AD-A16	4 039 SIFIED	A P VEN OH AFI	ROPOSE ICLE(U SCHOOL T/GSO/	D DESI AIR OF EN ENY/8	IGN FO FORCE NGINEE 5D-2	R AN I Inst Ring	NTERIA OF TEI J D HI	I SPAC CH NRI ALSELL	E RESC GHT-PF DEC 8	UE FE ITTERS 15 F/G	RRY ON AFB 22/2	1/ NL	3	~ 7
		د ء								i				
							•.							
	Ľ				R.									
							i i limit		}					



ġ,

ł

MICROCOPY RESOLUTION TEST CHART

AD-A164 039

CURITY CLASSIFICATION OF THIS PAGE				//				
R	EPORT DOCUM	ENTATION PAG		/				
REPORT SECURITY CLASSIFICATION		16. RESTRICTIVE M	ARKINGS					
SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT							
		Approved fo	or public r	elease;				
DECLASSIFICATION/DOWNGRADING SCHEDUL	_E	distributio	n unlimite	d.				
PERFORMING ORGANIZATION REPORT NUMBE	R(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)						
AFIT/GSO/ENY/85D-2		}						
NAME OF PERFORMING ORGANIZATION 66	OFFICE SYMBOL	7a. NAME OF MONI	TORING ORGAN	IZATION				
AF Institute of Technology	AFIT/ENS							
ADDRESS (City, State and ZIP Code)		7b. ADDRESS (City,	State and ZIP Cod	ie)				
Wright-Patterson AFB, OH 4543	3	1						
NAME OF FUNDING/SPONSORING BE ORGANIZATION	b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT	NSTRUMENT ID	ENTIFICATION N	UMBER			
Crew Systems Division	EC54		· <u></u>					
ADDRESS (City, State and ZIP Code)		10. SOURCE OF FUI	NDING NOS.	7464				
Johnson Space Center Houston IX 77058		ELEMENT NO.	NO.	NO.	NO.			
TITLE (Include Security Classification)	·····	-						
See Box 19.								
James D. Halsell, Jr., Capt, U	ISAF							
A TYPE OF REPORT 13b. TIME COV	ERED	14. DATE OF REPOR	RT (Yr., Mo., Day) 15. PAGE (COUNT			
M5 THESIS FROM			ber					
COSATI CODES 18	B. SUBJECT TERMS	Continue on reverse if no	cessary and ident	ify by block numbe				
ELD GROUP SUB GR	Spacecraft,	Rendezvous Spa	cecraft, R	escue Vehic	les,			
22 02	Space Rescue	1		D'	TIC			
ABSTRACT : Continue on reverse if necessary and id	lentify by block numbe	271						
Title: A PROPOSED DESIGN FOR	AN INTERIM SP	ACE RESCUE FER	RY VEHICLE		1 6			
Thesis Chairman: Joseph W. Wi	dhalm, Lt. Co	l., USAF		FEE	1 4 1986			
Assistant Pr	ofessor and D	eputy Head		U A				
Dept, of Aer	onautics and	Astronautics		X	A			
		Āp	proved for public	release IAW arp	100.1			
			m Weler	~ 16 DAN &	2			
		LI	NOR F. WOLVARH	•				
ATIN THE CODY		LT De Au	an ior Research a Force lastitute of	nd Protessional Der	velopment			
OTIC FILE COPY		LT De Au Wi	an ior Research o Porce Institute of Ight-Patterson AFE	nd Protessional Dev Technology (A2C) OH 45433	relopment			
OTIC FILE COPY		LY De Alu Wi	ner is WOLAVEN con tor Research o r Forme Institute of ight-Patterson AFE	nd Protessional Dev Technology (ABG) OH 45433	relopment			
DISTRIBUTION/AVAILABILITY OF ABSTRACT		21. ABSTRACT SEC	ANT & WOLAVER Con los Research o Porte lastitute of Ight-Patterson AFE	nd Professionar Dev Technology (A20) 3 OH 45433	elopment			
DISTRIBUTION/AVAILABILITY OF ABSTRACT	DTIC USERS	21. ABSTRACT SECU Unclassifi	an ior Research o r Porce Institute of Hight-Patterson AFE	nd Professional Dev Technology (A20) OH 45433				
DISTRIBUTION/AVAILABILITY OF ABSTRACT	DTIC USERS	21. ABSTRACT SEC Unclassific 22b TELEPHONE N	URITY CLASSIFI	nd Professional Dev Technology (ACO) OH 45433 CATION	7910pment			
DISTRIBUTION/AVAILABILITY OF ABSTRACT CLASSIFIED/UNLIMITED SAME AS RPT	DTIC USERS	21. ABSTRACT SEC Unclassific 22b TELEPHONE N (Include Area Co (513) 255-4	an ior Research o r Porce Institute of Ight-Patterson AFE URITY CLASSIFI ed UMBER oder 476	AFIT/EN	Pelopment			

0

SECURITY CLASSIFICATION OF THIS PAGE

This investigation proposed a method of connecting the Personnel Rescue Enclosure to the Manned Manauvering Unit using a modified flightqualified hardware item, the Apogee Kick Motor Capture Device. The resulting configuration is an immediately available but non-optimum vehicle for transferring stranded astronauts, housed within Personnel Rescue Enclosures, from a rotating stranded spacecraft to a nearby rescue spacecraft.

The flying qualities of this Interim Rescue Vehicle (IRV) were simulated using an existing NASA spaceflight simulation computer program. The results showed that the Manned Maneuvering Unit's control system was capable of limiting uncommanded rotations to within the control law's deadbands during all simulated maneuvers and in all control modes, except during transverse translations in the Backup control mode. The IRV's increased mass and increased center-of-mass/center-of-thrust offset significantly degraded acceleration capability and specific propellant consumption. Thruster plume impingement upon the attached Personnel Rescue Enclosure, however, was found to cause only minor additional performance degradation. The Satellite Stabilization control mode was found to have significant rotational-to-translational coupling which made it undesireable for IRV use.

Finally, procedures were outlined for using the IRV in an orbiterto-orbiter rescue scenario.



Acces	tion For	
NTIS	GRA&I	Ø
DTIC 2	r.a.b	
Unann	ounsed	
Justi	fication_	
Distr Avai	ibrtion/ lability	Codes
Dist	Sprola	1
Al		

86 2 1 2 0 5 0



A PROPOSED DESIGN FOR AN INTERIM SPACE RESCUE FERRY VEHICLE

THESIS

James D. Halsell, Jr., Captain, USAF AFIT/GSO/ENY/85D-2

Approved for public release; distribution unlimited

AFIT/GSO/ENY/85D-2

A PROPOSED DESIGN FOR AN INTERIM SPACE RESCUE FERRY VEHICLE

THESIS

Presented to the Faculty of the School of Engineering of the Air Force Institute of Technology Air University In Partial Fulfillment of the Requirements for the Degree of Master of Science in Space Operations

> James D. Halsell, Jr., B.S. Captain, USAF

> > December 1985

Approved for public release; distribution unlimited

Acknowledgements

While researching this thesis, I had the opportunity to work with many outstanding military, NASA, and industry people. I am sincerely grateful to my faculty advisor, Lt. Col. Joseph Widhalm, for his continuous guidance and assistance. Financial support without which this project would have been impossible was arranged by Col. Michael O'Connell, Head of AFIT's Operational Sciences Department, and Maj. Don Brown of Space Division's Manned Spaceflight Support Office.

I also wish to thank Lex Ray and Gary Henning of the Martin Marietta Corporation for offering the superb technical support of their respective departments, the Space Operations Simulation (SOS) Lab and the Johnson Space Center Manned Maneuvering Unit Group. In particular, Chris Mussack of the SOS Lab deserves credit for helping me to determine the effects of plume impingement on vehicle control.

Jack Tiffany, head of the AFIT Fabrication Shop, merits praise for the timely fashion in which he built the hardware explained in Appendix C. My thanks also to Dr. Kaleps and Louise Obergefell of the Air Force Aerospace Medical Research Laboratory, Mark Schmelz of the Lockheed Engineering and Management Services Company, and James Schlosser of the Johnson Space Center, for their help in determining vehicle mass properties. Four individuals deserve credit for their

ii

instruction on how to use the spaceflight simulation program: Jim Knoedler and Sam Wilson of the TRW corporation, and Andy Dougherty and Maj. G. J. Avvento of Johnson Space Center's Mission Planning and Analysis Division. My thanks also to Julias Becsey of the Aerospace Systems Division's Directorate of Planning Strategy for allowing me to use his Hewlett-Packard 9825 computer.

Finally, I reserve my deepest thanks for the project's sponsor, Charles E. Whitsett, Chief of the EVA Equipment Branch at the Johnson Space Center. In addition to acting as technical advisor, he made available the entire assets of the Crew Systems Division, introduced me to many of the aforementioned individuals, and provided financial support.

James D. Halsell, Jr.

Table of Contents

													Page
Acknowledg	gements	•••	••	••	••	•••	••	٠	• •	•	•	•	ii
List of Ac	cronyms	••	••	••	••	•••	•••	•	•••	•	•	•	vii
List of Fi	igures .	•••	••	•••	••	•••	•••	•	•••	•	•	•	viii
List of Ta	ables .	• •	••	•••	• •	•••	••	•	•••	٠	•	•	х
Abstract		••	• •	••	••	•••	• •	•	• •	•	•	•	xii
I. Intr	coduction	n.	• •	••	••	•••	•••	•	• •	•	•	•	1
	Overview Backgrou	v. Inda	nd L	 iter	 atur	 e Re	 Vie	• w	• •	•	•	•	1
	Problem	Stat	emen	 +		0 1.0		••	•••	•	•	•	Ř
	Assumpti	one	and	Scon	•••	•••	•••	•	•••	•	•	•	ă
	Assumption	and	Dro	cont	$\frac{1}{2}$	•••	• •	•	• •	•	•	•	10
	Approact	i anu	rie	sente	acio	•	•••	•	• •	•	•	•	10
II. PRE	and MMU	Desi	gn Re	evie	w .	•••	•••	•	•••	•	•	•	11
	Overview							_					11
	The Pers	sonne	1 Res	scue	Enc	1051	re	•		-			11
	DRF		ian	0040	Dire	1000		•	•••	•	•	•	11
			rau	• •	••	•••	• •	•	• •	•	•	•	12
	PRE	s ose		• •	•••	• •	• •	•	• •	٠	•	•	13
	PRE	Dev	erobi	ment	Sta	tus	• •	٠	• •	•	•	•	15
	The Manr	ned M	aneu	veri	ng U	nit	• •	٠	• •	٠	•	•	16
	MMU	J Des	ign	••	• •	• •	• •	•	• •	•	•	٠	16
	MMU	J Per	form	ance	•	• •	• •	•		•	•	•	19
	MMU	J Ope:	rati	on	• •	• •	• •	•		•	•	•	20
	MMU	J Dev	elop	ment	Sta	tus		•			•		27
	Chapter	Summ	ary	••		• •	• •	•		•	•	•	28
III. MMU/	PRE Conr	necti	on D	evic	e.	•••	•••	•	•••	•	•	•	29
	Chapter	Over	view	•				•		•	•	•	29
	Requiren	nents	•			• •	• •	•		•		•	29
	Ōff	-the	-She	1f									29
	Vis	sibil	itv					•					29
	Eas	se of	Use	· .									29
	Sto	wage										-	29
	Cri	tica	រ ឆំ: រ	te.	•••	•••	•••	•	• •	•	•	•	20
		ck D			• •		•••	•	• •	•	•	•	20
	Qui Cod	ion n' Fotu	espo.	1196	• •	• •	• •	•	• •	•	•	•	20
	241	-ecy	• •	••• па п	• •		•••	•	• •	•	•	•	20
	Dropost		ty di mo−t		ETIO	r man	ice	•	• •	•	٠	•	30
	rioposed	LON	nect	rud	vevi	ce	• •		• •	•	•	٠	32
	Apo	ogee	KICK	Mot	or C	aptu	ire	vev	106	•	٠	•	32

iv

	Modified ACD	36
	The Interim Rescue Vehicle (IRV)	36
	Fit Test	36
	IRV Design	38
	Requirements Achievement	40
	Off-the-Shelf	40
	Visibility	10
		20
		42
	Stowage	44
	Critical Fits	46
	Quick Response	46
	Safety	46
	Stability and Performance	46
	Chapter Summary	٠ Q
		10
IV.	Simulation Inputs	49
	Chapter Overview	۸ Q
		47
		49
	Mass Properties	51
	Coordinate Systems	53
	Component Mass Properties Data	55
	MMU and Pilot	55
	Modified ACD	56
		50
		51
		50
	Portable Oxygen System	72
	Mass Properties Correction	75
	Mass Properties Consolidation	79
	Plume Impingement	81
	Chapter Summary	85
v.	Simulation Objectives, Results, and Analysis	86
	Chapter Overview	86
	Simulation Objectives	86
	Simulation Runs	87
	Simulation Results	90
	Analysis of Results	ń i
	Validation 1	01
		01
		02
	IRV Performance 10	02
	Chapter Summary	07
VI.	IRV Operation	08
	Chapter Overview	08
	Preparations 1	о́я
	Pecula Orbiter	0 0 0 0
	Repute Officer	00
		09
	Rescue Operations	09
	IRV Recharging 1	12
	Spacesuited Stranded Astronaut Transfer 1	14









Co Ch	mments	15 16
VII. Conclu	sions and Recommendations 1	17
Ch Co Re	apter Overview1nclusions1commendations1	17 17 19
Appendix A:	MMU Thruster Label Diagram and Thruster Select Logic Tables 1	22
Appendix B:	EVA Equipment 1	32
Appendix C:	Visibility Experiment 1	43
Appendix D:	MILMU IRV Simulation Phase Plane Plots and End-Of-Simulation State Vector	
	Printouts 1	46
Bibliography		93
Vita		97



List of Acronyms

- AAH Automatic Attitude Hold
- ACD Apogee Kick Motor Capture Device
- CEA Control Electronics Assembly
- EVA Extravehicular Activity
- FSS Flight Support Station
- JSC Johnson Space Center
- IRV Interim Space Rescue Ferry Vehicle
- MILMU Man-In-The-Loop Maneuvering Unit
- MMU Manned Maneuvering Unit
- NASA National Aeronautics and Space Administration
- PRE Personnel Rescue Enclosure

TPAD Trunnion Pin Attachment Device

List of Figures

Figur	e	Page
1.1.	The Personnel Rescue Enclosure	4
1.2.	PRE Transfer via Remote Manipulator Arm	5
1.3.	PRE Transfer via Clothesline Trolley	6
1.4.	PRE Transfer via MMU	8
2.1.	The Personnel Rescue Enclosure (PRE)	12
2.2.	PRE Entry	14
2.3.	The Manned Maneuvering Unit (MMU)	16
2.4.	MMU Propellant System	17
2.5.	Manned Maneuvering Units (MMU) Mounted in Flight Support Stations (FSS)	21
2.6.	MMU Hand Controllers	22
2.7.	Automatic Attitude Hold System Control Logic	24
3.1.	Hughes 376 Rescue	33
3.2.	Apogee Kick Motor Capture Device (ACD)	34
3.3.	Detail of MMU/ACD Attachment	35
3.4.	Proposed Modified ACD	37
3.5.	Mockup Interim Space Rescue Ferry Vehicle (IRV)	39
3.6.	IRV Visibility Test Apparatus	41
3.7.	Hook Tool	43
3.8.	Modified ACE Attached to Unmodified Carrying Bracket	45
4.1.	IRV Dimensions and Coordinate Systems	54
4.2.	PRE Principal Axes	59
4.3.	Articulated Total Body Model Segmentation Scheme	61

4.4.	Victim Head-Up Orientation in PRE	63
4.5.	Portable Oxygen System Components and Principal Axes	73
6.1.	IRV Attached to Forward Bulkhead of Stranded Orbiter	111
6.2.	Spacesuited Crewmember Rescue	114
A.1.	Thruster Label Diagram	123
в.1.	Extravehicular Mobility Unit	133
в.2.	Mini-Work Station	135
в.3.	Wrist Tether	138
в.4.	Getaway Special Beam	141
в.5.	Portable Foot Restraint	142
D.1.	MILMU Simulation Phase Plane Plots and End-of-Simulation State Vector Printouts	147

List of Tables

Table		Page
I.	MMU/Pilot Mass Properties	56
II.	Modified Capture Device Mass Properties	57
III.	PRE Mass Properties	59
IV.	Victim Mass Properties Information	64
v.	Body Segment Inertia Matrix Rotations into Alignment with MMU Body Coordinate System	68
VI.	Victim Mass PropertiesHead Up Orientation .	73
VII.	Oxygen System Component Inertia Matrix Rotations into Alignment with MMU Body Coordinate System	76
VIII.	Portable Oxygen System Mass Properties Head Up Orientation	77
IX.	Mass PropertiesCombined PRE/Victim/Oxygen Bottle System (Victim Oriented Head Up)	78
х.	Mass PropertiesCombined PRE/Victim/Oxygen Bottle System (Victim Oriented Head Down	79
XI.	IRV Mass Properties	81
XII.	Basic Jet Force Table	82
XIII.	Forces and Moments Due to Plume Impingement .	83
XIV.	Effective Thruster Forces	85
XV.	Simulation ResultsSolo MMU/Primary Control Mode	91
XVI.	Simulation ResultsIRV/Primary Control Mode	94
XVII.	Simulation ResultsIRV/Backup Control Mode .	97
XVIII.	Simulation ResultsIRV/Satellite Stabilization Control Mode	99
XIX.	Solo MMU/IRV Performance Comparison	103

x

Ţ.

