-Drop testing is used when the store model being tested is to be released from an internal bay, or when the expected motion of the store would preclude captive trajectory testing (CTS) because of aircraft/sting interference (such as an unstable store model that might attain high pitch angles upon release in the tunnel air stream), or when the physical size of the test article prohibits the installation of a balance for normal captive trajectory testing, or for final store separation verification prior to flight testing (Allee, 1980). A balance, contained entirely within the models, consists of two structural members, an inner beam that is attached to the sting, and an outer tube that is attached to the model. The inner beam and outer tube are usually connected by six flexible load elements instrumented with strain-gauges. Dynamic drop testing is the only practical purely experimental method for simulating tumbling store bodies.

Information obtained from Free-Drop testing is used in design of new stores or modification of existing ones to make sure they separate cleanly, do not damage the aircraft, and stay on their intended flight path in the proper attitude.

Background

In years past, bombs were carried and dropped out of bomb bays. But as high-thrust engines became available, the weapons could be shifted outside and carried in considerable numbers from pylons attached to the lower surface of the wings. Problems became evident when the aircraft speed grew progressively faster. Large, unexpected aerodynamic forces were sometimes generated, resulting in violent vibrations and erratic motion of the stores upon

release. Free-Drop testing allows the problem of clean store separation to be investigated at the AEDC.

CHAPTER II

TEST FACILITIES

Wind tunnels in both the Von Karman Facility (VKF) and the Propulsion Wind Tunnel Facility (PWT) have tested Free-Drop models, although the majority have required the use of PWT's 4-foot Aerodynamic Wind Tunnel, 4T, operating in the speed range of subsonic and transonic. Other tests utilizing larger models than could be accommodated in 4T have been executed in PWT's 16-foot Propulsion Wind Tunnel, 16T, using the same techniques developed for 4T. Free-Drop tests requiring Mach numbers greater than 2.0 have been executed in the Von Karman Facility's Supersonic Wind Tunnel, A (Allee, 1980).

PWT 4-foot Aerodynamic Wind Tunnel

The Aerodynamic Wind Tunnel 4-foot Transonic Wind Tunnel in PWT, called 4T, is a closed circuit tunnel and can maintain continuous flow. Table 1 lists nominal values for Tunnel 4T. It is a variable density tunnel and offers two operating modes: an Independent Drive System (IDS) mode and a Plenum Evacuation System (PES) mode. The IDS operating mode offers significant energy savings but is limited to a maximum Mach number of approximately 1.3. The PES operating mode provides a Mach number capability of 0.1 to approximately 2.0 (Allee, 1980). Stagnation pressures from 200 to 3400 psfa are available at all Mach numbers for PES operation, while stagnation pressures from 1200 to 3400 psfa are available for Mach numbers from 0.2 to 0.85 for IDS operations (AEDC, 1994). The test section is a 4 foot square by 12.5

Table 1. Capabilities of the Propulsion Wind Tunnels (AEDC, 1994).

Propulsion Wind Tunnel Facility	Test Section Size Cross Section * Length (ft)	Total Temperature (°R)	Speed Range	Pressure Altitude (ft)	Dynamic Pressure (psf)	Reynolds No./ft
Aerodynamic Wind Tunnel 4T	4 * 4 * 12.5	540 to 600	Mach 0.2 to Mach 2.0	Sea Level to 65000	20 to 1400	$2.0 \cdot 10^5$ to $7.0 \cdot 10^6$
Propulsion Wind Tunnel 16T	16 * 16 * 40	540 to 600	Mach 0.06 to Mach 1.6	Sea Level to 90000	2 to 1100	$0.2 \cdot 10^6$ to $6.0 \cdot 10^6$
Propulsion Wind Tunnel 16 S	16 * 16 * 40	580 to 1080	Mach 1.5 to Mach 4.75	45000 to 155000	25 to 550	$0.1 \cdot 10^6$ to $2.4 \cdot 10^6$

feet in length. The walls are perforated, variable porosity (0.5 to 10 percent open) walls (Allee, 1980). The tunnel is completely enclosed in a plenum chamber from which air can be evacuated through the perforated walls.

PWT 16-foot Propulsion Wind Tunnel

The Propulsion Wind Tunnel 16-foot Transonic Wind Tunnel in PWT, called 16T, is also a continuous flow, variable density tunnel. See Table 1. The Mach number can range from 0.06 to 1.6 with stagnation pressures from 120 to 4000 psfa. The maximum attainable Mach number can vary depending upon the tunnel pressure ratio requirements with particular test installations. The maximum stagnation pressure attainable is a function of Mach number and available electric power. The tunnel stagnation temperature can be varied from approximately 80 to 160 degrees Fahrenheit depending upon the cooling water temperature. The tunnel is equipped with a scavenging system that removes combustion products when testing rocket motors or turbo engines. Recently, the operating envelope has been slightly increased to allow

testing in the high subsonic speed range at a unit Reynolds number of 6 million per foot (AEDC, 1994). The test section is a 16 foot square by 40 feet in length. It can be removed and loaded onto a transfer cart thus enabling remote model installations. The walls are also perforated to six-percent porosity (Allee, 1980).

VKF Supersonic Wind Tunnel A

The Von Karman Facility Tunnel A is a closed-circuit, continuous flow, variable density tunnel with an automatically driven flexible-plate type nozzle. See Table 2. The test section is 40 inches by 40 inches with a Mach number range of 1.5 to 5.5 at maximum stagnation pressures from 1.5 to 200 psia, respectively. The size of the tunnel permits the use of a model injection system that allows removal of the model from the test section while the tunnel remains on-line (Allee, 1980).

Table 2. Capabilities of the Von Karman Facility Wind Tunnels (AEDC, 1992).

Von Karman Facility	Test Section Size (in.)	Total Pressure (psia)	Total Temp. (°R)	Speed Range	Pressure Altitude (ft)	Dynamic Pressure (psf)	Reynolds No./ft
Supersonic Wind Tunnel A	40 * 40	1.5 to 200	530 to 750	Mach 1.5 to 5.5	16000 to 151000	53 to 1780	$0.3 \cdot 10^6$ to $9.2 \cdot 10^6$
Hypersonic Wind Tunnel B	50 diam	20 to 900	700 to 1350	Mach 6 or 8	98000 to 180000	43 to 590	$0.3 \cdot 10^6$ to $4.7 \cdot 10^6$
Hypersonic Wind Tunnel C	50 diam	200 to 1900	1650 to 1950	Mach 10	132000 to 188000	43 to 430	$0.3 \cdot 10^6$ to $2.4 \cdot 10^6$

CHAPTER III

MODELS

In Free-Drop testing, many variations of models exist. The aircraft is the supported model that will be dropping the store model, and is usually supported by a strut or a sting. The stores are any objects that an aircraft may deploy. In order to achieve certain mass densities, store models may be built from materials ranging from exotic metals and alloys (gold or kinertium) to light-weight materials such as balsa wood.

Historically, drop modeling has been very expensive. A major technological advancement aimed at reducing this high cost was recently developed by LWFC (Lockheed Ft. Worth Company - formerly General Dynamics). The models were designed using solid modeling techniques associated with a computer-aided design package. Each component of the store model was individually designed producing mass-balanced components. Certain types of complex assemblies were scaled to an accuracy never before obtained in drop testing. Mass-dense portions of the assembly were manufactured of ballasted steel or other heavy metals. The fuel tank, however, was made by a revolutionary process known as stereolithography. This involves using a computer-guided laser to solidify a liquid polymer resin into the store model. The laser is aimed into the vat of liquid and the store model essentially emerges from the resin complete and mass balanced.

Aircraft Model Support

For Free-Drop testing in Tunnel 4T, the parent aircraft model is normally supported from the ceiling of wind tunnel using the base strut of the captive trajectory support (CTS) structure. See Figure 1. The CTS strut can be moved both vertically and axially in the wind tunnel. The aircraft model is mounted by either a sting or strut which mates to a yoke attached to the CTS. Aircraft models tested in Tunnel 16T have usually been strut mounted from the test section ceiling as shown in Figure 2. However, a sting support system could be used for a particular test

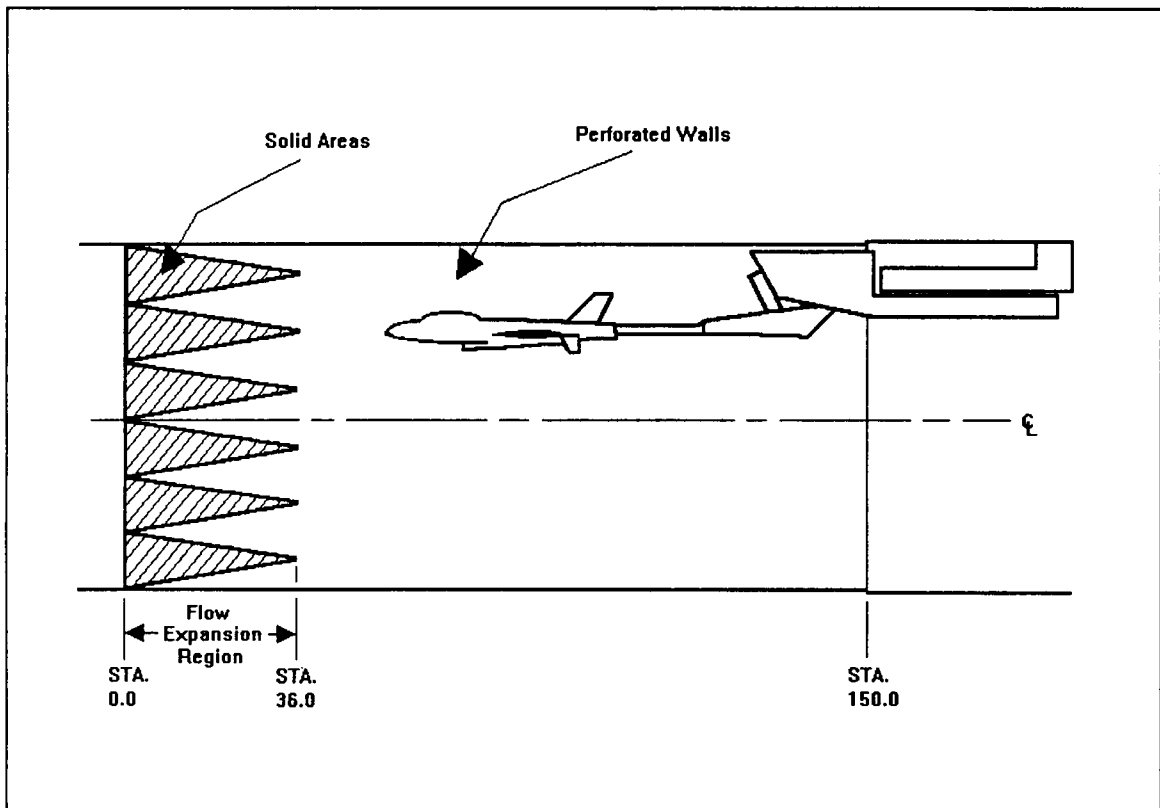


Figure 1. Typical Sting Mount Installation (Allee, 1980).

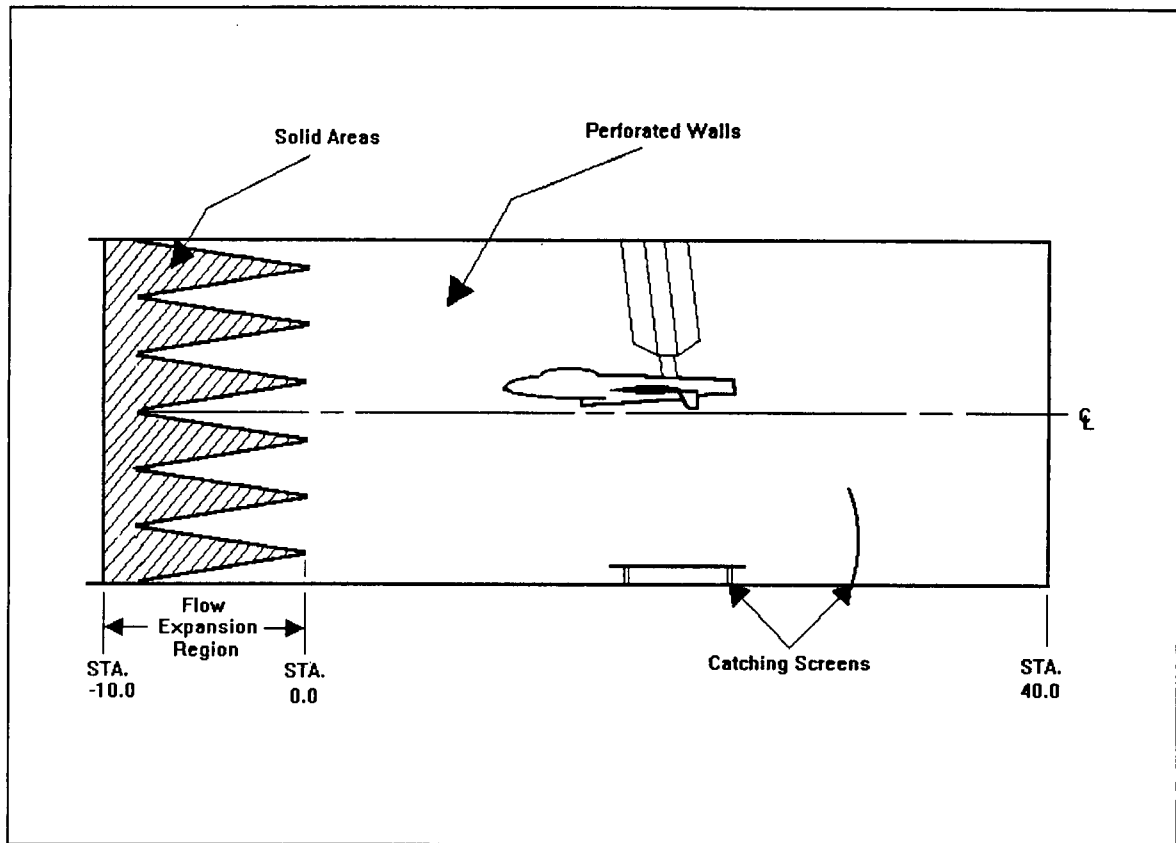


Figure 2. Typical Strut Mount Installation (Allee, 1980).

installation as shown in Figure 1. In Tunnel A, the aircraft model is mounted on a sting support mechanism in an installation tank directly underneath the tunnel test section. Doors seal the tank from the tunnel. When the model is prepared for testing, the doors are opened and the model is injected into the tunnel (Allee, 1980).