 \tilde{c}

AFIT/GSO/ENY/85D-2

Abstract

This investigation proposed a method of connecting the Personnel Rescue Enclosure to the Manned Maneuvering Unit using a modified flight-qualified hardware item, the Apogee Kick Motor Capture Device. The resulting configuration is an immediately available but non-optimum vehicle for transferring stranded astronauts, housed within Personnel Rescue Enclosures, from a rotating stranded spacecraft to a nearby rescue spacecraft.

The flying qualities of this Interim Rescue Vehicle (IRV) were simulated using an existing NASA spaceflight simulation computer program. The results showed that the Manned Maneuvering Unit's control system was capable of limiting uncommanded IRV rotations to within the control law deadbands during all simulated maneuvers and in all control modes, except during transverse translations in the Backup control mode. The IRV's increased mass and increased center-of-mass/center-of-thrust offset significantly degraded acceleration capability and specific propellant consumption. Plume impingement, however, was found to be of minor importance. The Satellite Stabilization mode was found to have significant rotational-to-translational coupling which made it undesireable for IRV use.

Finally, procedures were outlined for using the IRV in an orbiter-to-orbiter rescue scenario.

xii

A PROPOSED DESIGN FOR AN INTERIM SPACE RESCUE FERRY VEHICLE

I. Introduction

Overview

Currently, U. S. astronauts and U.S.S.R. cosmonauts conduct routine space operations without the "safety net" of a tested and ready space rescue plan. Realizing this deficiency, in July 1984, during a speech to the Conference on U. S.-Soviet Exchange, President Reagan proposed that the two countries conduct a joint space mission to demonstrate the capability of rescuing stranded astronauts and cosmonauts (24:16). Later that same year, the President signed Senate Joint Resolution 236, which directed the Administration to work toward more cooperative East-West ventures in space, including a joint simulated rescue mission (33). These overtures were subsequently curbed by a downward swing in the cycle of detente; however, recent press reports indicate that the political climate is again ripening for the approval of a joint mission (8:15).

The National Aeronautics and Space Administration (NASA) is not currently officially preparing for a joint space rescue mission. However, space rescue planning is important for the following reasons:

- 1. Should the political environment indeed improve, the joint space rescue demonstration mission will probably be scheduled on a "last-minute" basis. Planning accomplished now will allow a timely response to a Presidential directive to proceed.
- 2. Regardless of whether a joint U. S.-Soviet space rescue mission is ever flown, the need exists to develop and test the hardware and procedures necessary for rescuing the crew of a space shuttle orbiter stranded in orbit. As of now, neither hardware nor procedures are completely developed.

This thesis, while motivated by the prospect of a joint U.S.-U.S.S.R. demonstration mission, directly contributes to the development of a NASA space rescue contingency plan. It proposes an Interim Space Rescue Ferry Vehicle (IRV) consisting only of current or soon-to-be-available hardware, and which under emergency conditions could be made ready for launch in less than twelve hours. The flying qualities of this vehicle are explored, and procedures proposed for its use.

Because it is limited to off-the-shelf hardware not originally intended for this purpose, the IRV suffers obvious performance deficiencies and will no doubt be followed by a more capable version specifically designed for the rescue mission. However, the IRV presented in this thesis provides an immediate "stop-gap" rescue capability

until a more ambitious follow-on version is designed and built.

Background and Literature Review

Space rescue is defined as rendezvousing with a disabled spacecraft, transferring the crew members to the rescue vehicle, and returning them safely to earth. During the early 1960's, NASA conducted analyses to determine rescue requirements and capabilities for the Mercury, Gemini, and Apollo programs. Development was not pursued, however, because planners realized successful space rescue requires an ambulance spacecraft that is available for almost immediate launching, and maintaining such a capability was deemed impracticable at that time (32).

Today, this lack of a rescue vehicle is being resolved by the increasing space shuttle flight rate. The fourth orbiter made its first flight in October of this year, and the larger shuttle fleet plus expedited turnaround servicing procedures will, by 1990, allow NASA to launch a shuttle every two weeks (22). Such a flight frequency will permit each shuttle mission to serve as the standby rescue vehicle for the flight immediately preceding it.

Space rescue in the shuttle era is complicated by the lack of two capabilities taken for granted in preceding U.S. spacecraft. First, unlike the Apollo capsule, current shuttle orbiters cannot dock with other spacecraft; therefore, victims must conduct extra-vehicular activity (EVA, or



Figure 1.1. The Personnel Rescue Enclosure (1:198)

"spacewalk") to transfer to the rescue vehicle (1:197). This shortcoming will be partially alleviated within the next decade when a docking module is built to allow the onliter to mate with the space station. However, orbiters not destined to the space station will not carry this payload-reducing module, and therefore will still rely on the rescue procedures discussed in this report (6).

Second, weight and volume constraints dictate that only two spacesuits be carried on all shuttle missions, even though the crew usually numbers between five and eight astronauts (20:A1-101). Accordingly, some mechanism is necessary for transferring unprotected astronauts across the open void between the two spacecraft.

Anticipating this requirement, NASA developed the Personnel Rescue Enclosure (PRE) in 1975. This device, illustrated in Figure 1.1, is an inflatable life-support sphere which provides a thermally protected, puncture-resistant, pressurized environment within which a non-space-



Figure 1.2. PRE Transfer via Remote Manipulator Arm (1:202)

suited astronaut can survive for about one hour--long enough to be transported to the rescue orbiter. Three potential PRE transfer techniques were identified by Brown in 1977 (1:202-03):

1. Remote Manipulator Arm. Standard orbiter configuration includes a 50-foot long remote manipulator arm which is electromechanically operated by an operator located inside the cabin. Figure 1.2 shows how a rescuing orbiter could maneuver into very close formation with the disabled spacecraft and the remote manipulator arm used to pluck PRE spheres from the airlock door of the stranded vehicle. A rescue crewman, attached to the manipulator arm by foot restraints, would ride on the end of the arm and grasp the PRE by one of its handles. The arm operator, viewing the work area through the aft



Figure 1.3. PRE Transfer via Clothesline Trolley (1:203)

cabin windows and by remote television camera, would then swing the EVA astronaut, with PRE in tow, to the rescue vehicle's airlock door. Here the PRE would be handed off to a waiting rescue astronaut for insertion into the airlock. The sequence would be repeated until all PRE's were transferred. The spacesuited stranded astronauts would transfer to the rescue vehicle by riding the manipulator arm's foot restraints.

2. Clothesline Trolley. An adaptation of the manipulator arm transfer method is illustrated in Figure 1.3. Here, the shuttle is again maneuvered into close formation with the disabled vehicle and the end of the manipulator arm positioned at the side hatch or airlock hatch. However, the arm then remains stationary and

serves as the supporting structure for a continuous wire loop trolley on which the PRE's are attached and translated to the rescue vehicle. Two rescue astronauts, one positioned at each orbiter's hatch, serve to attach and disconnect the PRE's, and to provide the locomotive force for the trolley. As before, the spacesuited stranded astronauts would ride the manipulator arm to safety.

3. Ferry Vehicle. Both versions of the remote manipulator arm transfer method assume a stable (i.e., non-tumbling) disabled orbiter. However, if the disabled vehicle had uncontrollable rotation rates, the rescue orbiter would not be able to fly in close enough proximity for the arm to reach the airlock door. A smaller, more maneuverable ferry vehicle would be required which was capable of rendezvousing with the tumbling target vehicle and matching it's rotational rates so that no relative motion exists. Figure 1.4 depicts the Manned Maneuvering Unit (MMU) accomplishing PRE rescue under these difficult conditions. The MMU is an operational one-man "jetpack" allowing a spacesuited astronaut to make untethered excursions from the orbiter. An astronaut piloting an MMU equipped with a PRE attachment device would fly over to the tumbling spacecraft, match its rotational rates, and maneuver to the airlock hatch. A PRE would then be attached and transported to



Figure 1.4. PRE Transfer via MMU (1:203)

the rescue vehicle. The procedure would be repeated until all victims had been transferred.

Rogers reports that the Martin Marietta Corporation has recently completed preliminary simulations of a conceptual MMU/PRE combined vehicle which indicate the MMU/PRE retains adequate performance and stability for use in a space rescue scenario (26:8).

Problem Statement

÷

This thesis develops the ferry vehicle transfer method by answering three research questions:

1. What is a mechanically and operationally sound method

of attaching the PRE to the MMU, using only minimally modified and available flight-qualified hardware, to arrive at an Interim Rescue Vehicle (IRV)?

- 2. What is the stability and performance of the resulting IRV? The term "stability" refers to the ability of the MMU's control system to limit the IRV's dynamic response to maneuvers commanded by the pilot. The term "performance" refers to the IRV's translational and rotational acceleration capabilities, and the fuel expended to achieve these accelerations.
- 3. What procedures will the stranded and rescue crews follow to conduct a successful save using the IRV?

Assumptions and Scope

This thesis does not delve into the types of emergencies which would strand an orbiter and its crew and require a space rescue mission--it simply assumes that such a mission is necessary. This thesis also assumes that the disabled orbiter, although stranded in orbit, still has functioning life support systems, and that the remaining consumables provide the necessary time (at least three days) to prepare and launch a rescue mission.

The intent of this project was to propose a design which offers an immediately available "stop-gap" rescue capability which can be fielded in a matter of hours after notification of the rescue requirement. Therefore, only currently availa-

ble or soon-to-be-available flight qualified hardware was considered for use.

While the performance and stability of the proposed design were examined, this report does not venture a subjective opinion concerning the overall acceptability of the determined flight characteristics. However, the results have been made available to NASA for such use.

Approach and Presentation

Answering research question 1 (i.e., a suitable MMU/PRS connection device) first required a review of the design and capabilities of the PRE and MMU. This is presented in Chapter II. Chapter III lists the requirements for an acceptable MMU/PRE connecting device and presents the proposed device which meets most of the criteria. The resulting MMU/PRE combined vehicle is referred to as the IRV.

Obtaining the answer to research question 2 (i.e., IRV performance and stability) was accomplished using an existing NASA spaceflight simulation program. This computer program and the determination of required inputs concerning IRV mass properties and plume impingement are explained in Chapter IV. The actual simulation runs, their results, and the analysis are presented in Chapter V.

Research Question 3 is answered in Chapter VI, which proposes procedures for using the IRV to rescue the crew of a stranded orbiter. Finally, Chapter VII presents the conclusions and recommendations.

II. PRE and MMU Design Review

Chapter Overview

The proposed IRV consists of three major components: the MMU and its pilot, the PRE and its victim, and the asyet-undefined device connecting the PRE to the MMU. This chapter reviews the design and operation of the PRE and the MMU so that a suitable connecting device and realistic procedures for use can be proposed in later chapters.

The Personnel Rescue Enclosure

<u>PRE Design</u>. Figure 2.1 presents a detailed drawing of the PRE. The PRE is a puncture-resistant Kevlar pressure sphere with a diameter of 34 inches--small enough to fit through the airlock doors and orbiter side hatch.

Connectors penetrate the sphere which provide for attaching an air umbilical (for inflation and also for additional victim breathing oxygen) and a communication line. The sphere is also equipped with a pressure gauge, a small viewing window, and a pressure relief valve which limits maximum PRE pressure to 5.25 psia (28:1-4).

Two external carrying loops are positioned on opposite sides for ease of handling. A waist restraint belt is attached inside the sphere to prevent relative movement of the crewman and the PRE. Entry is through a zipper which cuts across one hemisphere, and can be operated from both inside and outside the PRE.



.

Figure 2.1 Personnel Rescue Enclosure (PRE) (28:8)

đ

_

A one-hour supply of breathing air is furnished by a portable oxygen system currently under development by Johnson Space Center's Crew Systems Division. The portable oxygen system is carried inside the PRE, nestled in the lap of the victim. The air is fed to the victim by a hose and mask. Additional breathing air can be supplied through the aforementioned air umbilical connector. This allows orbiter-furnished oxygen to be consumed, thus conserving the limited supply available from the portable oxygen system. The astronaut's exhalation products are dumped into the sphere to make up for slow leakage through the zipper, so that the desired 5.0 psia atmosphere is maintained (29).

<u>PRE Use</u>. Figure 2.2 depicts PRE entry and use. The PRE is designed to fold up and be stored in a small volume. When required, it is unstowed, unzipped, and the crewmember enters and fastens the restraint belt. Next, he positions the portable oxygen system between his legs and connects the bottle's regulator to the air umbilical connector. Finally, he dons the oxygen mask and insures a positive oxygen flow, then another astronaut helps close the zipper, sealing the PRE.

As already mentioned, two of the stranded astronauts are allocated spacesuits. After his fellow crewmember is sealed inside the PRE, one of these two astronauts connects the PRE's air umbilical connector to an air umbilical, two of which are available in the airlock. This umbilical provides compressed air at 900 psi to quickly inflate the



Figure 2.2. PRE Entry (7:4.7)

.

<u>ن</u>

sphere to 5.0 psia. Thereafter, the umbilical remains connected for as long as possible (optimally until just before PRE transfer) to provide breathing oxygen directly to the mask (though stepped down to the proper pressure by the portable oxygen system's regulator) so as to avoid depletion of the one-hour supply in the portable bottle (18:2.3-20).

Two PREs can be placed in the airlock and undergo the three-minute depressurization simultaneously; however, there is not enough room for an accompanying astronaut. Therefore, a spacesuited astronaut must already be waiting in the payload bay to disconnect the air umbilicals, remove the PREs, and close the airlock hatch (19).

Upon successful transfer to the rescue vehicle's airlock but before repressurization, another air umbilical can be connected if the one-hour oxygen supply in the air bottle is approaching exhaustion. Following airlock repressurization, the crewman exits the PRE. Total time of enclosure cannot exceed three hours because temperature and humidity inside the PRE begin to exceed habitability limits (29).

<u>PRE Development Status</u>. After two prototype models were built and extensively tested (but not man-rated) in 1976, PRE development halted because it was realized that the old nemesis of space rescue--lack of a rescue vehicle-would continue for another decade until the space shuttle fleet became fully operational. That has now occurred; therefore, ten new PREs are currently being built by Johnson Space Center's Crew Systems Division, and will be man-rated



Figure 2.3. The Manned Maneuvering Unit (MMU) (9:1-14)

and manifested on future space shuttle flights (29).

The Manned Maneuvering Unit

Contraction of the contraction of

<u>MMU Design</u>. The MMU concept was born out of a recognized need to furnish EVA astronauts with a personal propulsion system allowing untethered excursions of up to several hundred feet away from the orbiter.

Figure 2.3 details the MMU design. The MMU is a oneman propulsive backpack which attaches to the standard NASA spacesuit. Completely redundant propulsion, electrical, and



Figure 2.4. MMU Propellant System (9:1-20)

control subsystems insure that no single credible failure can disable the unit. This redundancy permits the MMU to be flown untethered and completely free of the mother ship.

The primary structure consists of an aluminum frame covered by aluminum skins, and is built using aircraft-type semimonocoque construction techniques. The basic configuration consists of two vertical towers connected by a backplate, and two control arms protruding forward from the midsection of each tower. Two propellant tanks attach to the rear of the backplate (9:2.26).

Figure 2.4 portrays a simplified schematic of the MMU $_3$ propulsion system. Two 1630 in pressure bottles contain

the propellant (gaseous nitrogen) at an initial pressure of 3000 psia. Each bottle supplies an identical, completely independent propulsion subsystem capable of providing translational forces and rotational moments. Each subsystem consists of an isolation valve which permits emergency shutdown, a regulator which reduces the gas pressure to a working pressure of 212 psia, and tubing which carries the gaseous nitrogen to four triads of cold jet nozzles located on the corners of the towers. There are a total of twenty-four thrusters. If required, the two propellant bottles can be interconnected via two toggle valves to insure that all nitrogen is made available for use. Upon command from the Central Electronics Assembly, solenoids open the appropriate thruster valve(s) and expel the gaseous nitrogen to produce 1.7 lbs of force per thruster (9:2-79).

Two 16.8 Volt potassium hydroxide batteries are enclosed within the backplate and provide six hours of electrical power before requiring recharge or replacement. These batteries supply two completely independent and redundant electrical systems which insure electrical power is supplied to all MMU systems (9:1-16).

Two hand controllers are located at the end of the adjustable arms and provide full six degrees-of-freedom maneuvering capability. These arms can be rotated downward while in flight to allow closer access to the worksite (9:4-1).

The hand controller commands are interpreted by dual

redundant Control Electronics Assemblies (CEA), which are also located in the backplate, beneath the batteries. The CEAs contain gyros, control logic, and amplifiers which deliver drive voltages to the thruster solenoids to open the thrusters required for the commanded maneuvers (9:1-12). The CEA and hand controllers are further explained in a latter section.

Presently, there are only two types of instruments on the MMU. The first consists of two thruster cues--one each located at eye-level on the inside upper section of the both towers--which illuminate when their respective propulsion system is firing. The second type of instrumentation consists of two fuel gauges (one for each propulsion tank), one mounted on each tower directly above the thruster cue (9:1-15).

<u>MMU Performance</u>. Thruster force is 1.7 lbs per thruster, and specific impulse is approximately 66 seconds. The two propellant tanks provide 23.2 lbs. of useable gaseous nitrogen, meaning a total impulse of approximately 1531 lb-sec is available (9:1-16). Assuming an average MMU mass (with astronaut attached) of 737 lbs., that implies a translational acceleration capability of .3 ft/sec and a total velocity change capability of approximately 67 ft/sec. For this configuration, the thrusters provide yaw, pitch, and roll accelerations of between 7.5 and 9.0 deg/sec (9:1-44).

In frictionless space, propellant consumption is directly proportional to the translational and rotational rates commanded by the pilot. Therefore, as long as time is
not a critical factor, there is a strong incentive for fuelconscious pilots to use translation rates of less than 1 ft/sec, and rotation rates of not more than 5 deg/sec (11:7).

The proposed IRV has a mass of approximately 1040 lbs; therefore, its predicted translational and rotational accelerations are significantly less than those of the solo MMU, as reported in Chapter V.

<u>MMU Operation</u>. Up to two MMUs are stored on the port and starboard sidewalls of the forward payload bay, attached to Flight Support Stations as shown in Figure 2.5. The Flight Support Station not only carries the MMU, but also provides foot restraints and handrails to assist the crewmember in servicing and donning/doffing the MMU. Connections between the MMU and Flight Support Station provide electrical power for MMU thermal control heaters and MMU propellant refueling.

To conduct a MMU flight, the pilot dons his spacesuit and undergoes depressurization in the orbiter airlock. He then opens the airlock door, exits into the payload bay, and translates via handrails to the Flight Support Station, where he faces the MMU and prepares it for flight. When ready, he turns to face away from the MMU, and backs into it so that latch receptacles on his life support backpack engage latch mechanisms on the MMU. Pulling rearward on two release handles frees the MMU from the Flight Support Station and the pilot flies away.



Figure 2.5. Manned Maneuvering Units (MMU) Mounted in Flight Support Stations (FSS) (26:2)

At mission termination, the MMU pilot "lands" on the FSS foot platform and doffs the MMU by performing the reverse of the donning procedure. Before entering the airlock, he prepares the MMU for its next flight by replacing the batteries and charging the propellant bottles (9:4-18--4-24).

Pilot control inputs are via the two hand controllers. The right hand controller inputs three degrees-of-freedom rotational commands and the left hand controller inputs three degrees-of-freedom translational commands. Figure 2.6



Figure 2.6. MMU Hand Controllers (12:36)

illustrates the pilot inputs required for the various translations and rotations, and the MMU body coordinate system used throughout this report. Commands can be enacted singly or in combination. Deflecting either hand controller fully opens the valves of the appropriate 1.7-pound thrusters, and the valves remain full open for as long as the hand controller remains deflected from the null position.

The Control Electronics Assembly fires the correct thrusters by matching the received hand controller inputs against Primary tabulated thruster select logic and sending drive voltages to the designated thruster solenoids. Should an in-flight failure of the propulsion, electrical, or control systems reduce the MMU to operating on only one of the two propulsion subsystems (and therefore on only half of its thrusters), the Control Electronics Assembly reverts to a Backup thruster select logic table which uses only thrusters of the remaining propulsion subsystem to maintain translational and rotational control authority.

Also, the Control Electronics Assembly has a third, pilot-selectable thruster logic table designed for zeroing out rotation rates when the MMU is attached to large payloads. Called the Satellite Stabilization control mode, it decreases thruster plume impingement on the payload by avoiding as much as possible the use of forward-firing jets, and increases control moments by firing more thrusters or by firing thrusters with longer moment arms from the combined vehicle's displaced center of mass. Satellite Stabilization mode was designed to permit the MMU to stop the rotation of a connected disabled satellite and allow subsequent capture by the orbiter's remote manipulator arm, and is not optimized for translational motion.

Appendix A presents the thruster select tables for the Primary, Backup, and Satellite Stabilization control modes, and a diagram showing the thruster labeling scheme used throughout this report (9:1-12).

By pushing a button on top of the right hand controller, the MMU pilot can implement the automatic attitude hold



Figure 2.7. Automatic Attitude Hold System Control Logic (9:2-35)

(AAH) feature of the Control Electronics Assembly, which stops all MMU rotation and holds the vehicle in the resulting attitude. Subsequent rotational commands issued by the pilot are heeded but AAH is lost in that axis of rotation until the AAH button is again depressed. Those axes not manually commanded continue in AAH.

Figure 2.7 is a phase plane plot which depicts AAH operation. The horizontal axis measures the MMU's attitude error (in degrees) from the desired attitude. The vertical axis measures the rate error (in deg/sec) at which the MMU is rotating away from or toward the desired attitude. The origin of the axes represents that situation where the MMU is at the desired attitude and is not rotating. Figure 2.7 is simplified in that it only presents information for one of the three axes. The circled numbers in the following discussion correspond to the circled numbers in the figure.

- Upon activation, AAH uses rate feedback from the CEA gyros to fire the proper thrusters full on so that the MMU rotation is automatically nulled to only .2 deg/sec. The correct thrusters are selected by referring to the thruster select logic tables currently designated for use by the pilot (Primary, Backup, or Sat Stab). After nulling the rotation rate to only .2 deg/sec, the thrusters are turned off and the orientation at that instant is designated as the desired attitude.
- The .2 deg/sec residual rate takes the MMU away from the desired orientation. When gyro attitude feedback senses that the attitude error exceeds the +/-1.25 degree deadband, the CEA pulses the proper thrusters three times per second, 10.6 milliseconds per pulse, to bring MMU attitude back within the deadband. The restoring pulses are stopped when gyro feedback senses that the MMU is converging back toward the desired attitude at a rate of at least .01 deg/sec. The procedure is repeated when the attitude deadband is violated on the opposite side, hence the MMU continues to slowly oscillate within +/-1.25 deg of the desired attitude.

3 Should a persistent torque overwhelm the corrective moments of the pulsed thrusters and continue to drive the MMU away from the desired attitude, the thrusters are turned full on when gyro feedback senses that the MMU has rotated six degrees away from the desired attitude.

4 During translation commands, an additional +/-.2 deg/sec rate limit is imposed, which may cause thruster firings even when the MMU is within the attitude deadband. The purpose of this limit is to prevent excessive attitude excursions which could be caused by the overwhelming moments created by the full-on thrusters during translations in certain MMU configurations. If, after the translation burn, the original attitude deadband has been exceeded, corrective burns will be made as explained in 2 and 3 (9:2-34--36).

Figure 2.7 does not reflect the effects of a limb motion filter, which briefly delays AAH response to transgressions of the +/-1.25 deg attitude deadband. This time delay reduces propellant wasted on temporary deadband violations caused by MMU pilot limb motions. The principle of angular momentum conservation tells us if, for example, the pilot moves his hand from the hand controller up to the tower (to activate a switch, perhaps), that the MMU will move to a new stationary attitude. Likewise, when the pilot moves his hand back to its original position, the MMU will

assume its original attitude. In other words, attitude displacements caused by pilot motion are inherently selfcorrecting. The limb motion filter allows a short time for this self-correction to occur before AAH enters the pulsed thruster mode (27).

AAH serves three useful purposes. First, it provides an easy and accurate way for the pilot to quickly null all rotation rates and to maintain the MMU in the resulting orientation. Second, AAH counteracts the rotations induced when pure translations are attempted with a MMU configuration that has the center of mass offset from the geometric center of thrust. Without the +/-.2 deg/sec rate limit explained in 4, above, translational commands would also cause such a configuration to spin out of control. Third, AAH limits uncommanded rotations due to non-zero products of inertia. The principal axes of the MMU typically do not align with MMU body coordinate system; therefore, dynamics theory tells us that thruster firings intended to produce rotations about only one axis actually result in coupled rotational components about all three axes. AAH provides corrective thrusts when uncommanded rotations exceed the +/-1.25 deg and +/- 6.0 deg deadbands. As the proposed IRV suffers from a significant offset between the center of thrust and center of mass, and also features principal axes not aligned with the MMU body coordinate system, the AAH system will be highlighted in Chapter V.

MMU Development Status. Two MMUs are fully operational

and stored ready for flight at Martin Marietta Aerospace Corporation in Denver CO. To date, they have been flown a total of seven times, including spectacular saves of two disabled communication satellites (34).

Chapter Summary

This chapter has summarized the knowledge base concerning the PRE and MMU which was required before conducting the research described in the following chapters. The next chapter describes the device proposed for connecting the PRE to the MMU.

III. MMU/PRE Connection Device

<u>Overview</u>

This chapter lists requirements for a suitable MMU/PRE connecting device, proposes an advantageous design for a MMU/PRE connecting mechanism, presents the resulting IRV, and then compares the proposed design to the requirements to determine acceptability.

Requirements

The objective of this project was to propose an immediately available space rescue rescue ferry vehicle. Research indicated that achieving this goal necessitated that the MMU/PRE connection device satisfy the following requirements:

<u>1.</u> <u>Off-the-Shelf</u>. Only currently available or soonto-be-available hardware be considered for use.

2. <u>Visibility</u>. The IRV pilot must have adequate visibility with the PRE connected to allow him to safely maneuver the IRV to the rescue vehicle.

<u>3.</u> <u>Ease of Use</u>. The connection device should be easy to use by a spacesuited astronaut. All controls should be within the IRV pilot's reach.

<u>4.</u> <u>Stowage</u>. The connecting device should be capable of being stowed in the orbiter's payload bay using currently available payload mounting hardware.

5. Critical Fits. Critical fits should be avoided.

On Mission 41C, the MMU was tasked to dock with and stabilize the failed Solar Maximum Satellite. The MMU carried a Trunnion Pin Attachment Device (TPAD) designed to automatically clamp over a pin protruding from the satellite. The approach failed, however, because an undocumented grommet stopped the TPAD one inch short of its intended travel, thus failing to trigger the automatic clamp. A manual jaws trigger should have been available to allow the MMU pilot to complete the connection (5).

<u>6.</u> <u>Quick Response</u>. The proposed IRV must be ready for flight within several hours of notification of an impending rescue mission. Therefore, all hardware modifications must be permissible in advance or achievable in minimum time.

7. <u>Safety</u>. Redundant systems should back up critical components so that foreseeable possible failures do not prevent completion of the rescue mission or cause injury to crewmembers.

8. <u>Stability and Performance</u>. The terms "stability" and "performance" were defined in Chapter I. The proposed IRV will exhibit improved stability and performance if the connecting device meets the following five sub-requirements:

<u>a.</u> <u>Minimum Mass</u>. Increases in mass will decrease the IRV's translational acceleration and total velocity change capabilities. The MMU/PRE connection device should be as light as possible.

b. Minimum Center of Mass Shift. Connecting the

PRE to the MMU will unavoidably shift the center of mass away from the geometric center of the MMU's thrusters, thus increasing the coupled rotations experienced during translational burns, as discussed in Chapter 2. Minimizing this shift by reducing the distance between the PRE and MMU will minimize the degradation to IRV performance and stability. In other words, the MMU/PRE connection device should be short.

<u>c.</u> <u>Minimum Moments of Inertia</u>. A short connection device of low mass will also achieve a related criterion: minimally increased moments of inertia. Moments of inertia measure a spinning body's resistance to changes in its rotation rates; consequently, achieving this goal will maximize the IRV's rotational acceleration capability.

<u>d.</u> <u>Rigid Connection</u>. The device should provide a rigid connection between the MMU and the PRE. A flexible connection would allow the IRV's center of mass and moments of inertia to vary with time, thereby possibly degrading stability below an acceptable level.

<u>e.</u> <u>Plume Impingement.</u> If the gas plumes expelled from the MMU's thrusters impinge upon the PRE or the connection device, moments and forces will be created which, in general, will create undesired translational and rotational accelerations, thus degrading the IRV's stability and performance. The connection device should position the PRE so that plume impingement is prevented or, where unavoidable, such that opposite jets are equally degraded so that sym-

metry of thrust is preserved.