Store Model Scaling

In order for the dynamic motion of a small-scale model released in a wind tunnel to be similar to a full-scale separation, two criteria must be met. First, the aerodynamic forces and moments on the model store must directly scale to flight forces and moments. Second, the inertial responses of the wind tunnel model to the applied forces and moments must be directly scaleable to flight motion responses. Unfortunately, it is physically impossible to fully satisfy both the aerodynamics and the motion (kinematics) of a scale model without some compromise. This is the reason scaling laws were developed. There are three primary techniques of scaling the store models: Froude Scaling, Heavy Scaling, and Light Scaling. Because the Mach number required for proper scaling of aerodynamic forces and moments differs from the Mach number required for proper scaling of dynamic motions, some form of compromise must be introduced into the scaling laws.

Froude Scaling

One possible compromise to the scaling laws is simply to set the reduced Mach number required for motion scaling and accept the errors in the model aerodynamics which result from the improperly-simulated compressibility effects. This simulation is only valid at low subsonic Mach numbers. As such, the Froude scaling laws are not very useful for store separations from high-performance aircraft, but are often selected for releases from slow-moving aircraft such as helicopters and cargo planes.

Heavy Scaling

The Heavy scaling law involves setting the Mach number required for aerodynamic scaling at the expense of compromises to the Mach number requirements for dynamic motion scaling. The mass of heavy-scaled models will be larger than for Froude-scaled models because of the increased Mach number requirement. The majority of drop tests at AEDC have used the Heavy Scaling technique. In the past, this technique has given good overall results in comparison with captive trajectory and flight test data (Allee, 1980).

Light Scaling

If an artificial gravity field were possible, Mach numbers for aerodynamic and motion scaling could be achieved simultaneously using Light Scaling. The difficulty with light scaling is, of course, how to simulate the required model scale gravitational acceleration, since it is not yet possible to change gravitational acceleration for a model in a ground test facility. Few approaches have been proposed and usually involve great complexity or mechanical difficulty. One method consists of executing the experiment at normal gravity and accept the errors or add corrections for them. Another approach involves mounting the model on a separate support which is accelerated upward during model release to achieve the artificial gravity. Still another approach involves attempting to generate a magnetic field around the wind tunnel test section which emulates the artificial gravity on a magnetically-balanced store model.

Store Model Release

In order to have a successful drop test, a reliable and repeatable means of releasing the store model on command is required. At AEDC, two techniques for store model release are

presently in use. The first technique uses a "burn bolt". The bolt has had the middle section machined to a smaller diameter. When the store model is commanded for release, a voltage current, sufficient to burn the bolt into two pieces, is applied. This can either release the store model directly or a hook-release mechanism can be activated which will release the store model. The second technique uses air pressure to actuate a hook-release mechanism. It is restricted to bay drops or pylons because of its physical size constraints. An advantage is that this technique avoids problems associated with high current circuits needed for burn bolt techniques (Allee, 1980).

As the store model is released, a method of applying an ejector force of sufficient magnitude at the correct point on the store model to impart the necessary initial linear and angular velocities is required. This is accomplished by the use of springs or air cylinders. Leaf springs, coil springs, and air pistons have all been used with good results (Allee, 1980). Air pistons have an advantage in that the ejector force can be easily changed during testing, but they are usually limited to bay drops because of their size. Leaf and coil springs can be fitted to smaller drop model mechanisms, but they require more time to calibrate or to change during testing.

Store Model Recovery

Because of the expense associated with the construction of the dynamically scaled models and potential for serious damage to the tunnel, a model recovery device is usually installed in the test section. The device will usually consist of stainless steel mesh screens. Figure 2 shows screens installed in the test section. Because of high speeds and forces, certain high Mach numbers prevent the screens from being used. Models will normally be damaged,

especially in Tunnel A even when they land in the screens; however, they can occasionally be salvaged and refurbished, depending upon the type of model and the method of construction (Allee, 1980).

CHAPTER IV

DATA ACQUISITION

Data acquisition involves several tasks working together to achieve quality results. In addition to having cameras in good working condition, they must record the drops at the correct time. This is accomplished by the sequencer. Once the film is obtained, a film reader will allow reading and plotting of the reference point on the store.

Camera/Film

Primary data are acquired by means of 16-mm, high-speed motion picture cameras mounted to give both side and bottom views of the model in the test section. The actual frame rates of the data cameras can be varied as required by the particular test program. The data cameras are positioned in such a manner that the relative positions of their lines of sight in the test section are accurately known. By using two orthogonally positioned cameras, three-dimensional, six-degree-of-freedom trajectory data can be determined (Allee, 1980).

The camera is the single most important aspect of data acquisition. In some cases, the film is treated as the final test data if a store contacts the aircraft during drop testing, as this test condition is considered unsafe for flight testing. In most cases, however, the film is read and analyzed through the data reduction processes.

If accurate three-dimensional trajectories are to be obtained, the two cameras (side and bottom) must be synchronized to ensure that the dropped store occupies the same position in

space when data from the two cameras are correlated. This synchronization is accomplished in the data reduction program. The frame rate for each camera is determined from the timing marks recorded on one edge of the film. Figure 3 shows a diagram of the film with identification markings. The event mark which is recorded on the other edge of the film in each camera establishes a time zero reference by identifying the frame of film on which store release occurs. It is where the continuous red border on the film turns black (Hood, 1988). The zero reference and the frame rate are used to calculate the elapsed time since release for each frame of data film for each camera. The side camera data are taken as the primary time reference, and the bottom

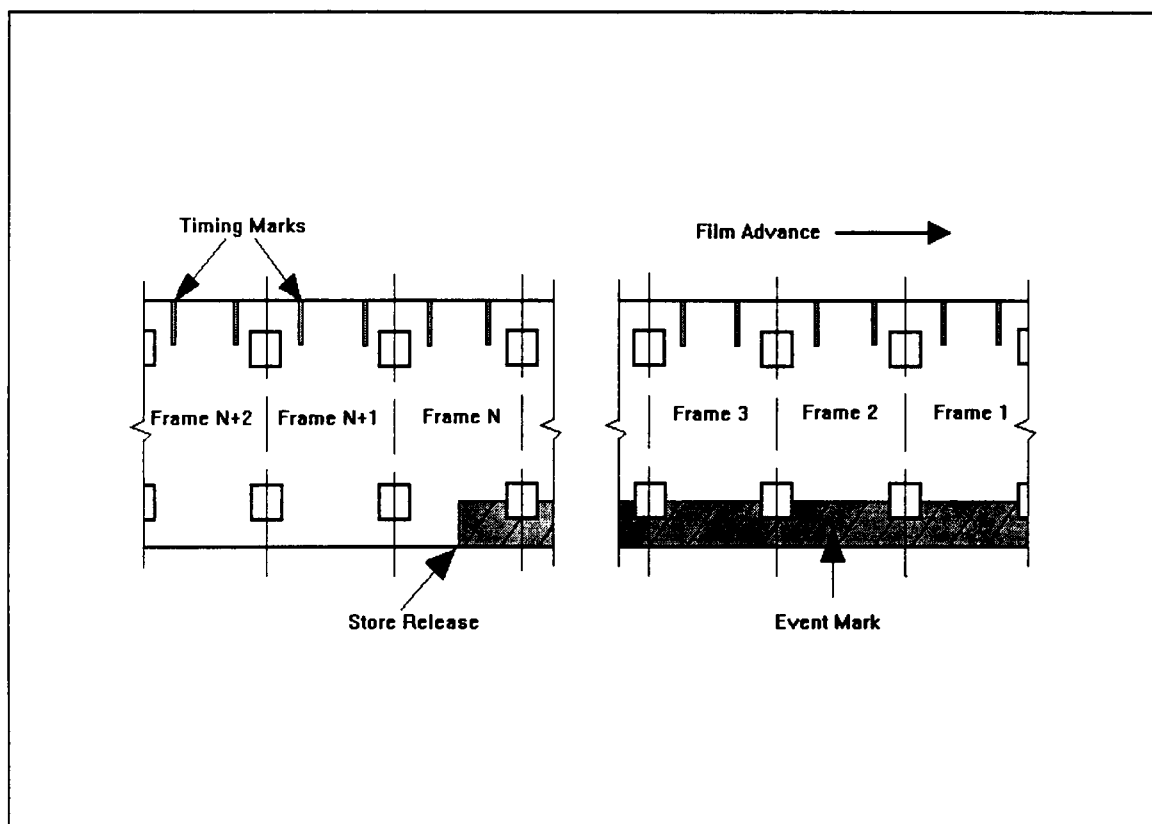


Figure 3. Recorded Film with Identification Markings (Allee, 1980; Hood, 1988).

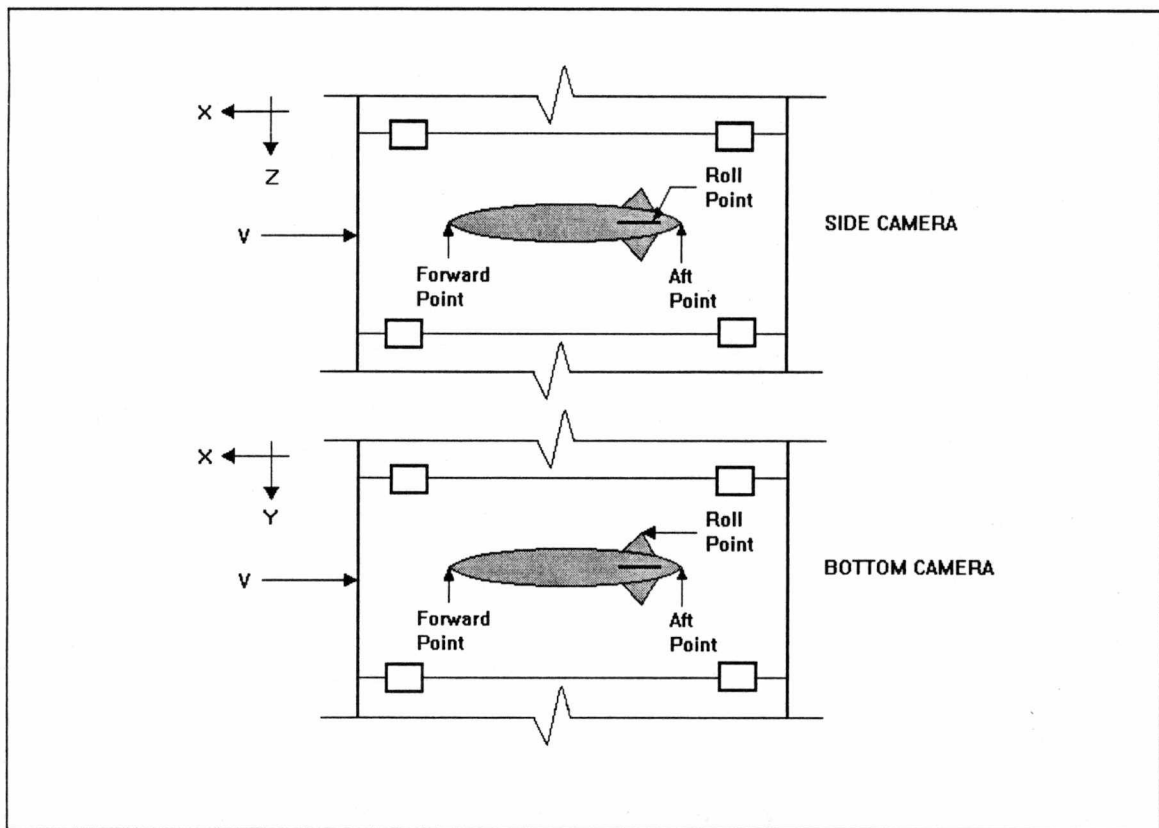
camera data are interpolated to obtain store positions at times corresponding to each frame of the side camera data

Sequencer

Data acquisition is controlled by a sequencer which is programmed to automatically actuate the test section lighting and cameras and to release the drop store at the proper time intervals. To allow the time of store release and the camera frame rates to be accurately determined, timing lines and an event mark signifying store release are optically placed on the data film of all data cameras.