Proposed Connecting Device

<u>Apogee Kick Motor Capture Device</u>. Tests conducted by this researcher at the Johnson Space Center, Houston TX, 23 Jun-3 Jul 85, revealed that an existing piece of flightqualified hardware, the Apogee Kick Motor Capture Device (ACD), can be modified to adequately meet most of the above criteria, and serve as the MMU/PRE connection device.

The ACD was originally built to allow the MMU to capture and stabilize two stranded Hughes 376 satellites. This was successfully accomplished in November 1984 during Mission 51D, when the Palapa B and Westar satellites were retrieved and returned to earth for repair. Figure 3.1 illustrates the MMU, with ACD attached to the controller arms, docking with a satellite.

ACD Design and Operation. Figure 3.2 details the ACD. It consists of four subassemblies: toggle finger, control box, structure, and grapple device.

The toggle finger subassembly was initially streamlined for insertion into the target nozzle. After insertion, the MMU pilot pulled on a lever located on top of the control box subassembly to extend three toggle fingers that trapped the probe inside the thrust chamber. By then turning a flywheel located on the aft end of the control box, the MMU pilot translated the toggle fingers toward him until they came to rest against the nozzle throat. Further tightening



Figure 3.1. Hughes 376 Rescue (5)

of the flywheel caused the satellite and MMU/ACD to translate toward each other until the satellite's nozzle bell came to rest against the ACD's structure subassembly ring, thus making a rigid connection. The MMU pilot then activated the automatic attitude hold feature of the MMU control system to zero out all rotation rates. After stabilization, the orbiter attached its remote manipulator arm to the grapple device subassembly. The MMU pilot then disconnected the MMU from the ACD, and the arm operator positioned the



È

)

ì

È

÷. • . • .

. .

Figure 3.2. Apogee Kick Motor Capture Device (ACD) (30:3-4)

34

آباً



Figure 3.3. Detail of MMU/ACD Attachment

remaining assemblage (ACD and satellite) inside the orbiter's payload bay (11).

<u>MMU/ACD Attachment</u>. The ACD connected to the MMU controller arms as illustrated in Figure 3.3. An attachment bar mounted on the rear of the ACD's control box interfaced with two mounting brackets, one each located on the inside of a hand controller box. Drop-in pins locked the attachment bar into the mounting brackets.

<u>ACD Status</u>. Two flight ACDs were built and used on Mission 51D. One of these is currently in storage in Building 7A at the Johnson Space Center, and the other is on display at the National Air and Space Museum in Washington

D.C. A third flight-quality unit was built for engineering qualification tests and served as the backup for the two flight units on Mission 51D. It, too, is stored at the Johnson Space Center and could be called into operational use if required.

<u>Modified ACD</u>. Measurements indicated that the ACD's structure subassembly was the correct size and shape to serve as a "basket" within which a attached PRE could be securely carried. The following modifications were proposed to remove all ACD components which interfered with the use of the structure subassembly for this purpose:

- Remove the guide ring, part number SDD39117409-001, from the structure subassembly.
- Remove the entire toggle finger subassembly, part number SED39117128-301.
- Remove the entire control box subassembly, part number SED39117360-301.
- 4. Remove the entire grapple fixture assembly (part number 10169-20400-01) and its three supporting struts (part numbers SDD 39117211-001 through -003).

The resulting modified ACD is shown in Figure 3.4.

The Interim Rescue Vehicle (IRV)

<u>Fit Test</u>. During tests at the Johnson Space Center during 25-27 Sep 85, this researcher modified a full-size



E

engineering model ACD according to the four steps listed above. The modified ACD was then attached to a full-size mockup MMU and a prototype PRE to arrive at the proposed Interim Space Rescue Ferry Vehicle (IRV). The IRV is presented in Figure 3.5.

<u>IRV Design</u>. Figure 3.5 shows how the modified ACD structure forms a "basket" within which the PRE neatly fits. The modified ACD contacts the PRE at eight points: midway along the four cross support struts and at the four foot pads. These multi-points of contact insure that the PRE Kevlar shell is not punctured due to overstress at any single location.

The PRE is rigidly held against the points of contact by tension provided by two tethers connected to the PRE carrying strap. The primary tether consists of a standard adjustable wrist tether with it's other end hooked to one of two waist attachment rings located on the front torso of the pilot's spacesuit. The secondary tether is the four-foot (maximum extension) adjustable self-reeling tether that is an integral part of the Mini-Work Station carried on the pilot's chest. In addition to anchoring the tether, the Mini-Work Station also carries up to four tool caddies, each carrying two EVA tools. The adjustable wrist tether and Mini-Work Station are standard, flight-tested EVA equipment, and details concerning their design and operation are in Appendix B.

Despite the major changes, the modified ACD rigidly





attaches to the MMU controller arms in the same manner as the unmodified ACD.

Requirements Achievement

This section assesses the degree to which the proposed modified ACD satisfies the requirements listed at the beginning of this chapter.

<u>1. Off-the-Shelf</u>. This requirement is fully satisfied.

2. <u>Visibility</u>. This requirement is adequately satisfied. The IRV pilot's horizontal line of sight lies 2-7/8 inches above the top of the PRE. This corresponds to a look-down angle of 3.34 degrees. The answer to the question, "Is this enough?" was obtained from experimental data and an astronaut interview.

Visibility Experiment. The IRV simulator shown in Figure 3.6 was constructed by the AFIT Fabrication Shop. It duplicated the obstruction to vision caused by the PRE with a 34-inch diameter styrofoam disc mounted 49.25 inches in front of the test subject "pilot." The disc height was adjustable by the test subject. The test subjects "flew" the simulator by pushing the castor-mounted disc in front of them.

Twenty-two USAF pilots were tested. Each was instructed to "fly" toward and "dock" with a space shuttle airlock hatch silhouette located on the wall, and to adjust the styrofoam disc to the tallest height which still permitted



Figure 3.6. IRV Visibility Test Apparatus

adequate visibility to complete the task.

Appendix C presents the experimental results and the calculations of the statistical measures of the results. The mean look-down angle required by the 22 subjects was .43 degrees, with a standard deviation of 1.02 degrees. Therefore, it can be said with greater than 99 percent confidence that the 3.34 degree look-down angle afforded by the proposed IRV is a statistically significant improvement over the average required by the test subjects (16:213).

Astronaut Interview. Astronaut Bruce McCandless, a designer of the MMU and pilot during its first flight, was interviewed at Martin Marietta Aerospace, Denver CO, 5 Sep 85. He expressed the opinion that ". . . only a couple of degrees look-down should be required. . ." to provide adequate visibility (13). He also pointed out that the IRV pilot always had the capability of improving his forward visibility by pitching the IRV down and thus moving the PRE further below his line of sight to the target (13).

While IRV pilots would no doubt appreciate more visibility, the aforementioned research indicates that the afforded 3.34 degrees is adequate.

3. Ease of Use. The fit test revealed one significant shortcoming in the proposed design. With the PRE nestled in position, the carrying handle falls eight inches short of the MMU pilot's reach; therefore, he cannot grasp the carrying handle and attach the two tethers. Two measures were proposed to alleviate this problem:



Figure 3.7. Hook Tool.

- Lengthen the PRE carrying handles from their current six inches to twenty inches. This can be quickly done by attaching fourteen-inch extender loops to the present straps.
- 2. The aforementioned lengthening will not insure that the PRE carrying strap always projects into the arc of the MMU pilot's reach. Therefore, provide him with a hook tool, depicted in Figure 3.7, which extends his reach by allowing him to hook the carrying strap and to pull it to within his grasp. This tool could result from a simple and quick modification to a standard EVA tool, the Probe (see Appendix B). The modified probe would be carried in a tool caddy affixed to the Mini-Work Station.

With the above two modifications, the Ease of Use requirement is fully satisfied. All pilot-operated items are current or slightly modified EVA support equipment pieces; therefore, little or no additional crew training would be necessary prior to mission execution.

<u>4.</u> <u>Stowage</u>. This requirement is fully satisfied. Despite the major modifications, the proposed connection device can still be carried on the same bracket used to stow the original ACDs in the orbiter payload bay during Mission 51D. This was confirmed by attaching a modified ACD to a full-size engineering model of the carrying bracket. The resulting configuration is illustrated in Figure 3.8.

During Mission 51D, two carrying brackets were attached to the side wall of a payload bay pallet. The pallet was required on that mission to serve as a berthing platform for the two salvaged satellites; however, during a rescue mission the pallet would serve no such additional purpose. As the pallet is large, heavy, and takes long to install in the orbiter payload bay, it is recommended for the rescue mission that two modified ACDs and their carrying brackets be mounted on two Get-Away Special Beams, attached in the normal fashion on the payload bay sidewalls (34).

The Get-Away Special Beam is described and illustrated in Appendix B. It is a standard flight hardware item which was originally designed to serve as a mounting platform for Get-Away Special Experiment Cans. The beam can be mounted in thirty different locations around the periphery of the





payload bay, and is capable of withstanding the loads and moments imposed by the attached modified ACD (20:B3-107). Mounting the ACD carrying brackets on the Get-Away Special Beams will require the drilling of several holes in each of the beams to match the already-existing mounting holes in the carrying brackets.

5. Critical Fits. This requirement is fully satisfied.

<u>6.</u> <u>Quick Response</u>. This requirement is fully satisfied. The modifications to the ACD took two man-hours, and it's estimated that modifications to two EVA Probe tools, twelve PRE carrying straps (six PREs), and two Get-Away Special Beams would total an additional 36-48 man-hours, provided the required materials were already on hand. Even if no modifications were performed in advance as a precautionary measure, a Johnson Space Center crisis action team could perform the work and have the equipment items on their way to Kennedy Space Center for installation in the rescue orbiter within half a day.

7. Safety. This requirement is fully satisfied. All hardware is flight-qualified. The two tethers and two PRE carrying straps provide redundant connection capability between the MMU and PRE, and the loads on both tethers and straps are only a fraction of their maximum rated strength.

8. Stability and Performance. The definitive answer to this requirement must await the results of the research explained in Chapter V; however, it can immediately be said

that the proposed IRV does not represent an optimum design. This is because the ACD was originally designed to satisfy the requirements of a completely different mission.

<u>a. Minimum Mass</u>. This requirement is not satisfied. The modified ACD weighs 36.41 pounds, while a MMU/PRE attachment device designed from scratch would weigh only 10-15 pounds (27). The excess mass of the modified ACD is attributable to the requirement for the original ACD to be able to withstand the loads induced if the orbiter's remote manipulator arm experienced a runaway condition with the MMU and Hughes 376 satellite attached (5).

<u>b. Minimum Center of Mass Shift</u>. This requirement is not satisfied. With the controller arms sized for the 50th percentile male astronaut (position "E"), the modified ACD positions the center of the attached PRE 4.74 feet away from the MMU's geometric center of thrust. A shorter attachment device specifically designed for this purpose could reduce this separation by about 18 inches.

<u>c. Minimum Moments of Inertia</u>. As requirements 8a. and 8b. were not achieved, it can be reasoned that such must also be the case with this requirement. The IRV's response to rotational commands can be expected to suffer because of higher than necessary moments of inertia.

<u>d.</u> <u>Rigid Connection</u>. This requirement is fully satisfied. Both the adjustable wrist tether and the Mini-Work Station tether are capable of maintaining enough tension on the PRE carrying strap so that the sphere is rigidly

held against the modified ACD structure. Also, as previously mentioned, the modified ACD rigidly attaches to the MMU in the same manner as the unmodified ACD.

e. Plume Impingement. This requirement is adequately satisfied. The modified ACD positions the PRE so that only the four forward firing thrusters impinge on the sphere, and it holds the sphere just 1.25 inches above the center of thrust, so that the four jets impinge about equally, nearly preserving symmetry of thrust. However, as mentioned in paragraph 8a., the modified ACD is bulkier than necessary. It therefore presents a greater surface area for impingement than would an optimum MMU/PRE connection device.

Chapter Summary

This chapter has answered Research Question 1 by listing requirements for a suitable MMU/PRE attachment device, and proposing modifications to the Apogee Kick Motor Capture Device (ACD) and prototype PRE which produce an interim space rescue ferry vehicle. The modified ACD adequately satisfies all requirements with the possible exceptions of performance and stability. The next two chapters investigate performance and stability of the proposed IRV.

IV. Simulation Inputs

Chapter Overview

An existing MMU flight simulation program, Man-in-the-Loop Maneuvering Unit (MILMU), was utilized to simulate the flying qualities and performance of the proposed IRV. This chapter describes MILMU and explains the determination of the required inputs concerning the IRV's mass properties and plume impingement. The next chapter will explain the simulation runs and the analysis of the results.

MILMU

MILMU is an adaptation of NASA's Desk Top Flight Simulator, which has been used for several years by JSC's Mission Planning and Analysis Division to plan space shuttle flights. TRW's Systems Engineering and Applications Division modified the program so that it models the flying qualities and performance of the MMU (37). The program was validated by its acceptable performance during the planning for the Westar and Palapa B rescue mission (38:3).

The program allows the user to specify the mass properties, initial translational state vector (which describes the orbit and the beginning location on that orbit), and initial rotational state vector (which describes the beginning attitude and angular rates) of both the MMU and a nearby freeflying satellite. In addition, plume impingement effects information can be entered. The program's primary

output is a near real time graphical presentation of the MMU pilot's view of space and the satellite.

Before simulation, MILMU uses the inputs concerning mass properties and plume impingement in a mechanics algorithm to develop a table of the ideal translational and rotational accelerations imparted to the MMU by each of the 24 thrusters. During simulation, the program uses a pointslope method to integrate the differential equations of motion of both the MMU and the satellite. At the end of each integration step, the new translational and rotational state vectors for the MMU and satellite are differenced and the satellite's relative position and attitude graphically portrayed on the screen.

Translational and rotational commands are generated either by the user (entered through the keyboard) or by MILMU's duplication of the MMU's automatic attitude hold control law. Just as in the actual MMU, MILMU interprets the commands by referencing the appropriate thruster select table and firing the designated jets. It then updates the translational and rotational state vectors to reflect the accelerations imposed by the thruster firings and uses these new state vectors in the next integration step.

MILMU automatically outputs a digital printout of the MMU and satellite initial and final state vectors. The final state vector printout also specifies the amount of propellant consumed during the simulation run. Upon request, MILMU draws a phase plane plot describing the MMU's

control response (21).

To simplify the simulation, MILMU departs from the real-world case in two ways: it assumes that the MMU/payload combination is a rigid body, and it does not model the time delay introduced by the limb motion filter (explained in Chapter III). The rigid body assumption is valid for IRV simulation if the victim remains motionless inside the PRE and if he holds the portable oxygen system stationary. The fit tests described in Chapter III confirmed that all other IRV component attachments are very nearly rigid, at least under the light acceleration loads imposed by the MMU's thrusters. The lack of limb motion filter modeling causes the MILMU-produced phase plane plots to be slightly "tighter" about the axes origin than actually experienced, but not enough to negate the usefulness of the results (36).

Using MILMU to simulate the stability and performance of the proposed IRV required the determination of inputs concerning mass properties and plume impingement. The remainder of this chapter details the work done to arrive at these inputs.