Film-Reader

Model trajectory data are determined from the time-correlated, high-speed motion picture film taken by the two primary data cameras. The store will generally clear the aircraft flowfield within 100 frames of the release. The data film is reduced by the use of a film reader whereby each frame of the film is projected onto the screen. Positions of the store reference points, relative to known points in the field of view, are measured along two orthogonal axes by manually positioning horizontal and vertical cross hairs located on the surface of the screen. See Figure 4. As is often the case, one or more of the three reference points may be visually obstructed by intervening portions of the aircraft or store. The film-reader operator will then place the crosshairs according to his/her best judgment. Digital output from the film reader is input to a computer for further data reduction and analysis.



CHAPTER V

SOFTWARE

After the on-line Free-Drop testing and filming are complete, the post-test data reduction and analysis are ready to commence. The post-test data reduction software can be divided into two parts: film-reader software and the facility computer software. The film-reader software is responsible for the grid board calibration, reading the film, storing and transmitting the film-reader raw data to the VAX 8650.

Film-Reader Software

The person responsible for reading the film can load the film or have it loaded by a qualified technician. An appropriate username and password are required to log onto the host computer. Once logged on, a command file executes the *FILM_READER* process. An option from the film-reader workstation is then selected. See Figure 5.

FILM_READER

Option one is the grid board calibration. It is selected only if the calibration film is loaded into the film-reader. It will allow creation of a new "GRID.BOARD" calibration file or modification of an existing file. The *FDGRID* process is executed on the "GRID.BOARD" calibration file to obtain constants for initializing the "FDCON.WRK" file. The following sections describe these files and processes. Options two and three allow store position readings

FILM READER WORKSTATION

Enter Option to Run:

1. GRID BOARD CALIBRATION
2. STANDARD DROP
3. BAY DROP
4. TRANSMIT DROP FILE
5. MENU OF DATA FILE RUNS
- E. EXIT

Enter Option >

Figure 5. Film-Reader Workstation.

to be taken with the film-reader. Either the standard drop or bay drop may be used. When the drop readings are complete, the file can be transmitted to the facility computer area for post-test analysis and reduction. At any time, option five may be chosen to obtain a log of run/points from the current drop file.

"GRID.BOARD" Calibration File

The grid board file allows for 5712 values. The first twelve are reserved for identification constants. Constants are parameters which maintain a certain value over the course of one point or drop. Locations 13 through 5712 are for data storage. See Table 3 for location layout. Each data point contains six pieces of information: camera #, calibration #, two count variables, and x and y coordinates. This allows for 475 points/camera:

$$2 \text{ cameras} * 6 * 475 = 5700 + 12 \text{ constants} = 5712.$$

Table 3. Grid Board Calibration File.

INDEX	DESCRIPTION
1	TUNNEL #
2	CALIBRATION #
5	NUMBER OF POINTS
6-7	SIGHT LINE INTERSECTIONS XY - CAMERA 1
8-9	SIGHT LINE INTERSECTIONS XY - CAMERA 2
13	DATA
...	...
5712	DATA

FDGRID

Once the "GRID.BOARD" file has been created, *FDGRID* can be executed on the calibration file. Sixteen constants pertaining to the calibration are obtained from the project engineer prior to executing *FDGRID* and inserted into the program. After executing *FDGRID*, an output file is generated for validation. Constants are obtained from this printout and inserted into the "FDCON.WRK" file to be used by the *FDCON* process.

FDGRID_PRT

This process allows printing of the "GRID.BOARD" calibration file into a user-friendly tabular format.

"FDCON.WRK" File

This is the constant work file that is created by an engineer or associate. It is a file that is based on the current file structure of the CTS constant files. See Table 4. The constant file is divided into subsets A-H, where subset A is called the main deck. It contains 150 constants for

Table 4. Constant Work File Structure.

RECORD #	SET #	DESCRIPTION
1 - 10		Reserved as "Holding Area"
11 - 19	B1 - B9	n1 con(n1) n2 con(n2) ... n60 con(n60)
21 - 29	C1 - C9	Same as Group B
31 - 39	D1 - D9	Same as Group B
41 - 139	E1 - E99	Trajectory or Grid/Flowfield Ref Axis
141 - 239	F1 - F99	Trajectory or Grid/Flowfield
241 - 339	G1 - G99	Same as Group B or Test Peculiar F
341 - 439	H1 - H99	Same as Group G
440 - 500	1 - 61	Trajectory/Survey Descriptions
501 ...	A1 - A9	con(1) con(2) ...con(150)

Free-Drop but is variable for CTS testing. The other subsets, B-H, are divided based on their functions. Subsets may or may not contain values. Subsets A-D may contain up to 9 sets each. Subsets E-H may contain up to 99 sets each. They are limited in the number of sets per subset due to the hardware thumbwheel knobs. Currently, hardware and software are being upgraded to allow more sets per subset. Programs access the constant file according to the hardware switches (constant box configuration). An example of a constant box configuration is:

Dialed-in information: 2 5 0 4 01 11 06 00
Constant Box Designation: A B C D E F G H

All constants from the main deck A are read into memory. Constants located in memory are overwritten by any constants in subset B according to the value's index. This process is then carried out on subsets C-H.

The file is initialized and modified using the currently existing utility *CONPRP*. Values obtained from the *FDGRID* process are inserted into this work file which will be used later in the *FDCON* process.

Post-Test Analysis Software

The post-test analysis software consists of all software and utilities which are used after the film has been read for the first time (some data points require rereading). This is the beginning of the final steps required in reducing the data to its final form. The original software was designed to reside on the Amdahl® 580/5860 Central Computer System. The Amdahl® utilizes IBM Corporation's Multiple Virtual Storage/Extended Architecture (MVS/XA) operating system.

There are several disadvantages of maintaining the software on the Amdahl® Computer. The most important disadvantage is that the turnaround time is very inconsistent. Since the jobs are submitted to a batch queue, turnaround time required can range from minutes to hours. In addition, software programs and data files used must have a file header and trailer consisting of Job Control Language (JCL) commands indicating job number, execution commands, file names, and other reference codes. Executing programs interactively and debugging problems are also not very simple tasks. Once the programs are compiled and linked, they are inserted into the NSC's (Network System Corporation's) HYPERchannel network to be transferred into the job queue on the Amdahl® Computer. They are usually not executed immediately since they are in a queue on a first-come-first-serve basis. The major tasks are the constant set generation process (*FDCON*), the Free-Drop raw data check process (*FDCHK*), the Free-Drop data reduction process (*FDROP*), and the Free-Drop comparison process (*COMPARE*). All tasks are described in detail later in the Improvement Phase I section.

CHAPTER VI

IMPROVEMENT PHASE I

The first phase of improvements consists of conversion of all files and software programs and utilities, pertaining to the post-test analysis processes, from the Amdahl® 580/5860 Central Computer to the Propulsion Wind Tunnel Facility Computer VAX 8650. All software was originally written in FORTRAN-4 and was converted to FORTRAN-77. The new code utilizes features from the VMS (Virtual Memory System) operating system on the VAX 8650. Not only does this permit immediate execution but it also eliminates JCL headers and trailers providing for more user-friendly software. The turnaround execution time has also been substantially reduced since the need to submit jobs to queues has been eliminated. The major processes still remain but have been modified to execute on the VAX 8650. New files have been created as have utilities to operate on them. All JCL command lines have been stripped out of the files and software. New command files have been written for compilation and linking of the Free-Drop software processes. All software modules have been stored in a CMS (Code Management System) library for maintainability and ease of use. The following sections describe the major processes and the files used and created after the conversion phase.

FDCON

The Free-Drop constant set generation process, *FDCON*, is the first major step in the post-test Free-Drop process. See Figure 6. It has been converted to execute on the VAX 8650.

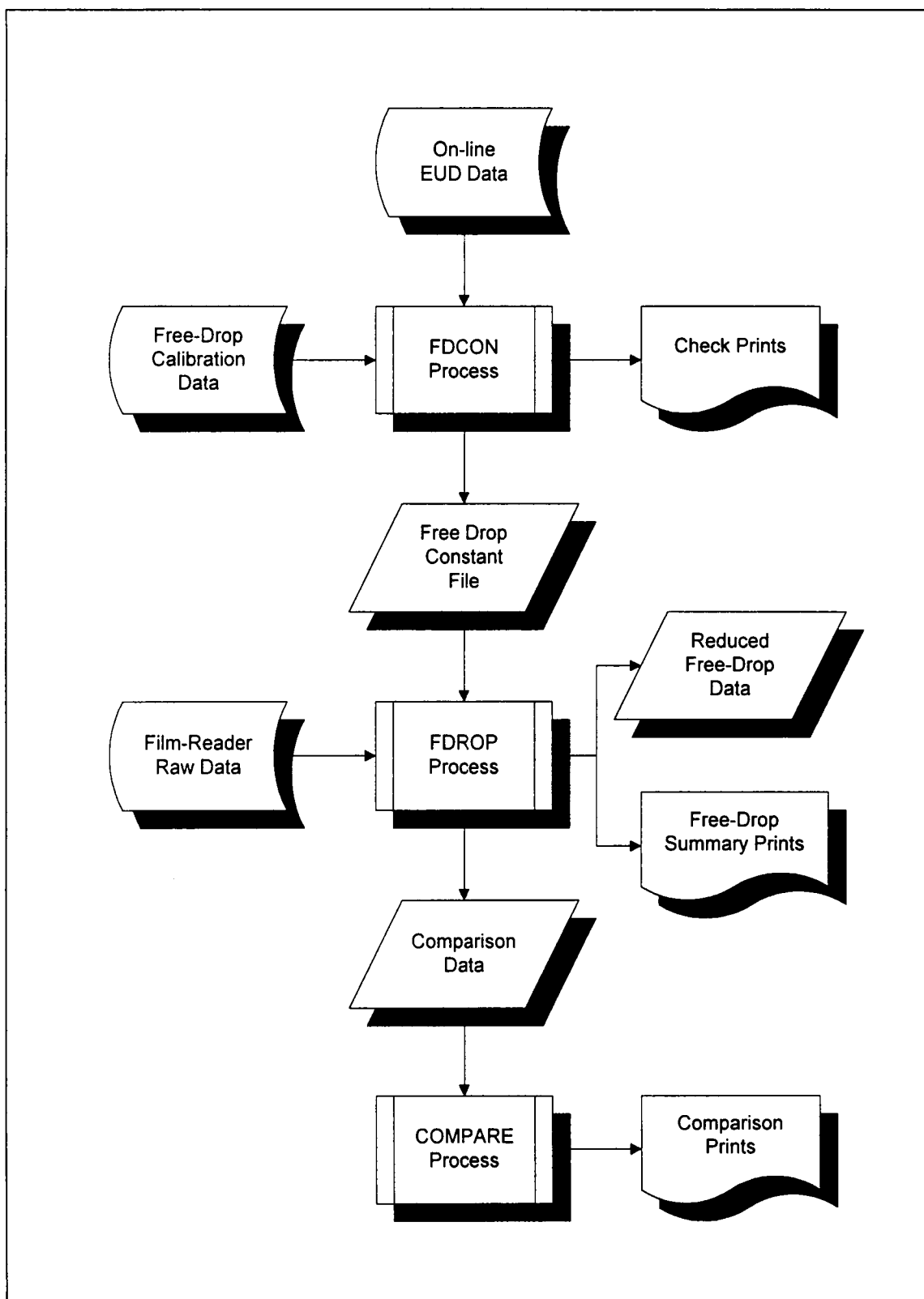


Figure 6. Overview of Free-Drop Post-Test Processes.

FDCON reads files and merges values to generate the constant sets to be used in subsequent processes. The process first requests a run range. Then the “*FDCON.WRK*” file is read and directly maps the values into the new constant set array. A set of paired values, usually test unique, are hard-coded in the subroutine *MKCON*. These paired values are locations that map EUD values from on-line testing to the constant set array. If this execution is the first time for this test, a constant set file, “*FDROPCON.DAT*”, is initialized along with the “*RUN_SET.DAT*” file. The constant set file and run-set file are then updated by appending the latest information. Printouts are then automatically spooled for printing. The following sections describe the files used and created by the *FDCON* process.