Mass Properties

The end products of this section are the weight of the IRV, the location of its center of mass, and the moments and products of inertia which describe how its mass is distributed about the center of mass. This information is referred to as the IRV mass properties. The reader is re-

minded that weight (units = pounds) is not a direct measure of mass, but rather of the force imposed on a body by gravity. Nevertheless, MILMU uses weight as its measure of component mass by assuming that all weight measurements were taken at the surface of the earth, where acceleration due to gravity is 32.2 ft/sec . MILMU converts the inputted weight into mass (units = slugs) by dividing by 32.2 ft/sec .

The moments of inertia are defined as:

Ixx = $\int_{m}^{2} (y^{2} + z^{2}) dm$ Iyy = $\int_{m}^{2} (x^{2} + z^{2}) dm$ Izz = $\int_{m}^{2} (x^{2} + y^{2}) dm$

and the products of inertia are defined as:

$$Pxy = + \int_{m} xy \, dm$$

$$Pxz = + \int_{m} xz \, dm$$

$$Pyz = + \int_{m} yz \, dm \quad (3:86) \qquad (1)$$

where x,y, and z are the coordinates of incremental mass dm. The moments and products of inertia can conveniently be represented in an inertia matrix, the entries of which are:

The following methodology was employed to arrive at the desired mass properties information:

- The vehicle was segmented into five components and mass properties information collected or, where necessary, generated for each part.
- The collected mass properties information was manipulated to reflect the orientations and positions of the components in the IRV.
- The weights of the five components were summed to arrive at the weight of the complete IRV.
- 4. The center of mass for the complete IRV was determined.
- 5. The Parallel Axes Theorem was employed to obtain the inertia matrix describing each component's mass distribution about the IRV's center of mass.
- 6. The component inertia matrices were summed to yield one inertia matrix explaining the distribution of the complete vehicle's mass about its center of mass.

<u>Coordinate Systems</u>. The IRV and its important dimensions are depicted in Figure 4.1. Also shown is the MMU body coordinate system. Its origin is at the geometric center of the MMU's twenty-four thrusters; the X-axis points forward, the Y-axis out the right side, and the Z-axis points down. The axes are fixed with respect to the MMU (10:6).





This axis system is used by MILMU as the "master" coordinate system--the one in which the location of all component mass centers are expressed. Also, MILMU requires that all component inertia matrices be defined about an axes system originating at the component mass center with axes parallel to the MMU body frame. Also shown in Figure 4.1 is a coordinate frame originating at the geometric center of the PRE with axes parallel to the MMU body frame. This coordinate system was used during some intermediate mass properties calculations.

Finally, each component also has its own coordinate system originating at its center of mass with axes oriented such that the component inertia matrix simplifies to:

$$I = \begin{bmatrix} Ixx & 0 & 0 \\ 0 & Iyy & 0 \\ 0 & 0 & Izz \end{bmatrix} (35:12) (3)$$

Such an axes frame is called the principal coordinate frame for that component. Much of the mass properties raw data was defined about such axes systems. Generally, the axes were oriented differently for each component, and not aligned with the MMU body coordinate frame.

One comment is necessary to avoid confusion. Even though the +Z axis of the MMU body coordinate system points down in Figure 4.1, the terms "up" and "down," or "above" and "below," will be used as would be by the MMU pilot. Hence "down," for example, means in the +Z direction.

<u>Component Mass Properties Data</u>. For the purposes of determining the mass properties of the IRV, the vehicle was broken into the following five components and mass properties information obtained for each.

<u>MMU and Pilot</u>. The mass properties of the solo MMU, with pilot attached, have been calculated by the Martin Marietta Corporation and validated by actual flight experience. The collected information is for a MMU with full propellant tanks, piloted by a 50th percentile male astronaut, hand controller arms adjusted to the "E" (average)
Table 1

Weight (lbs)	Center of Mass in MMU Body Coordinate System (inches)	Inertia Matrix About MMU Center of Mass (slug-ft ²)*
794.50	X = 0.55 Y = -0.05 Z = -2.54	Ixx = 37.2100 Iyy = 40.0800 Izz = 26.1200 Pxy = .0600
		Pxz = 2.5900 Pyz = .0100
*About an frame.	axes system parallel to t	he MMU body coordinate

MMU/Pilot Mass Properties (27)

length, and with the helmet television camera, helmet lights, and Mini-Work station attached. Table I lists the mass properties.

<u>Modified ACD</u>. The Lockheed Engineering and Management Services Co., of Houston TX, was contracted by NASA to determine the mass properties of the modified ACD. They used a computer program and data base originally produced to determine the mass properties of the unmodified ACD in preparation for the Westar and Palapa B satellite rescues on Mission 51D. The program and data base were validated during development by comparing its output to experimentally determined mass properties, and found to be accurate (30:iii). The mass properties of the modified ACD were

Tab	le	Ι	I
-----	----	---	---

36.41 X = 41.13 Ixx = 1.9897 Y = 0.15 Iyy = 1.9630 Z = -1.05 Izz = 2.3732 Due = -0.0184	Weight (lbs)	Center of Mass in MMU Body Coordinate System (inches)	Inertia Matrix About Capture Device Center of Mass (slug-ft ²)*
Pxy = -0.0184 $Pxz = 0.0459$ $Pyz = -0.0231$	36.41	X = 41.13 Y = 0.15 Z = - 1.05	Ixx = 1.9897 Iyy = 1.9630 Izz = 2.3732 Pxy = -0.0184 Pxz = 0.0459 Pyz = -0.0231

Modified Capture Device Mass Properties (31)

obtained by deleting from the data base the part numbers of the removed components, and having the program recompute the mass properties of the remaining structure. The results are listed in Table II.

<u>PRE</u>. No documentation on PRE mass properties could be found; therefore, experimental and analytical techniques were used to generate the required information.

<u>Weight</u>. A prototype PRE was weighed by personnel of the Crew Systems Division, Johnson Space Center, Houston TX. It weighed 11.5 pounds.

Inertia Matrix. The PRE closely approximates a 34-inch diameter, homogeneous, hollow sphere. The small viewing window, two carrying straps, and umbilical interfaces slightly disturb this approximation, but not enough to make it invalid. Noting that the inside and outside radii of the PRE sphere are approximately equal (i.e., the PRE's skin is thin compared to the radius of the sphere), the equations for the principal moments of inertia about a spherical shell's center of mass are:

$$Ixx = Iyy = Izz = (2/3) m r^{2} (15:472)$$
 (4

and, by definition

$$Pxy = Pxz = Pyz = 0$$
 (5)

where m is mass and r is the radius of the sphere. Because a sphere is symmetric about any axes system originating at its center, the principal axes can be oriented in any convenient direction. Therefore, as shown in Figure 4.2, they were aligned parallel with the MMU body coordinate system to lessen subsequent computational difficulty.

Applying Eqns (4) and (5) to the PRE:

Ixx = Iyy = Izz =
$$(2/3)$$
 (11.5 lbs/(32.2 ft/sec)) (1.4167 ft)

$$= 4778 \text{ slug-ft}$$
(6)

and

$$\mathbf{Pxy} = \mathbf{Pxz} = \mathbf{Pyz} = \mathbf{0} \tag{7}$$

PRE mass properties are summarized in Table III.



Figure 4.2. PRE Principal Axes

Table III

PRE M	ass P	rope	rties
-------	-------	------	-------

Weight (lbs)	Center of Mass in MMU Body Coordinate System (inches)	Inertia Matrix About PRE Center of Mass (slug-ft ²)*
11.5	X = 56.89 Y = 0.00	Ixx = 0.4778 Iyy = 0.4778
	2 = - 1.125	Izz = 0.4778
		Pxy = 0.0000 Pxz = 0.0000
*About an	axes system parallel to t	Pyz = 0.0000 he MMU body coordinate

<u>Victim</u>. The PRE houses a victim in a squatting position. Although the victim position within the PRE is fixed by the waist restraint belt, some manipulation of IRV mass properties was possible because the PRE can be attached to the modified ACD by either of its two carrying straps and at any roll angle about an axis parallel to the MMU's X axis. The choice of orientations was settled by referring to criterion 8a, in Chap III, which required that the shift of the IRV's mass center away from the MMU geometric center of thrusters be minimized. This was achieved by orienting the victim with his head down and his back toward the MMU. However, the mass properties data to follow was collected with respect to the head-up orientation. This inconsistency will be remedied following disclosure of the remaining mass properties information.

The victim defied mass properties modeling using one or two simple geometric shapes; therefore, the Air Force Aerospace Medical Research Laboratory's (AFAMRL) Articulated Total Body Model computer program was used to produce the required information. The Articulated Total Body Model was developed jointly by AFAMRL and the Department of Transportation and has successfully been used to model bioengineering problems ranging from automobile crashes to aircraft ejections. The data base includes the mass properties of the fifteen major body segments of the fiftieth percentile male Air Force pilot. The segmentation scheme is depicted in Figure 4.3.



...

. . . .

K	e	Y
_		_

HHead
NNeck
UT Upper Torso
Of Canton Morgo
CTCenter Torso
LTLower Torso
RUARight Upper Arm
RLARight Lower Arm
RULRight Upper Leg
RLLRight Lower Leg
RFRight Foot
LUALeft Upper Arm
LLA. Left Lower Arm
LULLeft Upper Leg
LLL. Left Lower Leg
LF Left Foot
211112020 1000

Figure 4.3. Articulated Total Body Model Segmentation Scheme (14:12)

61

..

A subroutine allows the user to designate the positions and orientations of these fifteen body segments with respect to a user-defined coordinate system, and the resulting body position is presented on a graphics terminal. The program then computes the center of mass of the entire body with respect to the defined coordinate system by the equation:

$$\overline{r} = (1/m) \sum_{i=1}^{m} \overline{r} \quad (3:49) \quad (8)$$
mass center i i
th

where m is the mass of the i component, \overline{r} is the posii th th tion vector of the i component, and $m = \sum m$. The program also outputs a list of the weights, principal moments of inertia, and Euler angles (3-2-1 rotation order) from the user-iefined coordinate system to the principal axes for each of the fifteen body parts.

The Articulated Total Body Model was used to curve the spine and fold the arms and legs of the body model until all body segments fell within the 34-inch diameter sphere. An iterative process taking advantage of the graphics capability of the program was used to insure that a natural body position was designated. The victim was oriented with his head up (with respect to the MMU pilot) and with his back to the MMU. The resulting orientation is shown in Figure 4.4. The program printouts giving the mass properties and orientation angles of the body segments, and the location of the center of mass of the entire body, are reproduced in Table IV. Note that the reference system used for this program was centered at the geometric center of the PRE, with axes

62

ومنافق فالمتحدث والمتعادية



ŀ

Table IV

)

Victim Mass Properties Information

(INGRITAL) ANSULAR ROTATION (DES) SEGMENT YAA PITCH ROLL S.0000 S.0000 S.0000 0.0000 0600.0 -3.0000 1 LT 2 CT 3 -73.0000 -103.0000 0.0000 UΤ 4 N u.JÜJC 0.0000 3.3000 5 -125.0000 0.0000 H. 6 RUL 25.0000 20.3000 0.0000 -15.0000 7 REL -20.0000 22.0000 25 З 6.0005 135.0000 15.0000 ý LUL -25.0000 90.0000 0.0000 -15.0000 10 LLL 22.0000 -20.0000 135.0000 35.0000 -45.0000 35.0000 11 LF 0.0000 -15.0000 12 C.3000 -90.0000 RUA 10.0000 13 RLA 180.0000 -10.0000 14 LUA 0.0000 15 -45.0000 LLA 100.0000 90.0000

(INERTIAL) LINEAR POSITION (IN.) SEGMENT х Y 2 0.0000 -2.0000 1 LT -11.5000 2 CT -10.4157 3 -3.7785 UT 0.0000 -9.9109 4 N 4.2237 6.0000 -11.7252 5 9.4997 H 0.000 -8.3010 Ô RUL -4.1920 6.5021 -2.1375 7 RLL 1.9567 9.0255 3.7735 8 R = 2.9817 5.5035 10.5331 7 LUL -4.1920 -5.6621 -2.1395 1.9367 10 LLL -9.0205 3.7736 11 LF 2.5317 -6.5036 13.8331 12 RUA 3.2050 6.54:0 -6.9937 13 RLA 5.5981 -0.7121 -2.795 3.8050 6.6931 -0.5433 2.7121 -6.9917 14 LUA 15 LLA

Table IV (cont)

				PRINCIPAL	MOMENTS	DE INERTIA
S	SEGMEN	1 T	NEIGHT	(L3.	-SEC.**2-	TN.)
I	SYM	PLOT	(LE.)	x	Y	2
1	LT	1	28.334	1.1859	0.7297	1.2733
ż	СТ	2	10.463	0.2795	0.1544	0.7014
3	บา	3	43.945	2.4619	1.9214	1.5497
4	N	4	2.745	0.0227	2-6229	0.0176
5	н	5	11.425	0.2470	2.2517	0.1474
0	RUL	6	10.320	1.3.55	1.3955	0.1770
7	RLL	7	8.155	J. 3636	0.3635	0.0459
Ġ	RF	8	1.734	0.0329	0.0313	0.0042
7	LUL	÷,	13.320	1.3955	1.3955	0.1770
10	LLL	Α	3.155	0.3636	0.3535	5.3459
11	LF	5	1.734	64.50	0.031+	0.3347
12	RUA	С	+ 613	0.1290	1191	0.0156
13	RL4	Э	5.065	0.0567	0.2563	0.01.3
14	LUA	Ξ	4.013	1790	0.1230	0.0700
15	LLA	F	1.165	0.2557	0.2563	0.0163

CENTER OF GRAVITY (IN.) X Y Z -2.049 0.000 -4.420 parallel to the MMU body coordinate frame.

The fifteen body segment principal inertia matrices in Table IV are defined about individual principal axes systems which generally differ in orientation from each other and from the MMU body coordinate system. Therefore, inertia matrices were obtained describing the mass distribution of each segment about an axes system originating at the segment's mass center but oriented parallel to MMU body coordinate system. This was done using:

a a to b
$$-1$$
 b a to b
I = (R) I R (35:13) (9)

where I is the inertia matrix about orthogonal axes with b the desired orientation, I is the inertia matrix about the a to b given axis system, and R is the transformation matrix representing the rotation from the desired to the known orientation. Applying Eqn (9) to the present situation:

body segment expressed in mmu axes system I

> from mmu to body principal axis system R (10)

A utility subroutine within the Articulated Total Body Model program generated the rotation matrix required in Eqn (10)

for each of the fifteen different body segments, using as input the orientation angles listed in Table IV. The subroutine's accuracy was checked by manually computing several of the rotation matrices and confirming identical results. Eqn (10) was then implemented on AFIT'S UNIX system using a matrix multiplication algorithm, and applied to each of the fifteen body segment principal inertia matrices. The rotation matrix and resulting inertia matrix after applying Eqn (10) are shown for each body segment in Table V.