On-line EUD File

During on-line dynamic drop testing, data are stored in an EUD (Engineering Units Data) file. The file is set up as 128 words per record (512 bytes per record). The first 300 records are reserved for the log information that contains run, point, and record number. The file naming convention is dependent upon the test number and the tunnel conducting the test. Usually, files are identified by “*Tx999EU.DAT*” where x is “F” for Tunnel 16T and x is “C” for Tunnel 4T and 999 is the test number. In the case of Free-Drop testing, x is replaced with an “A” to separate it from other types of testing (i.e. AMAPS and CTS). Files are pre-allocated on disk from 150,000 to 175,000 blocks. The number of parameters per point are set up to be a multiple of 128. Data stored contains tunnel conditions (Mach number, tunnel pressure, tunnel temperature, Reynolds number, velocity, dew point, etc.), model configuration, time/date, dialed-in values, calculated data, plus other information.

Constant Set File

This file was added to the Free-Drop Process during the Amdahl® 580/5860 to VAX 8650 conversion to facilitate modification and printing of the constant sets. When the constants were contained on the Amdahl® computer, an easy method of modification and printing did not exist. The current structure of the constant set file was made identical to constant set files from other types of testing at PWT. The file is called "FDROPCON.DAT" and is a direct access file with each constant set equaling one record. Each constant set has 150 constants; an increase from 100 to allow more storage space for each set. Table 5 shows the file structure of the constant set file. Each constant set record is accessed by set number + 4 and contains constants need for reducing Free-Drop data. An existing set of user-friendly utilities was taken and modified allowing access to the constant set file. The set of utilities have been added to the existing Engineers' Workstation. It is written using VAX/VMS Screen Management (SMG) and contains utilities currently in use which allow the engineers or associates to create, modify, or print constant sets. Figure 7 shows the screen layout and options available. This is an improvement that did not exist on the Amdahl® computer system.

Run/Set File

Since there was a new method of storing constants, a need existed to correlate particular run/point numbers with constant sets. The "RUN_SET.DAT" file was created to serve this purpose. When a new constant set is generated, the run/point number and corresponding set number is appended to this file. In addition to keeping track of each run/point number and set number, any data point can be reduced with any constant set number by simply modifying the file set number. This is also a major improvement over the Amdahl® computer since the time required to change a set of constants for a particular run/point number could be extensive.

Table 5. Free-Drop Constant Set File Structure.

RECORD	CONSTANTS
RECORD #1	Constant(1) = Test Number Constant(2) = Number of Constants Constant(3) = Last Constant Set Stored Constant(4) = Checkpoint Set Record Number Constant(5) = Record for Last Set of Constants Constant(6) = Temporary Storage Flag Constant(7) = Currently Unused . . . Constant(150) = Currently Unused
RECORD #2	Reserved
RECORD #3	Reserved
RECORD #4	Checkpoint Constant Set (optional) Constant(1) . . . Constant(150)
RECORD #5	Constant Set #1 Constant(1) . . . Constant(150)
RECORD #6	Constant Set #2 Constant(1) . . . Constant(150)
...	
RECORD #n	Constant Set #n-4 Constant(1) . . . Constant(150)

FACILITY COMPUTER - CONSTANT MANAGER

CONSTANT FILE INFORMATION	
TEST NUMBER: TF 001	NUMBER OF CONSTANTS: 150
CONSTANT FILE NAME: TF001CON	LAST SET STORED: 5
	DESCRIPTOR FILE NAME: TF001.DAT

MENU OPTIONS/INSTRUCTIONS	USER INFORMATION
1). EXIT 2). INITIALIZE CONSTANT FILE 3). ENTER CHECKPOINT CONSTANTS 4). CHANGE CHECKPOINT CONS 5). ENTER RUN CONSTANTS 6). CHANGE RUN CONSTANTS 7). PRINT CONSTANTS 8). COPY OR SHIFT CONSTANTS 9). GET LAB CALIBRATION CONS 10). CONSTANT RANGE PROTECTION	

USER INPUT
ENTER OPTION >

Figure 7. Free-Drop Constant Manager Options.

Descriptor File

The descriptor file is a file that is new to the Free-Drop process. It has existed for other types of testing for several years. It is a direct access file with only two records. It contains data reduction test setup information such as number of EUD values, number of constant values, where to store certain types of values in the EUD or constant file and how many to store, etc. It is initially copied from the on-line testing descriptor file in order to maintain test peculiar information about the on-line EUD file. The Free-Drop process, specifically the *FDCON* process, uses the descriptor file for EUD file record information, and constant information. Information in the descriptor file can be modified for each test without hard-coding values into

the program which will then require re-compiling and re-linking. A utility currently exists to modify and print the descriptor file.

FDCON Check Prints

The printouts have been converted to the VAX 8650 to use the standard header print with the classification stamp. The first printout is simply a tabulation of each constant set generated for each run number input. The second printout is tabulation of the constant set boxes. These show the on-line dialed-in selections to identify the CTS constants used for that run number on-line.

FDCHK

The Free-Drop Check process, *FDCHK*, is completely separate from the other post-test processes. See Figure 8. It checks out of range or out of sequence readings in the raw data obtained from film-reading. It is essentially a validation program for the raw data.

FDCHK Check Print

The tabulated prints obtained from the *FDCHK* process provide a quick reference check of raw data for the x and y readings. Figure 9 shows a sample tabulated print from the *FDCHK* process. The "TOL" column defines the count difference between consecutive readings. For row "20X", any column with a "1" specifies a difference of at least 20 counts between it and the preceding reading. The same applies for the other "X" rows, as well as the "Y" rows. Since the store descends from the aircraft in a smooth manner, the array of 1's should be consistent and smooth. The asterisks signify frames that were not read for this particular run and camera.

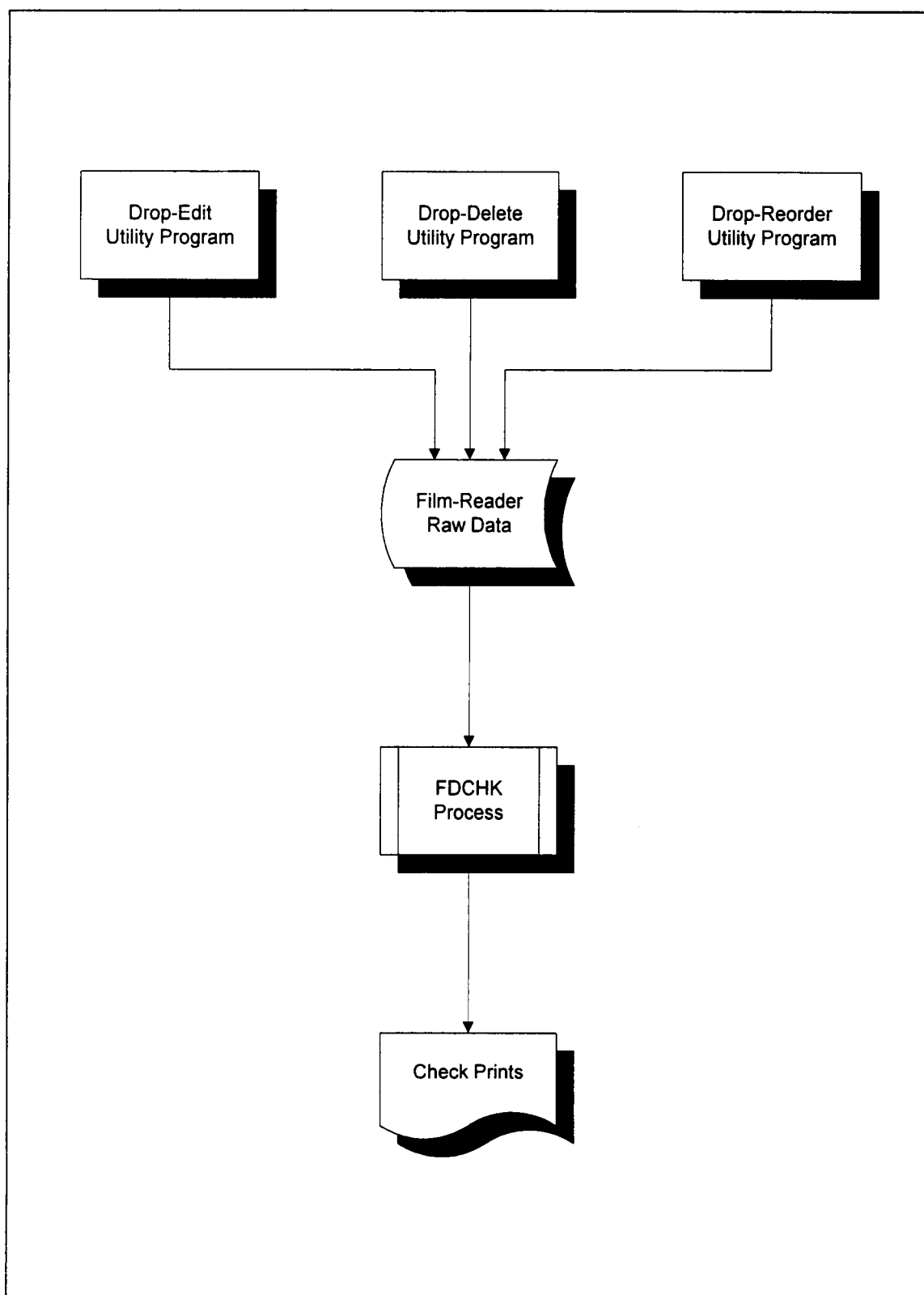


Figure 8. *FDCHK* Process.

[illegible]

Figure 9. Sample *FDCHK* Print.

Raw Data Utilities

Occasionally, the film-reader machine will drop (misinterpret) bits or readings may be accidentally skipped or repeated. Methods should exist to rectify this situation without rereading the entire run. Three new utility programs have been written to facilitate modification of the raw data readings. The *DROP_EDIT* utility will allow modification of a reading in the case of invalid bits in a drop run reading. It requests confirmation for each reading found with a dropped sign and will correct if desired. The *DROP_DELETE* utility will allow the deletion of points as in the case of duplicated readings. The *DROP_REORDER* utility will allow reordering of points after the modification or deletion of readings. A couple of other utilities exist: the *DROP_LOG* program will list all drops that have been read and stored in the raw data file and the *DROP_FILE_DUMPER* will simply tabulate raw data readings into a readable format.

Raw Data Print

Raw data print is obtained from the *DROP_FILE_DUMPER* process. See Figure 10. The header information contains test number, run number or drop number, read number, camera number, constants 1 through 4, index number, and initial frame number. Read number is identified by:

- (1) = Side Camera Nose Reading - Pitch
- (2) = Side Camera Tail Reading - Yaw
- (3) = Side Camera Roll Reading
- (4) = Bottom Camera Nose Reading - Pitch
- (5) = Bottom Camera Tail Reading - Yaw
- (6) = Bottom Camera Roll Reading.

DATE 1-JAN-99 JOB NO 9999
SVERDRUP TECHNOLOGY
AEDC GROUP
PROPULSION WIND TUNNEL
ARNOLD AIR FORCE BASE, TENNESSEE

001	1	1	0	10199	842674481	959658549	0	0
	0	0	0	10001	0	0	0	0

DATE: 10199 TIME: 12:00:00

TEST	RUN	READ	CAM	CON1	CON2	CON3	CON4	INDEX	INFM
1.	1.	1.	1.	2000.	7000.	0.	0.	37.	1.

[illegible]

*
*
*
UNCLASSIFIED
*
*

Figure 10. Sample Raw Data Print.

If no roll reading is required or taken, readings 3 and 6 are not present. Camera number is identified by a 1 if it is the side camera, and a 2 if it is the bottom camera. CON1 and CON2 are event mark readings YR1 and YR2, respectively. CON3 and CON4 are bay drop reference mark readings XREF and YREF. INDEX is the number of frames read for the drop. INFM is the initial frame after release where the first reading is taken. It is normally 1 except for bay drops. Each reading contains four parts: reading number, frame number or sequence number, x reading in counts and the y reading in counts.

FDROP

The Free-Drop data reduction process, *FDROP*, is the second major process in the post-test data reduction and analysis process. See Figure 6. This process takes files previously created along with the raw film data to create full-scale trajectory data. The Free-Drop process has been converted to run on the VAX 8650 and to use the new files required for its processing.

An option has been added to allow interactive selection of print pages. A user may select any or all of the standard six pages of reduced data tabulation. The standard error checking calls were also changed. The *DATIN* subroutine has been modified significantly. This routine reads film reader data, removes invalid frames, flags error conditions, and sets indices for data frames. Code was added to read the "RUN_SET.DAT" file for the constant set to access. Code was also added to read the new constant set file. Routines to open, read, and close files had to be replaced with VMS calls during the conversion phase. Many equations using trigonometric calculations have been replaced with VAX/VMS FORTRAN intrinsic calls, thereby reducing both the size and complexity of the program and execution time. New calculations have been added as requested.

After all calculations are complete, reduced Free-Drop data are written out to a Free-Drop EUD file. Storing post-test reduced data on the VAX 8650 is an improvement over the Amdahl® 580/5860 computer's data storage due to availability and ease of use. Although new code was required for this, currently existing utilities for EUD files can now be utilized. A new option has been added to allow transmission of reduced data to the new Analysis and Display System (ADS) for analysis and/or creating user data tapes. Requested tabulated prints are also created at this time as is the "COMPARE.DAT" file used in the *COMPARE* process.

Free-Drop EUD File

All Free-Drop post-test reduced data are stored into an EUD file, "FDROPEUD.DAT", on the VAX 8650. The file follows the same structure as other EUD files. The file is set up as 128 words per record (512 bytes per record). The first 300 records are reserved for the log information that contains run, point, and record number. Since reduced data from drops are not nearly as great as on-line testing, files are usually pre-allocated to a smaller amount of blocks, possibly between 20,000 and 50,000 blocks. The number of parameters is currently fixed at 384 (a multiple of 128) per point. Since Free-Drop EUD files are maintained on the VAX 8650, existing utilities including user data tape programs can be utilized.

Free-Drop Printout

The reduced data printouts have been converted to the VAX 8650 to use the standard header print with the classification stamp. The header lines printed at the top of each page which contain information such as test number, run number, tunnel conditions, and configuration information, have been modified. Certain calculated values have been added or deleted and other values are printed using different units.

"COMPARE.DAT" File

The comparison data file, "COMPARE.DAT", is a direct access file with a record size of 46. Table 6 shows the parameters that are stored in the file for comparison purposes in the subsequent process, *COMPARE*. See Figure 6.

COMPARE

The comparison process is the last step in the Free-Drop post-test analysis process. See Figure 5. It has been converted to execute on the VAX 8650. It compares any two requested runs and gives the deltas and also calculates the mean and standard deviation. New routines to open, read, and close files have been incorporated into the software. After comparisons are complete, "COMPARE_OUT.DAT" is tabulated for printing.

Table 6. Comparison File Parameters.

#	NAME	#	NAME	#	NAME	#	NAME
1)	TEST	13)	ZP	25)	CONFIG	37)	DNETA
2)	RUN	14)	DPSI	26)	TRAJ	38)	OMEGA
3)	POINT	15)	DTHA	27)	H	39)	STORE #
4)	T	16)	DPHI	28)	QA	40)	XPN
5)	X	17)	REY #	29)	WT	41)	XPT
6)	Y	18)	MACH	30)	IYY	42)	YPN
7)	Z	19)	PT	31)	XCGR	43)	YPT
8)	PSI	20)	P1	32)	YCGR	44)	ZPN
9)	THA	21)	Q1	33)	ZCGR	45)	ZPT
10)	PHI	22)	TT	34)	FEZ	46)	NRC
11)	XP	23)	ALPHA	35)	MEY		
12)	YP	24)	BETA	36)	DNU		

“COMPARE_OUT.DAT”

The comparison printout, “COMPARE_OUT.DAT”, has been converted to the VAX 8650 to use the standard header print with the classification stamp. See Figure 11. The printout contains each compared run, PARTA and PARTB, and their corresponding frame numbers, IA and IB. The deltas, DX, DY, DZ, DPSI, DTHETA, and DPHI, are also tabulated. The means and standard deviations are also included at the bottom of the page.

DATE 1-JAN-99 JOB NO 9999				*****						000001	
SVERDRUP TECHNOLOGY				*							
AEDC GROUP				* UNCLASSIFIED *							
PROPULSION WIND TUNNEL				*							
ARNOLD AIR FORCE BASE, TN				*****							
PART A	IA	PART B	IB	DX	DY	DZ	DPSI	DTHETA	DPHI		
3	1	4	1	0.0000	0.0000	0.0000	0.0100	0.3998	0.8124		
3	2	4	2	0.5500	0.0100	0.3071	0.0178	1.0896	4.8938		
3	3	4	3	0.5004	0.0201	0.4050	0.2130	1.9383	4.9084		
3	4	4	4	0.6400	0.1030	0.0450	0.2077	1.0045	6.8293		
3	5	4	5	0.4600	0.1300	0.3010	0.3451	0.9832	6.1233		
3	6	4	6	0.8080	0.0400	0.4512	0.1473	1.3892	5.2394		
3	7	4	7	0.7980	0.0510	0.0450	0.4590	1.2939	5.2644		
3	8	4	8	0.8010	0.0303	0.0987	0.3286	2.0001	6.8773		
3	9	4	9	0.8020	0.2000	0.1234	0.5869	2.3398	7.4445		
3	10	4	10	1.2030	0.9817	0.1678	0.9374	2.3894	9.0490		
3	11	4	11	1.4234	0.4384	0.3479	0.9630	3.0448	9.3022		
3	12	4	12	1.9823	0.3049	0.3423	0.8970	4.3646	9.4039		
3	13	4	13	1.9045	0.4326	0.2346	0.7930	5.4345	9.9034		
3	14	4	14	1.0943	0.1234	0.4333	0.4532	5.6646	8.4449		
3	15	4	15	2.0289	0.9018	0.8389	0.8630	5.4847	8.5429		
3	16	4	16	3.0203	0.1234	0.5435	0.4435	5.3437	8.9423		
3	17	4	17	3.0283	0.4564	0.5574	0.3340	6.0355	9.4525		
3	18	4	18	3.9873	0.4570	0.6475	0.3950	6.2846	9.9727		
3	19	4	19	2.0923	0.4560	0.3349	0.6535	5.1947	9.9828		
MEANX	2SIGX	MEANY	2SIGY	MEANZ	2SIGZ	MEANPSI	2SIGPSI	MEANP	2SIGP	MEANR	2SIGR
0.500	5.120	0.645	1.921	1.643	5.242	8.193	9.989	5.432	8.993	9.988	5.389

* UNCLASSIFIED *											

Figure 11. Sample COMPARE Print.

CHAPTER VII

IMPROVEMENT PHASE II

The second phase of improvements consists of providing a user-friendly GUI for the post-test analysis processes. The GUI was created while referencing the HCI (Human-Computer Interface) manual that has been adopted by the Department of Defense (DoD). The creation of an operator interface requires certain procedural checking (i.e. certain processes must be executed before others). The code also must handle some automated processing (file setup, file copying, initializing variables, etc.). This allows computer programming associates or engineers or their associates to execute the procedures without major intervention from the computer scientists.

Screen Design

The creation of a graphical user interface has taken the Free-Drop processes toward the direction of Automated Data Processing (ADP). To accommodate the expected growth in automated processing and control HCI diversity, the DoD has adopted software development standards and guidelines for data display and manipulation. HCI encompasses any interaction between the user and the system. This includes controls, displays, environmental concerns (e.g. lighting and noise), workstation layout, procedures and documentation. The design of these elements has a major impact on manpower, personnel selection, training, logistics, safety and human performance. The HCI is the human's window into a computerized system. Essentially,

it is that portion of the software and hardware that connects the user with the resident application programs and allows the user to input, manipulate and retrieve data. As such, it is the single most important aspect of the system design (DoD, 1992).

The screen layouts have been designed using the X-Designer tool which generates C language shell code from the design. The new C language code has been modified to function with the existing FORTRAN-77 code. X-Designer language generated code can only operate on a windows-type terminal. The following sections describe the new operator interface and define modifications required for automation and procedural checking.

Screen Layouts

Several manuals and guides have been referenced in creating the menu screen layouts. The DoD manual suggests several guidelines which have been incorporated. Figure 12 shows the Main Menu screen layout. Figure 13 shows the Raw Data Menu screen. Figure 14 shows the Constant Menu screen and the EUD Menu screen. Figure 15 shows the *FDCON* Menu screen and the *FDROP* Menu screen.

All windows contain a title bar that specifies the process name, Free-Drop, and the menu displayed. All windows are icon capable and movable by dragging (with a ghost shadow) (DoD, 1992). When the user executes the Free-Drop application, he may arrange the menus anywhere on the workspace. When the menus are maximized from the icon state, they will resume their original position on the workspace. A clock with date and time is continuously displayed for user information (DoD, 1992). All colors are eye-pleasing and not overstated so as not to cause eye strain. The active window is bordered in a different shade to avoid confusion. Both the DoD (1992) and Shneiderman (1987) suggest limiting the number of colors per window to four, and

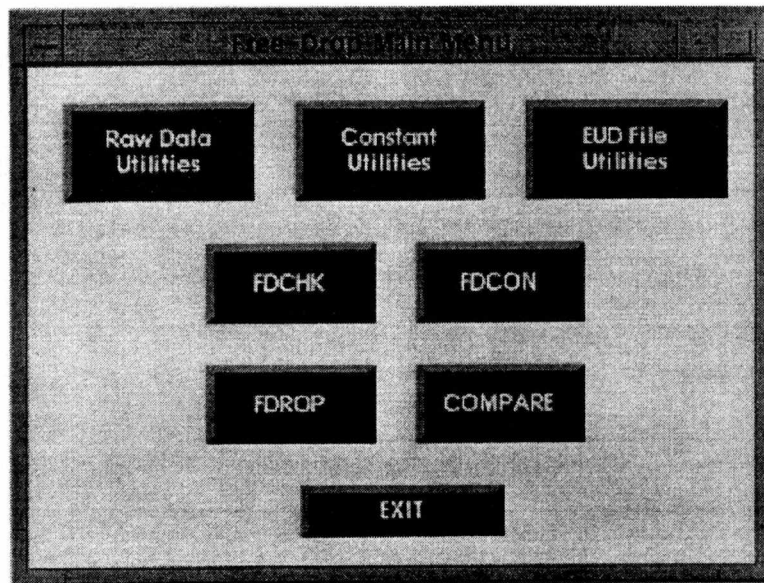


Figure 12. Free-Drop Main Menu Screen.

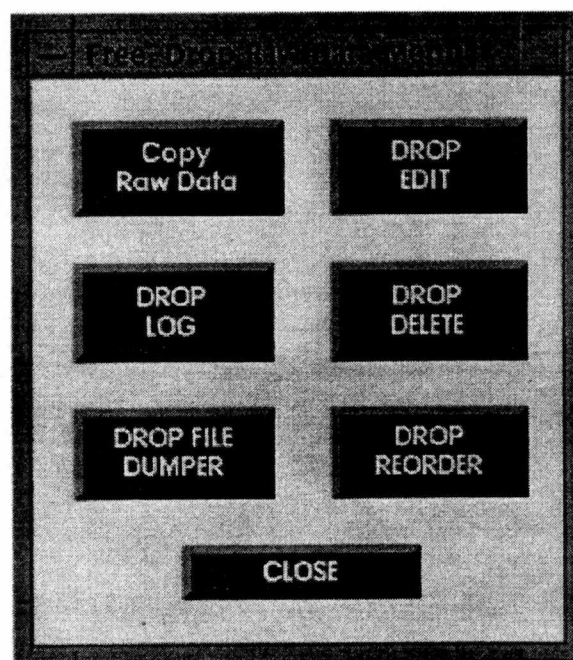


Figure 13. Free-Drop Raw Data Menu Screen.

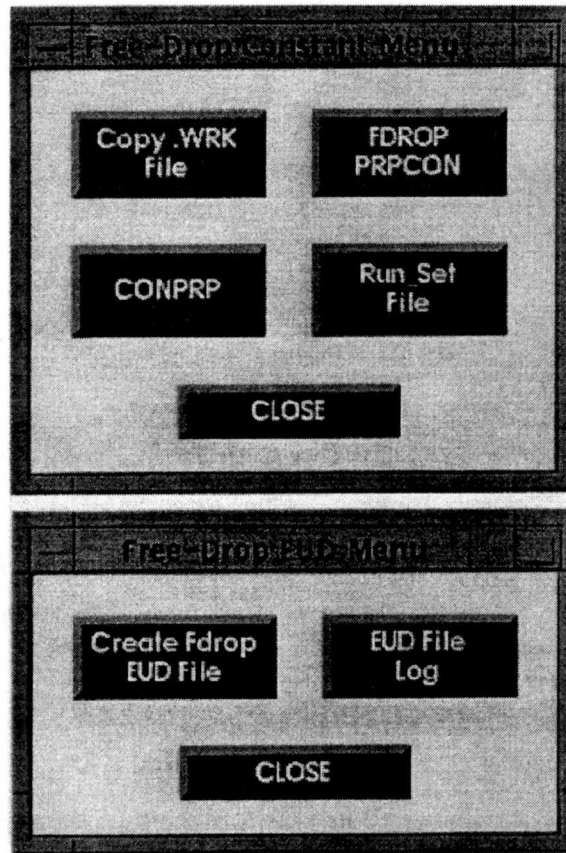


Figure 14. Free-Drop Constant Menu and EUD Menu Screens.