The Parallel Axes Theorem was used to combine the inertia matrices of the fifteen body segments to obtain the inertia matrix of the entire victim defined about a coordinate system originating at the victim's center of the mass and parallel to the MMU body frame. The Parallel Axes Theorem states that, given an inertia matrix defined about an orthogonal coordinate system originating at the center of mass of a rigid body, an inertia matrix defined about an offset but parallel coordinate system can be found according to:

to: $I2 = Ic + m \begin{bmatrix} 2 & 2 & & & \\ b + c & -ab & -ac & \\ & 2 & 2 & & \\ -ab & c + a & -bc & \\ & & & 2 & 2 \\ -ac & -bc & & a + b \end{bmatrix} (3:89)$ (11)

where I is the desired inertia matrix; I is the given 2 c inertia matrix defined about a parallel axis system located

Table V

Body Segment Inertia Matrix Rotations into Alignment with MMU Body Coordinate System

Segment	Rota	tion Angles Rotation Ma	(deg) trix	Resulti	.ng Inerti (slug-in ²)	a Matrix
	Yaw	Pitch	Roll			
LT	0000-0	-5-0000	0.0000	1.190	0.000 0.730	-0.007
	0.99619 0.00000 -0.08716	0.00000 1.00000	0.03715 0.00000 0.93619	-0.007	0.00	1.272
ст	0.000	-30-0000	û. 0000	0.307	0.000	-0.480
	0.86603 0.00000	0.00000 1.00000	0.50000 0.00000	-0.048	0.000	0.363
	-0.5000	0-00000	J. 86603			
UT	0.0000	-75.0000	0 . 000£	1.704	0.000	0.203
	0.25882 0.00000 -0.96593	0.00000 1.00000 0.00000	0.96593 0.00000 3.25882	0.203	0000.0	2.408
*Defined with axe	about an a s parallel	xis system to MMU bod	originating at t ly coordinate sys	he segment cer tem.	iter of ma	ıss and

Table V (cont)

Segment	Rotat and R	ion Angles otation Ma	(deg) trix	Resulti	ing Inerti (slug-in ²)	a Matrix
	Yaw	Pitch	Roll			
N	0000	-105.0000	0.000	0.018 0.000	0.000 0.023	-0.001 0.000
	-0.25882 0.00000 -0.95593	0.00000 1.00000 0.00000	0.96593 0.00000 -9.25882	-0.001	0.000	0.023
Н	0°000	-125-0000	0.000	0.179	0.000	-0.047
	-0.57358 0.00000 -0.81915	0.00000 1.00000 0.00000	0.81915 0.00000 -0.57358	-0.047	000.00	0.214
RUL	25-0000	90.0000	0000-0	0.395 -0.467	-0.467 1 178	000.0
	0.00000 -0.42262 0.93631	0.00000 0.90631 0.42262	-1.00000 0.00000 0.00000	000.0	000.0	1.395
RLL	-20-0000	-15-0000	20-0000	0.326 -0.026	-0.026	0.100
	0.90767 0.23821 -0.34552	-0.33037 0.91330 -0.23321	0.25582 0.33037 0.07777	0.100	690.0	0.102

Table V (cont)

in N

Segment	Rotat and R	ion Angles otation Ma	(deg) trix	Resul	ting Inerti (slug-in	a Matrix
	Yaw	Pitch	Roll			
RF	0.0000	135.0000	15.3000	0.019	0.005	0.013
	-0.73711 0.15301 0.68301	0.00000 0.96593 -0.25882	-0.70711 -0.18301 -0.58301	0.005 0.013	0.030 -0.005	-0.005 0.019
rur	-25.000	90.00.00	0.000	0.395	0.467	000
	0.00000 0.42262 0.93631	0.00000 0.90631 -0.42262	-1.00000 0.00000 0.00000	0.000	1.178	0.000
TTT	20-0000	-15.0000	-20.000	0.326	0.026	0.100
	0.90767 -0.23821 -0.34552	0.33037 0.91330 0.23821	0.25942 -0.33037 0.90767	0.026	0.346	-0.069
TF	0000-0	135.0000	-15.0000	0.019	-0.005	0.013
1	-0.70711 -0.18301 0.68301	0.00000 0.96593 0.25382	-0.73711 0.18301 -0.68301	-0.005	0.030	0.019

ਮੇ •

1

Table V (cont)

Segment	Rotat and R	ion Angles otation Ma	(deg) trix	Result	ing Inerti (slug-in2	a Matrix)
	Yaw	Pitch	Roll			
RUA	10.3000	35-0000	0-000°C	0.094	-0.006	-0.051
	0-80571 -0-17365 0-56486	0.14224 0.98431 0.09960	-3.57358 0.00000 0.81915	-0.006	-0.009	-0.009
RLA	-130.0020	-45-0000	2000-06-	0.256	000.0	0.000
	-9.70711 -0.70711 0.00000	0.00000 0.00000 -1.00000	0.70711 -0.70711 0.00000	0000.0	0.016	0.000
A11.1	-10-0000	35-0000	0.000	0.044	0.006	-0,051
	0.30671 0.17365 0.56436	-0.14224 0.98481 -0.09950	-0.57358 0.06030 0.31915	-0.051	0.128	0.055
TLA	180.0000	-45.0000	0000-06	0.256	000-0	000000
	-0.70711 0.70711 0.00000	0.00000 0.00000 1.00000	0.70711 0.70711 0.00000	0000.0	0.016	0.256

=

at the segment's center of mass; and a, b, and c are the x, y, and z distances, respectively, from the new coordinate system origin to the center of mass of the segment.

Eqn (11) was applied to obtain inertia matrices describing the mass distribution of the fifteen body segments about the victim center of mass. The calculations were accomplished by a mass properties subroutine within MILMU, using as input the inertia matrices listed in Table V (con- 2 verted into units of slug-ft) and the weights and offset distances from the PRE geometric center in Table IV. The results were checked manually to confirm accuracy. The resulting matrices were then summed to obtain an inertia matrix defining the entire victim's mass distribution. The mass properties of the victim are summarized in Table VI.

Portable Oxygen System. As explained in Chapter II, the victim carries with him a portable oxygen system containing a one-hour supply of oxygen. This system is in the preliminary design phase and specific mass properties information was unavailable; therefore, this component was modeled as a 25-pound hollow cylinder eighteen inches long and six inches in diameter, with flat circular end disks. It was assumed that the head-up victim would position the bottle between his legs at a pitch angle of -52.5 degrees from the MMU body frame. Figure 4.5 depicts the oxygen system parts, their principal axes, and their orientation with respect to the MMU body frame.

	Tal	b 1	е	V	I
--	-----	------------	---	---	---

Weight (1bs)	Center of Mass in PRE Frame System (inches) ¹	Inertia Matrix About Victim Center of Mass (slug-ft ²) ²
173.54	X = -2.85	IXX = 1.6807
	Y = 0.00	Iyy = 2.3576
	Z = -4.20	Izz = 2.2339
		Pxy = 0.0000
		Pxz = -0.0077
		Pyz = 0.0000

Victim Mass Properties--Head Up Orientation

¹Axes system originating at the PRE center with axes parallel to the MMU body coordinate frame.

 $^{2}\operatorname{About}$ an axes system originating at the victim's center of mass and with axes parallel to the MMU body coordinate frame.





Assuming the inside and outside radii are approximately equal (i.e., the walls of the bottle are thin compared to its radius) the equations for the principal moments of inertia of a hollow cylinder are:

Ixx = Iyy =
$$(1/2)$$
 m r + $(1/12)$ m l

and

$$1zz = m r (15:471)$$
(12)

and the equations for the principal moments of inertia of a thin circular disk are:

$$1xx = 1yy = (1/4) m r$$

and

W

$$1zz = (1/2) m r (14:498)$$
(13)

and

Applying Eqn (13) to the end disks:

Ixx = Iyy = (1/4) (1.775 lbs/(32.2 ft/sec)) (.25 ft) = .0009 slug-ft

and

$$Izz = (1/2) (1.775 lbs/(32.2 ft/sec)) (.25 ft)^{2}$$

= .0017 slug-ft (15

In Eqns (14) and (15), mass was attributed to the cylinder and end caps in proportion to the ratio of their respective areas to the total area of the portable oxygen system.

Just as with the victim body segments, Eqn (10) was applied to transform the three oxygen system component inertia matrices from their principal axes systems to coordinate systems parallel to the MMU body coordinate system. Table VII presents the results of these calculations. Eqn (11) was then applied to translate the inertia matrices to the center of mass of the portable oxygen system, and the resulting matrices summed to obtain the complete oxygen system's mass properties, which are summarized in Table VIII.

<u>Mass Properties Correction</u>. As already noted, the mass properties information for the victim and portable oxygen system was collected for the head-up victim orientation, but the desired victim orientation is head down. Before consolidating the mass properties information for the IRV, this inconsistency was corrected by combining the PRE, victim, and portable oxygen system into a single mass entity which

Table VII

Oxygen System Component Inertia Matrix Rotations into Alignment with MMU Body Coordinate System

Segment	Rotatic and Rot	on Angles (d tation Matri	eg) x	Resulti	ing Inertia (slug-in)	a Matrix
	Yaw	Pitch	Roll			
Cylinder	0.00	-52.50	0.00			
	.609 .000 793	.000 1.000 .000	. 793 . 000 . 609	11.5498 0.0000 7.2387	0.0000 20.9836 0.0000	7.2387 0.0000 15.4289
End Caps	sal	me as cylind	er	0.2021 0.0000 -0.0600	0.0000 0.1240 0.0000	-0.0600 0.0000 0.1700





Ta	b1	е	V	I	Ι	I
----	----	---	---	---	---	---

Portable Oxygen System Mass Properties Head Up Orientation

● アンドロセントの 御書 アイブイン たいとう ● アイ・マンド・

Weight (lbs)	Center of Mass in PRE Frame (inches) ¹	Inertia Matrix About Oxygen System Center of Mass (slug-in ²) ²
25.00	X = -6.35 Y = 0.00 Z = 4.87	Ixx = 0.1060 Iyy = 0.2095 Izz = 0.1486 Pxy = 0.0000 Pxz = -0.0794 Pyz = 0.0000

1An axes system originating at the PRE center and with axes parallel to the MMU body coordinate frame.

²About an axes system originating at the victim's center of mass and with axes parallel to the MMU body coordinate frame.

was then rotated 180 degrees to the desired orientation.

First, the center of mass of the PRE, head-up victim, and portable oxygen system with respect to the center of the PRE was determined by applying Eqn (8):

Table I	X
---------	---

Mass Properties--Combined PRE/Victim/Oxygen Bottle System

Weight (lbs)	Center of Mass in PRE Frame (inches)	Inertia Matrix About System Center of Mass (slug-ft ²) ²
210.04	X = -3.11	Ixx = 2.6965
	Y = 0.00	Iyy = 3.5600
	Z = -3.07	Izz = 2.9434
		Pxy = 0.0000
		Pxz = -0.2153
		Pyz = 0.0000
1 _{An axes s} axes para	system originating at the ballel to the MMU body coord	PRE center and with dinate frame.
2 hout an	avec system originating a	t the combined system's

(Victim Oriented Head Up)

center of mass and with axes parallel to the MMU body coordinate frame.

Next, the MILMU mass properties subroutine was used to apply Eqn (11) to translate the head-up inertia matrices for the PRE, victim, and oxygen system to the head-up center of mass. Summing the matrices yielded the total inertia matrix for this combination, the mass properties of which are summarized in Table IX.

It was determined by inspection that rotating the PRE and its contents 180 degrees about the X-axis resulted in the system mass center moving to -3.11i + 0j + 3.07k inches (relative to the PRE frame). Eqn (9) was then applied to

Table X

Mass Properties--Combined PRE/Victim/Oxygen Bottle System

Weight (lbs)	Center of Mass in PRE Frame (inches) ¹	Inertia Matrix About System Center of Mass (slug-in ²) ²
210.04	X = -3.11	Ixx = 2.6965
	Y = 0.00	Iyy = 3.5600
	Z = 3.07	Izz = 2.9434
		Pxy = 0.0000
		Pxz = 0.2153
		Pyz = 0.0000
1 _{An axes s}	ystem originating at the	PRE center and with

(Victim Oriented Head Down)

parallel to the MMU body coordinate frame.

²About an axes system originating at the combined system's center of mass and with axes parallel to the MMU body coordinate frame.

rotate the inertia matrix for the PRE/Head-Up Victim/Oxygen Bottle system to obtain the inertia matrix for the PRE/Head-Down Victim/Oxygen Bottle system, the inertia properties of which are summarized in Table X.

Mass Properties Consolidation. The mass properties of the MMU/Pilot, modified ACD, and PRE/Head-Down Victim/Oxygen System were consolidated into one IRV mass entity as follows.

Weight. The IRV's weight was found by summing the weights of its components:

<u>Mass Center Location</u>. The PRE/Head-Down Victim/ Oxygen Bottle System mass center location was transformed into the MMU body coordinate system, then Eqn (8) was applied to determine the mass center of the entire IRV:

$$\overline{r} = (1/1040.95 \text{ lbs})[(794.50 \text{ lbs})(.55i - .05j - 2.54k)$$

$$+ (36.41 \text{ lbs})(41.130i + .150j - 1.05k)$$

$$+ (210.04 \text{ lbs}) (53.78i + 0j + 1.95k)]$$

$$= 12.71i - .03j - 1.58k \text{ inches} \qquad (18)$$

Inertia Matrix. The MILMU mass properties subroutine was used to apply Eqn (11) to translate the inertia matrices for the MMU/Pilot, modified ACD, and PRE/Head-Down Victim/Oxygen System to the IRV's mass center. Summing the matrices yielded the total inertia matrix for the IRV, the mass properties of which are summarized in Table XI. This information was used by MILMU simulate the response of the IRV to MMU thruster firings.

Table X.	Τa	ab	1	е	X	1
----------	----	----	---	---	---	---

IRV Mass Propertie	[R	V	Mas	s P	rop	per	:ti	.es	
--------------------	-----	---	-----	-----	-----	-----	-----	-----	--

Weight (1bs)	Center of Mass in MMU Body Coordinate System (inches)	Inertia Matrix About IRV Center of Mass (slug-ft ²)*
1040.95	X = 12.71	Ixx = 42.6209
	Y = -0.03	Iyy = 154.5021
	Z = -1.58	Izz = 139.6117
		Pxy = 0.1794
		Pxz = 11.5398
		Pyz = - 0.0042
*About an a frame.	axes system parallel to the	ne MMU body coordinate

Plume Impingement

Table XII lists the forces created by each of the MMU's 24 thrusters. An identical table is used by MILMU to determine the accelerations produced by thruster firings. However, this table was inappropriate for modeling the IRV because the attached PRE lies within the exhaust plume region of the MMU's four forward-firing thrusters. The impingement of the nitrogen gas against the PRE sphere produces forces and moments which change the effective forces and moments created by the four forward-firing jets.