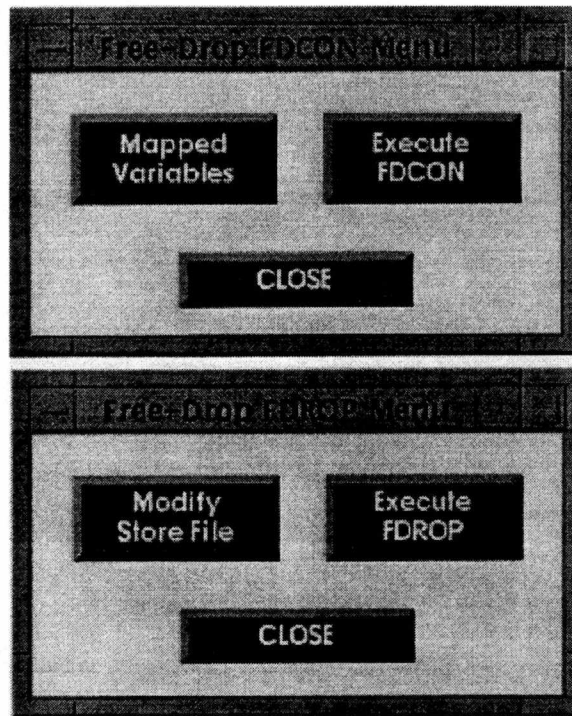


Figure 15. Free-Drop *FDCON* Menu and *FDROP* Menu Screens.

limiting the number of colors per application to seven. The colors of the Free-Drop process have been kept within this acceptable limit for both the individual windows and the entire application. Buttons were chosen for all user interaction with the menus for simplicity. The Main Menu screen layout is divided into three sections: utility options, process options, and the exit program option. The utility options are usually required before executing the processes so they are offered at the top of the screen. All close buttons are at the bottom of each screen to maintain consistency and familiarity.

All previous incorporations were all accomplished through the X-Designer software. Once the design is thoroughly thought out, X-Designer can be used to design the screens. Each menu requires a form with buttons. Each menu can be attached to the main menu automatically

through the linking option. Each menu window can be made to automatically close by utilizing the callback option. Every window color, button background color, highlight color, top and bottom shadow color can be selected from an array of colors. For ease of modification, global names have been selected and bound to colors throughout the application. If, after several testing efforts, users wish to change colors, they can be altered with minimal effort. After the design is complete, the option to generate C code can be selected. This will actually create the main C routine complete with all code and include files to execute the design with no software modification. The stubs code can also be generated from X-Designer. It contains "call-back" code or subroutine and function calls including the Main Menu exit option. The main C code can be generated at any time for checkout options. The stubs routine should only be created once. Since code must be added to the routine, generating it again will write over any modifications to the file.

Software Modification

Many software modifications have been incorporated into both the original code and the generated code to allow the user interface to execute properly and error-free. Most of the new code has been added to perform validation checks and to improve robustness. Code has been added to the C stubs routine to call an intermediate FORTRAN routine with the menu option chosen. The FORTRAN routine spawns the correct process depending upon the option chosen. All interactive programs spawn a DECterm™ window which allows user input to the processes. All windows are icon capable and contain scrolling capabilities. Each menu has a close option which will close and erase the screen. This will return control to the Main Menu screen. Any/all menus may be displayed on the workspace at the same time. The user does not need to close the

window if an option from another menu is desired. The Main Menu screen has an exit option. This will exit the user interface and all windows will erase. The following sections list each window's options along with the software modifications for each process.

Raw Data Utilities Menu

The Raw Data Utilities Menu (Figure 13) contains utility programs that operate on the film-reader raw data. After the data had been read (or re-read), it was manually copied from the film-reader area. The *Copy Raw Data* option has been added as a button to this menu. Checks have been incorporated to inquire if the raw data file currently exists on the Facility Computer. If it exists, the program will inform the user to confirm his request to copy. The *DROP LOG* and *DROP FILE DUMPER* options also perform checks for the existence of a raw data file. The user is allowed to spawn the tabulated prints from these utilities to one of several print queues. The remaining options, *DROP EDIT*, *DROP DELETE*, and *DROP REORDER* also perform raw data checks.

Constant Utilities Menu

The Constant Utilities Menu (Figure 14) contains utility programs that operate on constants from both the constants work file and the constant sets file. The *Copy .WRK File* option allows the user to copy the constants work file to the data reduction area upon the Project Engineer's completion of entering constants. Checks have been included to insure copying does not overwrite currently existing constants. The *CONPRP* option allows access to the constant work file. Initialization can be performed from this option. Checks have been included to prevent erasing of existing constants. Modification and printing of the constants can be obtained from this option. The *FDROP PRPCON* option will allow access to the constant sets created

from the process *FDCON*. Code has been supplied to inform the user if constant sets do not yet exist. The user can modify, list, and print constant sets from this option. The *Run_Set File* option will allow viewing of the "Run_Set.Dat" file. This file contains run numbers with corresponding constant set numbers created from the *FDCON* process.

EUD File Utilities Menu

The EUD File Utilities Menu (Figure 14) allows the creation of the Free-Drop EUD data file. Checks have been included to prevent the creation of a new file if the EUD file has been previously created. The *EUD File Log* allows the user to list stored run/points from the Free-Drop EUD file and the on-line EUD file.

FDCHK

The *FDCHK* option will allow execution of the process through user interaction from an interactive window. The user can then spool the tabulated print to a selected queue. A check has been added to ensure the existence of the film-reader raw data before the user is allowed to execute this process. Other minor improvements have been made to the standard print for readability.

FDCON Menu

The *FDCON* option (Figure 15) is the first of several in line processes executed for Free-Drop post-test analysis. The *Mapped Variables* option allows the user to modify the variable mappings which were normally hardcoded into the program. Since mappings usually vary from test to test (different EUD files, different tunnels, test peculiar equations, etc.), this is a very valuable addition to the software. Validation checks must be performed on the mappings.

Constant indices must be in the range from 1 to 150. EUD indices must be in the range from 1 to the number of on-line EUD values for the test. This number is contained in the descriptor file. The *Execute FDCON* allows execution of the *FDCON* process. Many checks must be performed internally prior to actual execution. The on-line EUD file and the constants work file must be accessible for this process to execute. Code has been added to initialize the Free-Drop descriptor file the first time *FDCON* is executed. It is copied from the on-line descriptor file and applicable indices are changed for the post-test analysis software. If run numbers are entered for processing, duplicate run number checks have been included. They are allowed but confirmation from the user is requested. Tabulated printouts can also be spooled to the desired print queue. The standard printouts have been modified with minor improvements.

FDROP Menu

The *FDROP* option (Figure 15) is the second step of several in line processes executed for Free-Drop post-test analysis. The *Modify Store.Dat* option allows the user to input the test peculiar configuration names into a file. This information used to be obtained from the project engineer and inserted into the code. This option will initialize a file this first time and allow modifications any successive time. The *Execute FDROP* will execute the process with user interaction through a DECterm™ window. Checks have been performed to insure that constant sets have been generated through the *FDCON* process. In order to transmit the reduced data to the ADS system, the file must have been previously set up for the test. The user will be presented with this question. If the file has not been set up, the user should exit the program and put in a request for ADS file initialization. The user can select any pages for output and spool them for print.

COMPARE

The *COMPARE* option is the last step in the Free-Drop data reduction. Checks have been installed to insure that the *FDROP* process has been previously executed and created the "COMPARE.DAT" file. Before the improvements, the smallest frame number was required when comparing two runs. Since this was not immediately known, the software has been modified to handle this internally. The *COMPARE* printout has also been improved. The user can spool the print to the desired print queue.

CHAPTER VIII

VALIDATION RESULTS

A sample data set has been run through the final processes to ensure validation and provide an example of the all the steps necessary to complete Free-Drop analysis on a wind tunnel drop. All data are fictitious and used solely for the aid of demonstration.

The first step after filming the drop is analyzing the data on the film-reader machine. Once the film had been read, an appropriate username and password was obtained. Once logged on to the VAX Facility Computer, the Free-Drop Main Menu appears. From the Main Menu, the Raw Data Utilities option was selected. The film readings can now be copied to the working directory by selecting the Copy Raw Data option from the Raw Data Utilities Menu. The *Drop Log* option was selected next to obtain a current listing of sample drop runs that were read using the film-reader. Figure 16 shows the drop runs used for this example. According to Figure 16, drop run 1 only had the pitch reading from camera 1 and camera 2 analyzed. Drop run 2 had all six readings analyzed. Drop runs 3, 4, and 5 had the pitch and yaw readings analyzed but not the roll readings. Drop run 6 had all readings analyzed. Run 0 signifies the end of the raw data file. For this example, drop runs 2 and 6 will be used since all readings were obtained. The *Drop File Dumper* option can be selected to obtain raw data printouts similar to Figure 10. This printout contains the actual readings that were analyzed from the film. A quick glance at the raw data can signal that some readings may be incorrect.

The next step, *FDCHK*, was chosen from the Main Menu. This will provide a more accurate check for consistency in the reading values. A printout was obtained and values were checked. The printout obtained is similar to Figure 8. This example will assume all data have

MENU OF DATA FILE RUNS FOR FD001.RDF							
RUN	1	1	0	0	4	0	0
RUN	2	1	2	3	4	5	6
RUN	3	1	2	0	4	5	0
RUN	4	1	2	0	4	5	0
RUN	5	1	2	0	4	5	0
RUN	6	1	2	3	4	5	6
RUN	0	0	0	0	0	0	0

Figure 16. Drop Log Listing.

been obtained correctly (coordinates are correct and no bits have been missed). If the data had been incorrect, *Drop Edit*, *Drop Delete*, or *Drop Reorder* could have been executed on the raw data accordingly from the Raw Data Utilities Menu.

Before the constant set file could be generated, the Copy .WRK File was selected from the Constant Utilities Menu. This will copy the work file created on-line by the Project Engineer to the working directory. The engineer can enter or modify these values by selecting the *CONPRP* option from this menu. The next step, *FDCON*, was chosen from the Main Menu. The *FDCON* menu will allow the user to modify selected variables from the on-line EUD file to be mapped into the constant sets. The Execute *FDCON* option was selected next. This will create a "RUN_SET.DAT" file containing the sample drop runs 2 and 6 and their corresponding set numbers 2 and 3 (set 1 is the reserved checkpoint set). The *FDROP PRPCON* option can be chosen to modify or print any constant set. The Run_Set File option can be selected to alter the

set number used for a particular drop run. Any subsequent drop runs executed will append to the "RUN_SET.DAT" file. The FDCON process generates printouts of all 150 constants for each drop run as well as constant box configuration information. The constant box configuration information is the dialed-in information used to select each set number of constants from each constant group from the work file. See Figure 17.

The next step is to create an EUD file for the reduced data. From the Main Menu, the EUD File Utilities Menu was selected. From the EUD File Utilities Menu, the Create Fdrop EUD File option was selected. This created and initialized the standard Free-Drop EUD file.

Before data could be reduced to its final form, an ADS graphics file setup request was made. The appropriate programmer set up this file accordingly. The VAX Facility Computer operator was informed to start the ADS router for data shipment. After these steps were complete, FDROP, was selected from the Main Menu. The Modify Store File was then selected and sample store names were entered. The Execute *FDROP* option was then selected to reduce the data to its final form for both tabulated print and transmission to the graphics system.

RUN				POINT			
2				2			
A	B	C	D	E	F	G	H
1	2	1	0	1	3	7	1

RUN				POINT			
6				2			
A	B	C	D	E	F	G	H
1	2	1	0	4	2	7	0

Figure 17. Constant Box Configuration.

Summary 1 was selected for print. Figure 18 contains the sample data for Drop Run 2 and Figure 19 contains the sample data for Drop Run 6. If a log of the Free-Drop reduced data EUD file is desired, the EUD File Log option can be selected from the EUD File Utilities Menu.

Comparisons were made for this example. The *COMPARE* option was chosen from the Main Menu. Figure 20 shows the comparison printout obtained when comparing the sample drop runs 2 and 6.

Figure 21 shows the Drop Run 2 time history plot for the Flight Axis (X, Y, Z, PSI, THA, and PHI). Figure 22 shows the Drop Run 6 time history plot for the Pylon Axis (XP, YP, ZP, DPSI, DTHA, and DPHI).

DATE 4-APR-96													00000001

SVERDRUP TECHNOLOGY													
AEDC GROUP													

UNCLASSIFIED													

PROPULSION WIND TUNNEL													

ARNOLD AIR FORCE BASE, TENNESSEE													

TEST RUN MACH PT P Q TT T V RE H QA FRAMES USED TRANSONIC 4T													
TC-1 2 1.195 1766.8 733.3 733.1 556.7 433.0 1218.5 3.714 10.00 1449.5 31													
SCALING LAW MODEL SCALE WTM IYYM XCGM YCGM ZCGM THETM-DOT SCALE													
HEAVY PARAMETERS 1.833 18.732 9.648 0.000 -0.765 -119.200 0.067													
NOROLL FULL SCALE WT IYY XCG YCG ZCG THETA-DOT ISIM IERROR HSIM L													
0 PARAMETERS 815.4 396.0 12.06 0.00 -0.96 -30.78 404.6 -2.17 10.10 20.46													
ALPHA BETA IP IY CONFIG TRAJ A/C STORE STORE NO HOOK RELEASE TIME SUMMARY 1													
1.05 0.00 -2.50 0.50 250 3 F16 MISSILEI 16 0.000													
PN T X Y Z PSI THA PHI DL DL2 XP YP ZP DPSI DTHA DPHI													
1 -0.0051 0.00 0.00 0.00 0.71 -1.14 -71.9 236.75 38.15 0.00 0.00 0.00 0.71 0.32 -71.89													
2 0.0046 0.01 0.01 -0.01 1.61 -0.39 -71.8 236.65 39.03 0.01 0.01 0.01 1.61 1.07 -71.72													
3 0.0144 0.02 0.02 -0.02 2.19 0.39 -71.8 236.62 38.74 0.02 0.02 0.02 2.19 1.84 -71.74													
4 0.0241 0.04 0.01 -0.02 3.65 1.71 -71.8 236.60 38.33 0.04 0.01 0.02 3.65 3.16 -71.68													
5 0.0339 0.06 0.02 -0.02 4.73 2.09 -71.6 236.57 37.23 0.06 0.02 0.02 4.73 3.54 -71.50													
6 0.0437 0.07 0.03 -0.03 4.81 1.04 -71.6 236.57 34.62 0.07 0.03 0.03 4.82 2.49 -71.46													
7 0.0534 0.10 0.05 -0.05 7.21 2.34 -71.0 236.25 31.42 0.10 0.05 0.05 7.22 3.78 -70.85													
8 0.0632 0.13 0.06 -0.06 9.08 2.89 -70.6 236.04 28.16 0.13 0.06 0.06 9.10 4.33 -70.37													
9 0.0729 0.16 0.08 -0.07 11.89 5.08 -69.8 235.73 25.71 0.16 0.08 0.07 11.92 6.51 -69.49													
10 0.0827 0.20 0.10 -0.09 14.81 6.88 -68.8 235.36 21.60 0.20 0.10 0.09 14.86 8.29 -68.47													
11 0.0925 0.24 0.14 -0.13 17.51 8.20 -67.7 234.86 19.35 0.24 0.14 0.13 17.58 9.59 -67.27													
12 0.1022 0.30 0.20 -0.17 22.22 11.90 -65.7 233.83 14.81 0.30 0.20 0.18 22.34 13.24 -65.16													
13 0.1120 0.34 0.24 -0.21 27.02 15.79 -63.5 232.73 11.57 0.34 0.24 0.22 27.22 17.08 -62.78													

Figure 18. FDROP Summary 1 Print - Run 2.

14	0.1217	0.38	0.30	-0.26	30.95	18.04	-61.4	231.58	8.48	0.37	0.30	-0.27	31.20	19.29	-60.57
15	0.1315	0.41	0.37	-0.32	34.97	20.40	-59.1	230.11	4.51	0.41	0.37	-0.33	35.29	21.59	-58.19
16	0.1412	0.45	0.45	-0.38	39.41	22.69	-56.3	228.30	0.95	0.44	0.45	-0.39	39.80	23.82	-55.31
17	0.1510	0.47	0.52	-0.43	44.16	25.78	-53.2	225.30	-2.06	0.46	0.52	-0.44	44.66	26.82	-52.05
18	0.1608	0.51	0.62	-0.49	49.06	28.04	-49.9	221.85	-3.34	0.49	0.62	-0.51	49.66	28.99	-48.69
19	0.1705	0.54	0.73	-0.56	54.02	30.57	-46.4	216.09	-5.32	0.53	0.73	-0.57	54.73	31.42	-45.01
20	0.1803	0.57	0.88	-0.65	58.14	31.48	-43.4	210.63	-6.53	0.56	0.88	-0.66	58.91	32.24	-41.96
21	0.1900	0.57	0.98	-0.66	62.82	32.93	-40.0	203.59	-3.11	0.56	0.98	-0.68	63.68	33.59	-38.45
22	0.1998	0.59	1.16	-0.72	66.56	33.37	-37.2	195.05	2.71	0.57	1.16	-0.74	67.45	33.94	-35.61
23	0.2096	0.57	1.38	-0.82	70.96	33.68	-34.2	186.00	17.55	0.55	1.38	-0.83	71.89	34.14	-32.54
24	0.2193	0.52	1.65	-0.90	75.41	33.48	-31.1	174.65	42.66	0.50	1.65	-0.91	76.35	33.84	-29.44
25	0.2291	0.41	1.92	-1.01	79.97	33.56	-28.2	164.46	81.11	0.39	1.92	-1.02	80.93	33.80	-26.49
26	0.2388	0.24	2.31	-1.18	85.08	33.07	-25.1	152.30	128.04	0.21	2.31	-1.19	86.03	33.19	-23.34
27	0.2486	-0.73	3.57	0.20	90.40	32.30	158.0	143.93	142.81	-0.73	3.57	0.21	91.32	32.28	159.75
28	0.2584	-1.04	3.72	0.14	96.23	31.94	161.3	139.04	84.81	-1.04	3.72	0.17	97.13	31.77	162.99
29	0.2681	-1.32	3.72	0.18	100.81	31.97	163.8	135.93	-6.85	-1.31	3.72	0.21	101.69	31.68	165.46
30	0.2779	-1.58	3.56	0.31	105.33	31.88	166.2	137.10	-88.29	-1.57	3.56	0.35	106.19	31.48	167.86
31	0.2876	-1.79	3.31	0.49	109.42	31.83	168.3	140.03	-152.29	-1.78	3.31	0.54	110.26	31.33	169.94
MEANL1 2SIGL1 MEANL2 2SIGL2 200.02 102.32 19.52 102.41															

* UNCLASSIFIED *															

Figure 18. *FDROP* Summary 1 Print - Run 2 (continued)

DATE 4-APR-96										*****										00000002									
SVERDRUP TECHNOLOGY										*****																			
AEDC GROUP										*****																			
PROPULSION WIND TUNNEL										*****																			
ARNOLD AIR FORCE BASE, TENNESSEE										*****																			
TEST RUN MACH PT P Q TT T V RE H QA FRAMES USED TRANSONIC 4T																													
TC- 1 6 0.499 231.4 195.3 34.0 545.7 519.8 557.0 0.326 40.00 67.6 32																													
SCALING LAW MODEL SCALE WTM IYYM XCGM YCGM ZCGM THETM-DOT SCALE																													
HEAVY PARAMETERS 1.821 18.543 9.660 0.000 -0.766 -119.200 0.067																													
NOROLL FULL SCALE WT IYY XCG YCG ZCG THETA-DOT ISIM IERROR HSIM L																													
0 PARAMETERS 815.4 396.0 12.07 0.00 -0.96 -30.78 403.2 -1.81 40.16 20.46																													
ALPHA BETA IP IY CONFIG TRAJ A/C STORE STORE NO HOOK RELEASE TIME SUMMARY 1																													
14.72 0.00 -2.50 0.50 250 2 F16 MISSILE2 20 0.000																													
PN T X Y Z PSI THA PHI DL DL2 XP YP ZP DPSI DTHA DPHI																													
1 -0.0077 0.00 0.00 0.00 0.04 -1.96 -71.9 236.83 37.19 0.00 0.00 0.00 0.04 -14.18 -71.95																													
2 0.0021 0.01 0.01 -0.01 1.05 -1.08 -71.8 236.73 38.42 0.02 0.01 -0.01 1.08 -13.29 -72.02																													
3 0.0119 0.02 0.02 -0.03 1.67 -0.25 -71.8 236.68 38.97 0.03 0.02 -0.02 1.71 -12.46 -72.17																													
4 0.0216 0.04 0.03 -0.03 2.67 0.51 -71.8 236.64 38.68 0.04 0.03 -0.02 2.73 -11.69 -72.38																													
5 0.0314 0.06 0.02 -0.03 4.35 1.63 -71.6 236.61 38.22 0.07 0.02 -0.01 4.42 -10.55 -72.57																													
6 0.0411 0.08 0.03 -0.03 5.02 1.29 -71.5 236.60 36.75 0.08 0.03 -0.02 5.11 -10.88 -72.62																													
7 0.0509 0.10 0.05 -0.05 5.96 0.78 -71.2 236.40 34.04 0.11 0.05 -0.02 6.08 -11.37 -72.51																													
8 0.0607 0.13 0.07 -0.06 8.15 1.72 -70.7 236.15 30.69 0.14 0.07 -0.03 8.28 -10.37 -72.48																													
9 0.0704 0.16 0.08 -0.07 10.12 2.86 -70.2 235.94 27.85 0.17 0.08 -0.04 10.24 -9.16 -72.40																													
10 0.0802 0.19 0.10 -0.08 13.22 4.88 -69.3 235.62 24.74 0.21 0.10 -0.04 13.27 -7.01 -72.07																													
11 0.0899 0.24 0.12 -0.11 15.96 6.25 -68.2 235.24 21.38 0.25 0.12 -0.05 15.93 -5.50 -71.58																													
12 0.0997 0.28 0.18 -0.15 19.20 8.13 -66.9 234.59 18.42 0.31 0.18 -0.09 19.03 -3.42 -70.85																													
13 0.1094 0.33 0.23 -0.19 24.08 12.22 -64.7 233.63 14.20 0.36 0.23 -0.12 23.50 1.03 -69.68																													

Figure 19. FDROP Summary 1 Print - Run 6.

DATE 4-JAN-96 JOB NO 9999				*****						000001	
SVERDRUP TECHNOLOGY				*		*					
AEDC GROUP				*		UNCLASSIFIED		*			
PROPULSION WIND TUNNEL				*		*					
ARNOLD AIR FORCE BASE, TN				*****							
PARTA	IA	PARTB	IB	DX	DY	DZ	DPSI	DTHETA	DPHI		
2	1	6	1	0.0000	0.0000	0.0000	0.6725	0.8264	0.0264		
2	2	6	2	-0.0011	0.0009	-0.0010	0.5595	0.6882	0.0368		
2	3	6	3	-0.0025	-0.0028	0.0037	0.5210	0.6407	0.0174		
2	4	6	4	-0.0004	-0.0124	0.0158	0.9748	1.2019	0.0272		
2	5	6	5	-0.0047	-0.0047	0.0062	0.3786	0.4681	0.0145		
2	6	6	6	-0.0095	-0.0004	0.0010	-0.2041	-0.2530	-0.0419		
2	7	6	7	0.0054	0.0015	-0.0015	1.2438	1.5515	0.1921		
2	8	6	8	0.0008	-0.0030	0.0045	0.9354	1.1740	0.1355		
2	9	6	9	0.0077	-0.0019	0.0026	1.7683	2.2216	0.4470		
2	10	6	10	0.0063	0.0025	-0.0021	1.5912	2.0001	0.4329		
2	11	6	11	0.0093	0.0185	-0.0212	1.5514	1.9538	0.5135		
2	12	6	12	0.0179	0.0210	-0.0228	3.0204	3.7697	1.1306		
2	13	6	13	0.0122	0.0134	-0.0131	2.9451	3.5678	1.2553		
2	14	6	14	0.0096	0.0262	-0.0281	2.1551	2.5590	1.0348		
2	15	6	15	0.0090	0.0302	-0.0324	2.1757	2.5450	1.1725		
2	16	6	16	0.0073	0.0270	-0.0275	2.3719	2.7402	1.3645		
2	17	6	17	0.0102	0.0313	-0.0298	2.7369	3.0479	1.6540		
2	18	6	18	0.0129	0.0382	-0.0341	2.4228	2.6975	1.4870		
2	19	6	19	0.0208	0.0509	-0.0413	2.4726	2.6900	1.6188		
2	20	6	20	0.0251	0.0684	-0.0559	1.5011	1.6994	0.9307		
2	21	6	21	0.0184	0.0334	-0.0094	1.5109	1.8228	1.0213		
2	22	6	22	0.0303	0.0801	-0.0482	0.9667	1.3095	0.6182		
2	23	6	23	0.0332	0.1153	-0.0739	0.5634	0.9697	0.3415		
2	24	6	24	0.0295	0.1341	-0.0756	0.3309	0.8693	0.2151		
2	25	6	25	0.0197	0.1615	-0.0997	0.0819	0.5151	0.0688		
2	26	6	26	0.0107	0.2336	-0.1537	-0.0413	0.3301	-0.0172		
2	27	6	27	-0.0086	0.1757	-0.1166	-0.0569	0.1389	-0.0330		
2	28	6	28	-0.0185	0.1046	-0.0703	-0.0299	0.0408	-0.0305		
2	29	6	29	-0.0181	-0.0101	0.0182	-0.1170	0.1161	-0.1047		
2	30	6	30	0.0055	-0.1290	0.0990	-0.1117	0.0850	-0.1244		
2	31	6	31	0.0269	-0.1993	0.1485	-0.1849	0.1128	-0.2456		
MEANX	2SIGX	MEANY	2SIGY	MEANZ	2SIGZ	MEANPSI	2SIGPSI	MEANP	2SIGP	MEANR	2SIGR
0.009	0.026	0.032	0.160	-0.021	0.111	1.120	2.034	1.422	2.225	0.489	1.168

*		*									
*		UNCLASSIFIED									
*		*									

Figure 20. COMPARE Print - Run 2 and Run 6.