The Martin Marietta Corporation provided a table of the moments and forces caused by impingement of the MMU's four forward-firing thruster plumes upon the PRE. The table is

ſ	AD-A16	4 839	A P Veh Oh	ROPOSE ICLE(L School	D DES	IGN FO FORCE Nginee	R AN 1 Inst Ring	NTERI OF TE	N SPAC CH NRI RLSELL	E RESI GHT-PI DEC 1	UE FE	RRY On Afe	2.	13	÷
	UNCLAS	SIFIE) ÂFI	T/GS0/	ENY/8	5D-2					F/G	22/2	NL		-
												•			
								-							
-	-	_													_



£.,

MICROCOPY RESOLUTION TEST CHART

Table XII

THRU	ISTER	******	FORCE (LB)	*****	EFFECTIV	VE LOCAT:	ION (IN)	С
N0.	ID.	×	Y	Z	STA	BL	WL	(FŤ)
1	BIA	-1.700	0.000	0.000	-4.50	13.45	21.00	0.000
2	DIA	0.000	0.000	1.700	-4.50	13.45	21.00	0.000
3	11A	0.000	-1.700	0.000	-4.50	13.45	21.00	0.000
4	D2A	0.000	0.000	1.700	4.50	-13.45	21.00	0.000
5	F2A	1.700	0.000	0.000	4.50	-13.45	21.00	0.300
6	R2A	0.000	1.700	0.000	4.50	-13.45	21.00	0.000
7	F 3 A	1.700	0.000	0.000	4.50	13.45	-21.00	0.000
8	L3A	0.000	-1.700	0.000	4.50	13.45	-21.00	0.000
9	U3A	0.000	0.000	-1.700	4.50	13.45	-21.00	0.000
10	B4A	-1.700	0.000	0.000	-4.50	-13.45	-21.00	0.000
11	R4A	0.000	1.700	0.000	-4.50	-13.45	-21.00	0.000
12	U4A	0.000	0.000	-1.700	-4.50	-13.45	-21.00	0.000
13	DIB	0.000	0.000	1.700	4.50	13.45	21.00	0.000
14	F1B	1.700	0.000	0.000	4.50	13.45	21.00	0.000
15	L1B	0.000	-1.700	0.000	4.50	13.45	21.00	0.000
16	B2B	-1.700	0.000	0.000	-4.50	-13.45	21.00	0.000
17	D2B	0.000	0.000	1.700	-4.50	-13.45	21.00	0.000
18	R2B	0.000	1.700	0.000	-4.50	-13.45	21.00	0.000
19	B3B	-1.700	0.000	0.000	-4.50	13.45	-21.00	0.000
20	L3B	0.000	-1.700	0.000	-4.50	13.45	-21.00	0.000
21	U 3 B	0.000	0.000	-1.700	-4.50	13.45	-21.00	0.000
22	F4B	1.700	0.000	0.000	4.50	-13.45	-21.00	0.000
23	R4B	0.000	1.700	0.000	4.50	-13.45	-21.00	0.000
24	U4B	0.000	0.000	-1.700	4.50	-13.45	-21.00	0.000
*								
ሞክም	netor	identif	ication	o foo	ownlained	in An	nondiv 1	

BASIC JET FORCE TABLE

reproduced in Table XIII. It was produced by a Fortran 77 implementation of the McDonnell Douglas Technical Services Corporation's Plume Impingement Model, which was originally designed to calculate the effects of orbiter reaction control system jet firings on nearby free-flying satellites. The model was modified to reflect the location, thrust, and firing direction of the MMU's jets. Additional inputs included the size of the PRE sphere, and its location with respect to the MMU body coordinate system. Two simplifying assumptions were made:



NO.	ID.	X	Y	Z	rol	pch	y a w
1	BIA	0.173	-0.083	0.122	-0.007	-0.595	-0.391
2	DIA	0.000	0.000	0.000	0.000	0.000	0.000
3	LIA	0.000	0.000	0.000	0.000	0.000	0.000
4	D2A	0.000	0.000	0.000	0.000	0.000	0.000
5	F2A	0.000	0.000	0.000	0.000	0.000	0.000
6	R2A	0.000	0.000	0.000	0.000	0.000	0.000
7	F 3A	0.000	0.000	0.000	0.000	0.000	0.000
8	L3A	0.000	0.000	0.000	0.000	0.000	0.000
9	USA	0.000	0.000	0.000	0.000	0.000	0.000
10	84 8	0.144	0.070	-0.115	0.006	0.531	0.331
11	R4A	0.000	0.000	0.000	0.000	0.000	0.000
12	U4A	0.000	0.000	0.000	0.000	0.000	0.000
13	DIB	0.000	0.000	0.000	0.000	0.000	0.000
14	F1B	0.000	0.000	0.000	0.000	0.000	0.000
15	LIB	0.000	0.000	0.000	0.000	0.000	0.000
16	B2B	0.173	0.083	0.122	0.007	-0.595	0.391
17	D2B	0.000	0.000	0.000	0.000	0.000	0.000
18	R2B	0.000	0.000	0.000	0.000	0.000	0.000
19	B3B	0.144	-0.070	-0.115	-0.007	0.531	-0.331
20	L3B	0.000	0.000	0.000	0.000	0.000	0.000
21	U3B	0.000	0.000	0.000	0.000	0.000	0.000
22	F4B	0.000	0.000	0.000	0.000	0.000	0.000
23	R4B	0.000	0.000	0.000	0.000	0.000	0.000
24	U4B	0.000	0.000	0.000	0.000	0.000	0.000

PRE IMPINGEMENT EFFECTS TABLE

Thruster identification code explained in Appendix A.

- Only the four forward-firing thrusters impinge on the PRE. The modified ACD holds the PRE well in front of the MMU and out of the plume impingement fields of all but the forward-firing thrusters; therefore, this is a valid assumption (25).
- 2. The modified ACD was not modeled so as to simplify implementation. This assumption appears reasonable because only the "basket" portion of the

modified ACD (that part closest to the PRE) lies within a region of significant plume dynamic pres-2 sure (approximately .1 lb/ft) (25). It was reasoned that impingement which would actually be incurred by the ACD structure would be closely approximated in the model by the additional impingement experienced by unshadowed portions of PRE lying directly behind the modified ACD.

The Plume Impingement Model integrated the local dynamic pressure of each of the MMU's forward-firing thrusters over the surface area of the PRE sphere, arriving at a resultant force vector due to impingement from that thruster. The vector was resolved into components in the MMU body coordinate system to arrive at the X, Y, and Z components of force due to impingement from that thruster. The resultant force vector was also crossed with its moment arm from the MMU's geometric center of thrusters, and the resulting vector resolved into components in the MMU body coordinate system to arrive at the moments about the X, Y, and Z axes due to impingement (2).

MILMU added the forces due to impingement (Table XII) to the basic forces caused by the thrusters (Table XIII) to arrive at the net effective forces for each thruster to be used in the simulation. These effective forces are listed in Table XIV.

Table XIV.

THRU	JSTER	*****	FORCE (LB)	******	EFFECTI	VE LOCAT	ION (IN)	
NO.	ID*	×	Y	Z	STA	BL	WL	(FT)
1	BIƏ	-1.527	-0.083	0.122	-4.72	12.16	19.08	-0.001
2	D18	0.000	0.000	1.700	-4.50	13.45	21.00	0.000
3	LIA	9.999	-1.700	0.000	-4.50	13.45	21.00	0.000
4	028	0.000	0.000	1.700	4.50	-13.45	21.00	0.000
5	F2A	1.700	0.000	0.000	4.50	-13.45	21.00	0.000
6	RZA	0.000	1.700	0.000	4.50	-13.45	21.00	0.000
7	F 3A	1.700	0.000	0.000	4.50	13.45	-21.00	0.000
8	L 3A	0.000	-1.790	0.000	4.50	13.45	-21.00	0.000
9	U 3A	0.000	0.000	-1.700	4.50	13.45	-21.00	0.000
10	B4A	-1.556	0.070	-0.115	-4.68	-12.35	-19.19	0.000
11	R4A	0.000	1.700	0.000	-4.50	-13.45	-21.00	0.000
12	U4A	0.000	0.000	-1.700	-4.50	-13.45	-21.00	0.000
13	DIB	0.000	0.000	1.700	4,50	13.45	21.00	0.000
14	FIB	1.700	0.000	0.000	4.50	13.45	21.00	0.000
15	LIB	0.000	-1.700	0.000	4.50	13.45	21.00	0.000
16	B2B	-1.527	0.083	0.122	-4,72	-12.16	19.08	0.001
17	D2B	0.000	0.000	1.700	-4.50	-13.45	21.00	0.000
19	R2B	0.000	1.700	0.000	-4.50	-13.45	21.00	0.000
19	B3B	-1,556	-0.070	-0.115	-4.68	12.35	-19.19	0.000
20	L3B	0.000	-1.700	0.000	-4,50	13.45	-21.00	0.000
21	U3B	0.000	0.000	-1.700	-4.50	13.45	-21.00	0.000
22	F4B	1.700	0.000	0.000	4.50	-13.45	-21.00	0.000
23	R4B	0.000	1.700	0.000	4.50	-13.45	-21.00	0.000
24	U4B	0.000	0.000	-1.700	4.50	-13.45	-21.00	0.000
*								
			~ · · ·	-	_
Th:	ruster	identi	ticatior	n code	explained	d in Ap	pendix	Α.

PRE JET FORCE TABLE

Chapter Summary

This chapter introduced the MILMU computer program which was used to analyze the IRV's performance and stability, and presented the determination of the required inputs concerning IRV mass properties and plume impingement. The next chapter explains the simulation runs and their results. scribed in Chapter II. They graphically describe the automatic attitude hold (AAH) control system's success or failure at limiting undesired rotations due to the presence of non-zero products of inertia, plume impingement, and the offset between the center of mass and center of thrust.

- 5. Items 1. through 4. while operating in the Backup control mode. As described in Chapter II, the Backup mode allows continued operation after a malfunction has disabled one of the two propulsion subsystems. The results will indicate if stability and performance would allow an IRV forced to operate in this mode to complete its return trip to the rescue orbiter, maintaining the PRE in tow.
- 6. Items 1. through 4. while operating in the Satellite Stabilization control mode. As described in Chapter III, the Satellite Stabilization mode was designed to reduce plume impingement and increase control authority when heavy payloads were attached to the front of the MMU. The results will indicate if this mode offers better IRV performance and stability than the Primary control mode.

Simulation Runs

MILMU was implemented on a Hewlett-Packard 9825T minicomputer, and it took 7.5 seconds actual time for the pro-

V. <u>Simulation Objectives</u>, <u>Results</u>, <u>and Analysis</u>

Chapter Overview

This chapter answers Research Question 2 (i.e., IRV stability and performance) by explaining the simulation runs made with MILMU and presenting and analyzing the results.

Simulation Objectives

Research Question 2 was "What are the stability and performance of the proposed IRV?" Answering this question required obtaining the following information:

- IRV response to translation commands along all three axes.
- IRV response to rotation commands about all three axes.
- 3. Specific propellant consumption (propellant consumed/change achieved in translational or rotational velocity) for the maneuvers listed in 1. and 2. Note that this factor, divided into the 23.2 pounds of useable gaseous nitrogen propellant, yields the total change in translational or rotational velocity possible if all propellant were spent on that one maneuver. This parameter provides a useful comparison tool.
- Phase plane plots for all three axes during the maneuvers listed in 1. and 2. Phase plane plots were de-

cessor to propagate the state of the IRV system through one integration step and then to update all of the pilot's displays and process his flight control inputs. Two types of simulation runs were made:

- 1. Five-second translation burns were commanded in the +X, +Y, and +Z directions, with AAH on. The simulation was continued until all induced rotational rates were nulled. Rotational rates were considered to be nulled when they were reduced below .1 deg/sec and had an algebraic sign opposite of the attitude error. Translational acceleration along the commanded axis was determined by dividing the resulting change in translational velocity by five seconds. Undesired coupled translational accelerations along the other two axes were determined by referring to the MILMU-produced acceleration response matrix. Specific propellant consumption was determined by dividing the propellant consumed by the resulting translational velocity. Stability was indicated by the phase plane plots.
- 2. One- or two-second positive rotational burns were commanded about the X axis, and five-second positive rotational burns about the Y and Z axes. The simulation was continued until all except the desired rotation rate were nulled. Rotations were considered nulled when they met the criteria in 1., above. Rotational acceleration was determined by dividing the resulting

angular rate by two or five seconds, as appropriate. Undesired coupled translational accelerations were determined by referring the the MILMU-produced acceleration response matrix. Specific propellant consumption was determined by dividing the propellant consumed by the resulting angular rate. Stability was indicated by the phase plane plots.

Simulation Runs 1. and 2. were made in four different mass properties/control mode configurations:

- Solo MMU/Primary Control Mode. The program implementation was validated by comparing MILMU-predicted solo MMU translational and rotational acceleration rates to published MMU performance information.
- 2. IRV/Primary Control Mode.
- 3. IRV/Backup Control Mode. Only the Backup B Mode (used when the A propulsion subsystem is lost) was simulated. Similar results would be obtained in Backup mode A.
- 4. IRV/Satellite Stabilization Control Mode. Analysis of this control mode depended primarily on study of the thruster select tables (Appendix A) and the response matrix (explained below), instead of on simulation. However, rotations about all three axes were simulated to confirm the conclusions.
Simulation Results

Appendix D contains the phase plane plots for each simulation run, and constitutes the simulation results for stability. Accompanying each phase plane plot is the endof-simulation state vector printout. Tables XV through XVIII present the simulation results for performance. Each table presents two sources of acceleration information. The first is a MILMU-produced response matrix which lists the IRV's ideal response to all possible combinations of pilot commands, as determined by application of the dynamics equations:

translational acceleration = $\sum forces/mass$ (19) and

rotational acceleration = \sum moments/inertia (20)

The response matrices take into account all forces (including plume impingement, if appropriate) but do not reflect degradation due to AAH modulation of thruster ontime as necessary to maintain the desired attitude. This reduction was documented in the second part of each table, where the final translational or rotational rate (obtained from the appropriate end-of-simulation state vector printout in Appendix D) was divided by the commanded on-time (one, two, or five seconds) to arrive at the actual acceleration.