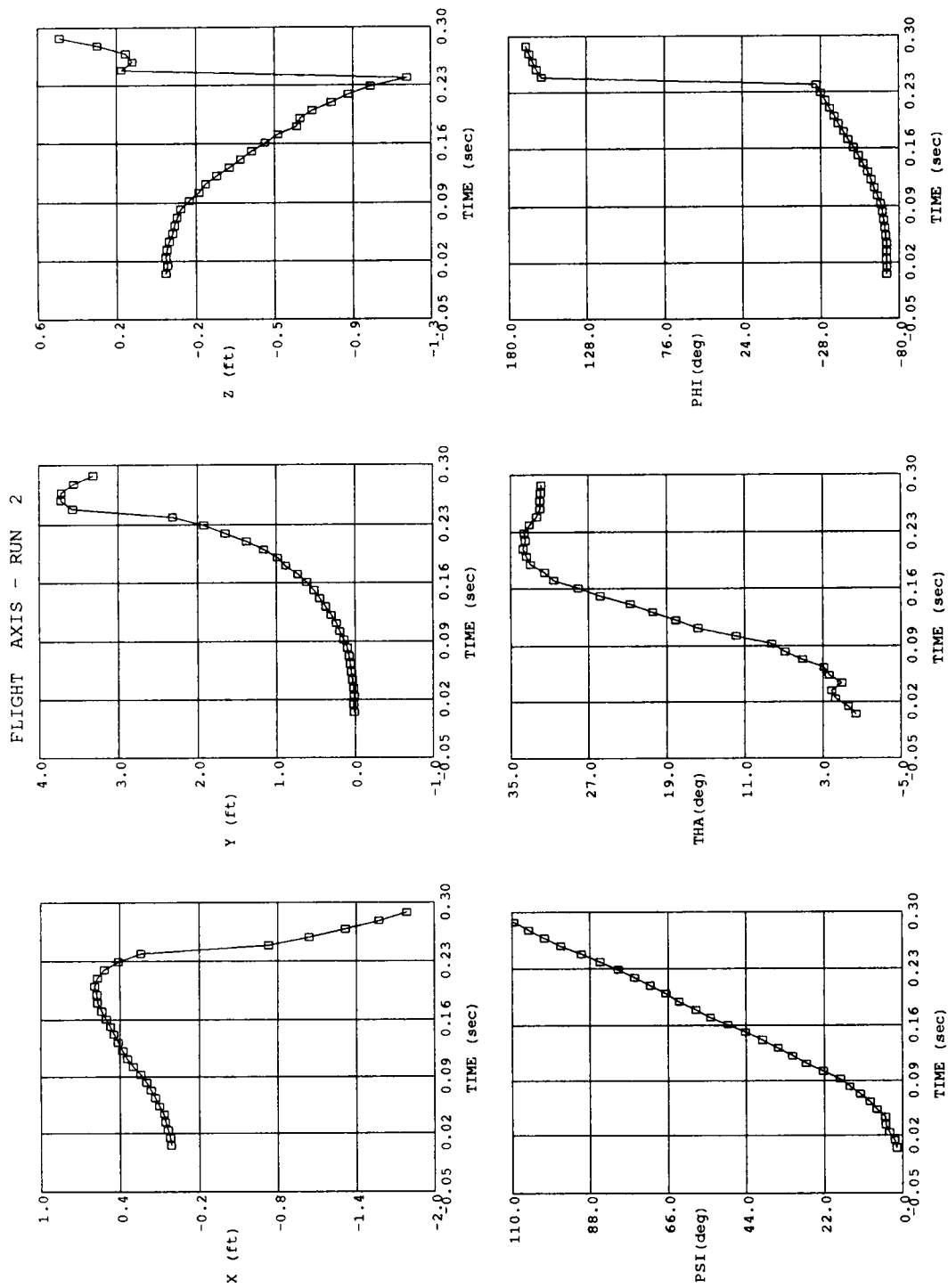


Figure 21. ADS Plot - Run 2 Flight Axis.

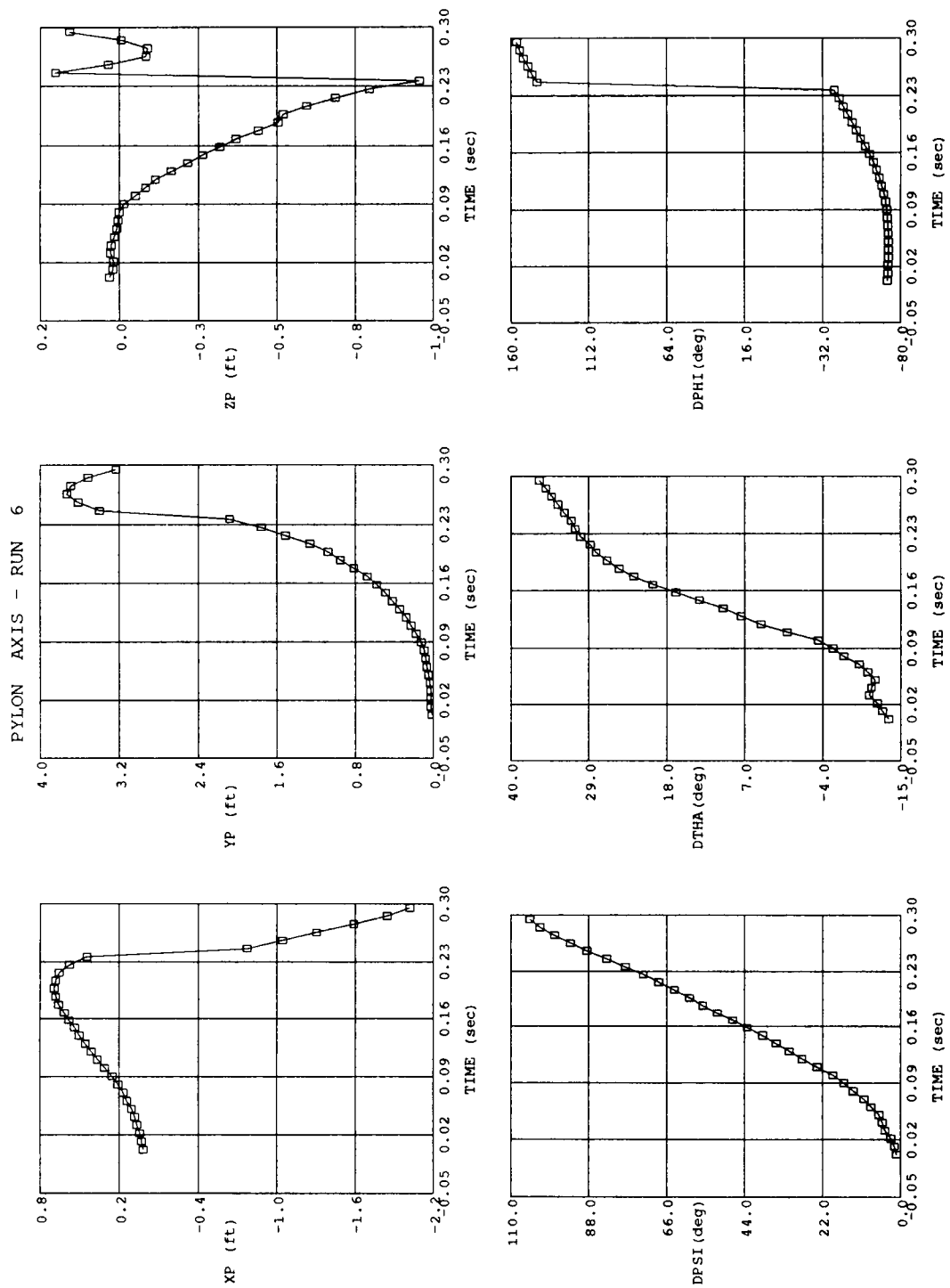


Figure 22. ADS Plot - Run 6 Pylon Axis.

CHAPTER IX

SUMMARY

Dynamic Drop testing provides a very valuable tool in the determination of store separation characteristics and for final verification of the store trajectory prior to flight testing. In order to maintain a high quality of testing, the post-test data reduction and analysis processes have been improved in turnaround time, ease of use, and ease of maintainability.

Improvements

Improvement Phase I, conversion from the Amdahl® 580/5860 Computer System to the VAX 8650, significantly reduced turnaround time. On a side by side comparison basis between the processes before and after the conversion, one can see the improvements. Reducing a Drop run on the Amdahl® could range from an hour to several days. Reducing a Drop run on the VAX 8650 may require up to one hour. Pinpointing exact improvement percentages is difficult due in large part to the uncertainty of the time required to process on the Amdahl® Computer. Amdahl® processing required the programmer to obtain certain information to insert into JCL command lines within the software and data files. Not all information was readily available. If an error occurred in the JCL command lines, a programmer would not be notified until he submitted it into the router and waited for completion. The delay times varied due to the status of the HYPERchannel data router (on-line or off-line), the number of (and priority of) files in the router, and the correct transmittal of the files. Since conversion, all files and software are

contained on the VAX 8650. Files can be setup immediately and in some cases, automatically. Execution times are almost instantaneous. If all post-test data reduction is completed error-free (ideal, but not real-world), the turnaround time has improved dramatically. If errors occur, such as incorrect constants, the turnaround time increases exponentially due to the differences in correcting such errors.

Improvement Phase II, creation of a user interface, significantly reduced turnaround time while improving ease of use. Post-test analysis preparation, including file initialization and setup, now requires less time due to the automation of the software. Reducing a Drop run with both improvements implemented could take only minutes. Prior to this improvement, depending on programmer knowledge and expertise of Free-Drop test preparation, a significant amount of time was required for file setup. The processes are now executed with a simple button press (mouse-click). The entire post-test data reduction is more streamlined and robust.

Future Improvement Areas

Several costly options exist for future improvements to the current system. The film-reader machine could be replaced with an automated film-analyzing machine. The cameras could be replaced with cameras which automatically digitize the drops and store them into the computer where analysis could be accomplished on the spot in near real-time. Both options appear extremely beneficial to Free-Drop testing and AEDC. Although AEDC is a world leader in testing and research, shrinking budgets and declining testloads force improvements on a more cost-effective scale. If Free-Drop testing increases, the previous improvement options should be investigated.

LFWC has achieved a new film data reduction capability which was developed in support of actual flight test film applications. Because mutually orthogonal cameras are usually not available for flight drop tests, the LFWC system tracks multiple points and combines them to obtain the store yaw and roll. This capability is much more sophisticated than the track-three-points AEDC capability, and should be investigated as a future improvement to the film-reader software.

Other areas of improvement, which are much more cost-effective, also exist. One option is to provide a user-friendly operator interface for the film-reader software. A plotting option for the film-reader as the film is read into the machine could improve productivity. DataViews[®], a graphical software package created by the makers of X-Designer, is an ideal plotting package for this purpose. DataViews[®] uses C calls and can be implemented directly into the X-Designer code. Combining the film-reader software and post-test analysis software into one streamlined process could then be achieved.

BIBLIOGRAPHY

BIBLIOGRAPHY

AEDC. Test Highlights, Spring/Summer 1994.

Allee, E. G. Jr. "Description of Dynamic Drop Store Separation Testing", Store Separation Testing Techniques at the Arnold Engineering Development Center, Volume IV. ARO Inc., June 1980, AEDC-TR-79-1.

DoD - Defense Information Systems Agency. Human Computer Interface Style Guide, Version 1.0. Center for Information Management, February 12, 1992.

Hood, D. W. The PWT Film Reader System. ADP and Control Systems Branch Operating Instruction OI-ICW-002, 1988.

Rubinstein, Richard and Harry Hersh with the assistance of Henry F. Ledgard. The Human Factor - Designing Computer Systems for People. Digital Equipment Corporation, 1984, QA 76.9 S88 R83.

Shneiderman, Ben. Designing the User Interface: Strategies for Effective Human-Computer Interaction. Reading, Massachusetts: Addison-Wesley Publishing Company, May, 1987 QA 76.9 I58 S47 1987.

VITA

Donald Trent Loman was born in Nashville, Tennessee on March 29, 1963. He attended schools in the public school system of Davidson County, where he graduated from DuPont High School in 1981. In the same year, he entered Volunteer State Community College in Gallatin, Tennessee with studies in Engineering. In 1983, he became interested in Computer Science and transferred in the fall to Tennessee Technological University in Cookeville, Tennessee. He graduated with a Bachelor of Science degree in Computer Science in March 1987. That same month, he entered work with Calspan Corporation at Arnold Engineering Development Center in Tullahoma, Tennessee. In 1990, he continued his education by entering the University of Tennessee Space Institute in Tullahoma. He officially started his Engineering Science and Mechanics curriculum in 1992. The Masters Degree was granted in August, 1996.

He is presently employed as a Senior Programmer Analyst with Sverdrup Technology at Arnold Engineering Development Center, Arnold AFB, Tennessee.