Table XV

Simulation Results--Solo MMU/Primary Control Mode

PART 1--RESPONSE MATRIX

	T	TUDI -	OHOL MA	TUTU					
	CMD●	******	*******	ACCELE	RATIONS +	*******	******	PROF	PELLANT
		TRANS	L FT SEC	SEC	ROTAT	DEG SE	C SECH	NDOT	LBSEC
Ċ	. D		7 7	Z	rol	pch	ົບ ສ.ພ	A	В
•				-					-
•	+90	0.075	a aaa	a aaa	-0 001	2 059	-0.061	0 0522	0 0522
-	- 00	0.2.0	0.000	0.000	0.001	2.000	-0.001	0.0000	0.0000
÷	-00	-0.2.5	0.000	0.000	0.001	-2.000	0.001	0.0000	0.0000
3	0+0	0.000	0.000	0.000	0.014	8.505	0.005	0.0533	0.0000
4	++0	0.138	0.000	0.000	0.014	9.535	-0.026	0.0266	0.0266
5	-+9	-0.138	0.000	0.000	0.015	7.477	0.035	0.0266	0.0266
5	0-0	0.000	0.000	0.000	-0.014	-8.506	-0.005	0.0000	0.0533
7	+-0	0.138	0.000	0.000	-0.015	-7.477	-0.035	0.0266	0.0266
8	0	-0.138	0.000	0.000	-0.014	-9.535	0.026	0.0266	0.0266
Э	00+	0.000	0.000	0.000	0.586	0.003	8.418	0.0533	0.0000
10	+0+	0 138	0 000	a aaa	0.585	1 032	9 297	0.0266	0.0266
11	-94	-0 120	0.000	0.000	0.500	-1 976	0 440	0.0200	0.0200
1 7	-0+	-0.133	0.000	0.000	0.000	-1.020	0.440	0.0200	0.0200
14	0++	0.000	0.000	0.000	0.000	3.509	8.422	0.0200	0.0400
13	***	0.138	0.000	0.000	0.599	9.538	8.391	0.0799	0.0266
14	-++	-0.138	0.000	0.000	0.600	7.480	8.453	0.0266	0.0799
15	0-+	0.000	0.000	0.000	0.572	-8.503	8.413	0.0266	0.0266
16	+-+	0.138	0.000	0.000	0.571	-7.474	8.382	0.0266	0.0799
17	+	-0.138	0.000	0.000	0.572	-9.532	8.444	0.0799	0.0266
18	00-	0.000	0.000	0.000	-0.586	-0.003	-8.418	0.0000	0.0533
19	+0-	0.138	0.000	0.000	~0.586	1.026	-8.448	0.0266	0.0266
20	-0-	-0.138	0.000	0.000	-9.585	-1.032	-8.397	0.0266	0 0266
21	0 ÷ -	0.100	0.000	0.000	-0.572	9 502	-9 412	a a266	0.0200
22		0.000	0.000	0.000	-0.572	0.003	-0.413	0.0200	0.0200
22	++-	0.138	0.000	0.000	-0.372	7.032	-0.444	0.0266	0.0799
23	-+-	-0.138	0.000	0.000	-0.571	7.474	-8.382	0.0799	0.0266
24	8	0.000	0.000	0.000	-0.600	-8.509	-8.422	0.0266	0.0266
25	+	0.138	0.000	0.000	-0.600	-7.480	-8.453	0.0799	0.0266
26		-0.138	0.000	0.000	-0.599	-9.538	-8.391	0.0266	0.0799
	CMD			ACCELE	DOTIONS -			0000	а с т памт
	CMD	******	*******	ACCELE	RATIONS +	*******	******	PROF	ELLANT
	CMD	TPANS	L (FT SEC	ACCELE SEC	RATIONS + Rotat	••••••• • DEG/ SE	C/SEC)	PROF WDOT	ELLANT
¢	CMD Serve	TPANS	L (FT SEC Y	ACCELE (SEC) 2	RATIONS + Rotat rol	•••••• • DEG - SE pch	******* C∕SEC) yaw	PROF Widot A	PELLANT ×LB SEC + B
с	CMD Seco	TPAN5	L KFT SEC V	ACCELE SEC) Z	RATIONS ** Rotat rol	•••••• (DEG/SE pch	******* C/SEC) yaw	PROF WDOT A	PELLANT •LB SEC • B
C 1	CMD 566 +00	TPANS :: 0.000	L (FT SEC 7 0.275	ACCELE SEC> Z 0.000	RATIONS ** Rotat ro1 -2.230	(DEG/SE pch -0.004	C/SEC) yaw -0.910	PROF WDOT A 0.0533	ELLANT VLB SECV B 0.0533
C 1 2	CMD 5744 +00 -00	TPANS :: 0.000 0.000	L (FT SEC 7 0.275 −0.275	ACCELE SEC) 2 0.000 0.000	RATIONS ** ROTAT rol -2.280 2.280	····· ·DEG-SE pch -0.004 0.004	-0.910 0.910	PROF WDOT A 0.0533 0.0533	ELLANT - LB SEC - - B - 0.0533 - 0.0533
C 1 2 3	CMD 400 -00 0+0	TPANS :: 0.000 0.000 0.000 0.000	U ≤FT SEC 7 0.275 −0.275 0.000	ACCELE SEC) 2 0.000 0.000 0.000	RATIONS +: ROTAT ro1 -2.280 2.280 9.226	••••••• • DEG-SE pch -0.004 0.004 0.004 0.014	-0.910 0.912 0.915	PROF WDOT A 0.0533 0.0533 0.0533	ELLANT LB SEC - B 0.0533 0.0533 0.0000
0 1 2 3 4	CMD +00 -00 0+0 ++0	TPANS 	U (FT SEC 7 0.275 -0.275 0.000 0.138	ACCELE SEC) 2 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol -2.280 2.280 9.226 8.086	· DEG-SE pch -0.004 0.004 0.014 0.012	-0.910 0.910 0.915 0.460	PROF WDOT A 0.0533 0.0533 0.0533 0.0533	ELLANT • LB SEC • B 0.0533 0.0533 0.0000 0.0266
0 1 2 3 4 5	CMD +00 -00 0+0 ++0 -+0	TPANS 	U +FT SEC 7 -0.275 0.000 0.138 -0.138	ACCELE SEC) 2 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol -2.280 2.280 9.226 8.086 10.365	(DEG-SE pch -0.004 0.004 0.014 0.012 0.015	C-SEC) yaw -0.910 0.910 0.915 0.915 0.460 1.370	PROF WDOT A 0.0533 0.0533 0.0533 0.0266 0.0266	ELLANT ·LB SEC · B 0.0533 0.0533 0.0000 0.0266 0.0266
0 1234 5 6	CMD +00 -00 0+0 ++0 -+0 -+0	TPANS 0.000 0.000 0.000 0.000 0.000 0.000	U + FT SEC 7 -0.275 0.000 0.138 -0.138 0.000	ACCELE SEC) 2 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol 2.280 9.226 8.086 10.365 -9.226	 (DEG/SE pch -0.004 0.004 0.004 0.014 0.012 0.016 -0.014 	-0.910 9.910 0.910 0.915 0.460 1.370	PROF WIDOT H 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266	ELLANT • LB SEC • B 0.0533 0.0000 0.0266 0.0266 0.0233
0 1234567	CMD +00 -00 0+0 ++0 -+0 0-0	TPANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	U + FT SEC ∀ 0.275 -0.275 0.000 0.138 -0.138 0.000 0.129	ACCELE SEC) 2 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol -2.280 9.226 8.086 10.365 -9.226	(DEG/SE pch -0.004 0.004 0.014 0.014 0.012 0.016 -0.014	-0.910 yaw -0.910 0.910 0.915 0.460 1.370 -0.915 -1.270	PROF WDOT H 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0000 0.0266	ELLANT - LB SEC - B 0.0533 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266
0 12345670	CMD +00 -00 0+0 +0 -+0 0-0 +-0 +-0	TPANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	U + FT SEC 7 -0.275 0.000 0.138 -0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.148 0.148 0.1488 0.1488 0.1488 0.1488 0.1488 0.1488	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol -2.280 9.226 8.086 10.365 -9.226 -10.365 -9.65	(DEG) SE pch -0.004 0.004 0.014 0.012 0.016 -0.014 -0.016	-0.910 9.910 0.915 0.460 1.370 -0.915 -1.370	PROF WDOT H 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT ·LB SEC · B 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 123456780	CMD +00 -00 0+0 ++0 -+0 0-0 +-0	TPANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.275 -0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 -0.138	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol -2.280 2.280 9.226 8.086 10.365 -9.226 -10.365 -8.086	 DEG SE pch 0.004 0.004 0.014 0.012 0.016 0.016 0.012 	-0.910 9.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460	PROF WDOT A 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT • LB SEC • B 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 123456789	CMD +00 -00 0+0 ++0 -+0 +-0 +-0 +-0 0	TPANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.275 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol -2.280 2.280 9.226 8.086 10.365 -9.226 -10.365 -8.086 0.000	(DEG) SE pch -0.004 0.004 0.014 0.012 0.014 -0.016 -0.016 -0.012 0.000	-0.910 0.910 0.913 0.460 1.370 -0.915 -1.370 -0.460 0.000	PROF WIDOT H 0.0533 0.0533 0.0255 0.0265 0.0265 0.0265 0.0265 0.0265 0.0266	ELLANT - LB SEC - B 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 1234567890 10	CMD +00 -00 +00 +00 ++0 0 +-0 -00 +-0 +00 +-0 +00 +0	TPANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.275 -0.275 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 0.000 0.138	ACCELE SEC) 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol -2.280 9.226 8.086 10.365 -9.226 -10.365 -8.086 0.000 -0.944	 DEG SE pch 0.004 0.014 0.012 0.016 -0.014 -0.012 0.002 0.002 0.002 0.001 -0.001 0.001 	-0.910 9.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361	PROF WDOT H 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT - LB SEC - B 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 12345673901 101	CMD + 00 0+0 ++0 0-0 ++0 +-0 0-0 +-0 00+ +0+ -0+	TPANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.275 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 -0.138 -0.138	ACCELE SEC) 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol -2.280 9.226 8.086 10.365 -9.226 -10.365 -8.086 0.000 -0.944 1.336	 DEC SE pch 0.004 0.014 0.012 0.016 0.014 0.016 0.016 0.012 0.016 0.012 0.012 0.012 0.000 0.001 0.003 	-0.910 9.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271	PROF WDOT H 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT ·LB SEC · B 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 123456789011 112	CMD + 000 0+00 + +00 + +00 + -00 + -00 + 00 +	TPANS 	0.275 0.275 0.275 0.000 0.138 0.138 0.138 0.138 0.138 0.138 0.138 0.138 0.138 0.138 0.138 0.000	ACCELE SEC) 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol -2.280 3.226 8.086 10.365 -9.226 -10.365 -8.086 0.000 -0.944 1.336 9.422	 DEG SE pch -0.004 0.004 0.014 0.012 0.016 -0.016 -0.012 0.000 -0.001 0.003 0.015 	-0.910 9.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.731	PROF WJOT H 0.0533 0.0533 0.0253 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT LB SEC - B 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 1234567890112 11123	CMD + 80 8+8 - 80 8+8 - 8 8+8 - 8 8+8 - 9 8-9 - 9 8 - 9 8 - 9 8 4 - 9 8 8 4 - 9 8 9 8 4 - 9 8 9 8 4 9 8 9 8 9 9 9 9 9 9 9 9 9 9 9	TPANS 	0.275 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 0.138 0.138 0.000 0.138	ACCELE SEC) 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol -2.230 9.226 8.086 10.365 -9.226 -10.365 -8.086 0.000 -0.944 1.336 9.422 8.086	 DEG SE pch 0.004 0.014 0.012 0.016 0.016 0.016 0.012 0.000 0.001 0.003 0.015 0.012 	-0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271 3.731 0.460	PROF WJOT H 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT - LB SEC - B 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 123456789011234 111234	CMD + 888 8+88 - 848 - 848 - 448 - 4488 - 448 - 448 - 448 - 448 - 448 - 448 - 448 - 448 -	TPANS 	0.275 -0.275 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol -2.280 9.226 8.086 10.365 -9.226 -10.365 -8.086 0.000 -0.944 1.336 9.422 8.086 10.365	 DEG SE pch 0.004 0.014 0.14 0.16 0.012 0.014 0.012 0.012 0.001 0.002 0.001 0.003 0.012 0.016 0.012 0.012 0.016 	-0.910 9.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271 3.731 0.450 1.370	PROF WDOT H 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT LB SEC - B 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 1234567890112345 1012345	CMD +00 0+0 ++00 ++0 0+0 ++0 0++0 +-0 +-0 +	TPANS 0.000	0.275 0.275 0.275 0.000 0.138 0.000 0.138 0.138 0.0000 0.138 0.0000 0.138 0.0000 0.138 0.0000 0.138 0.0000 0.138 0.0000 0.138 0.0000 0.138 0.0000 0.138 0.0000 0.138 0.00000 0.00000 0.00000 0.00000 0.0000000 0.00000000	ACCELE SEC 2 0.000	RATIONS + ROTAT rol -2.280 9.226 8.086 10.365 -9.226 -10.365 -8.086 0.000 -0.944 1.336 9.422 8.086 10.365 -9.030	 DEC SE pch 0.004 0.014 0.012 0.016 0.014 0.016 0.012 0.000 0.001 0.003 0.015 0.016 0.013 	-0.910 9.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.361 3.271 3.731 0.460 1.370 1.901	PROF WDOT H 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT LB SEC. B 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 12345678901123456 11123456	CMD + 000 0+00 0+00 0+00 + 00 + 00 + 00 +	TPANS 	0.275 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138	ACCELE SEC 2 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS +- ROTAT rol -2.280 2.280 9.226 8.086 10.365 -9.226 -10.365 -8.086 0.000 -0.944 1.336 9.422 3.086 10.365 -9.030 -10.365	 DEG SE pch -0.004 0.014 0.012 0.016 -0.016 -0.012 0.000 -0.012 0.003 0.015 0.013 -0.016 -0.013 -0.016 	-0.910 910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.731 0.460 1.370 -0.460 1.370 -0.460 1.370 -0.460 1.370 -0.361 -0.910 -0.915 -1.370 -0.460 -0.915 -0.915 -1.370 -0.460 -0.915 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.900 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.915 -1.370 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.460 -0.370 -0.370 -0.460 -0.370 -0.460 -0.370 -0.370 -0.370 -0.370 -0.460 -0.370 -0.3	PROF WJOT H 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT LB SEC - B 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 123456789011234567 111234567	CMD + 00 0+0 ++00 0++0 0++0 0++0 +-0 +-0 +-0 +	TPANS 	0.275 0.275 0.275 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.	ACCELE SEC) 2 0.0000 0.000 0.000 0.0000 0.0000 0.0000 0.000000	RATIONS +- ROTAT rol -2.280 9.226 8.086 10.365 -9.226 -0.365 -8.086 0.000 -0.944 1.336 9.422 8.086 10.365 -9.030 -0.365 -8.086	 DEG SE pch 0.004 0.014 0.012 0.016 0.016 0.016 0.012 0.000 0.012 0.001 0.003 0.015 0.012 0.016 0.012 0.012 0.012 0.012 0.012 0.013 0.016 0.013 0.016 0.012 0.016 0.012 0.013 0.016 0.012 0.016 0.012 0.016 0.013 0.016 0.012 0.016 	-0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271 3.731 0.460 1.370 -1.370 -1.370 -0.460 0.000 -0.460 -0.361 -0.460 -0.361 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.460 -0.915 -1.370 -0.460 -	PROF WIDT H 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT LB SEC B 0.0533 0.0000 0.0266 0.0
$ \begin{array}{c} 0 \\ 1234567890112345679\\ 1112345679 \end{array} $	CMD + 000 0+00 + +00 0-00 + +00 + -00 + +++ 0++++ 0++ 0+++++ + -00 + -00 + -00 + -00 + -00 + -00 + -00 -00 + 00 + -00 + -00 + 00 + 00 + 	TPANS 	0.275 0.275 0.275 0.000 0.138 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.138 0.000 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.0000 0.0000 0.0000 0.138 0.0000 0.0000 0.138 0.00000 0.138 0.00000 0.00000 0.138 0.000000 0.0000000000000000000000000	ACCELE SEC 2 0.0000 0.0000 0.000000	RATIONS + ROTAT rol -2.280 9.226 8.086 10.365 -9.226 -10.365 -9.036 -0.944 1.336 9.422 8.086 10.365 -9.030 -10.365 -9.030 -0.948 10.365 -9.030 -0.948 -9.030 -0.948 -9.030 -0.365 -0.365 -0	 DEG SE pch 0.004 0.014 0.012 0.016 0.012 0.016 0.012 0.000 0.012 0.001 0.003 0.012 0.016 0.013 0.016 0.012 0.016 0.012 0.016 0.012 0.016 0.012 0.016 0.012 0.022 	-0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 2.361 3.271 3.731 0.460 1.370 1.370 1.370 1.370 1.370 -0.901 -1.370 -0.901 -0.901 -0.901 -0.901 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.900 -0.915 -1.370 -0.9000 -0.90000 -0.90000 -0.90000 -0.90000 -0.90000 -0.90000 -0.90000 -0.900000 -0.90000 -0.9000000000 -0.900000	PROF WDOT H 0.0533 0.0533 0.0266	ELLANT LB SEC - B 0.0533 0.0533 0.0266 0
0 12345673901123456789	C M D + - 00 0 + + 00 0 + + 00 + 00 + - 00 + - 00 + - + + + + + - 00 0 + - + + + + + - 00 0 + 00 + - 0 + - + + + + - 00 0 +	TPANS 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	L FT SEC 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0	ACCELE SEC 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS + ROTAT rol -2.280 2.280 9.226 8.086 10.365 -9.226 -10.365 -8.086 0.000 -0.944 1.336 9.422 8.086 10.365 -9.030 -10.365 -8.086 0.000 -0.365 -9.030 -0.944 -0.365 -9.030 -0.365 -0.026 -0.02	 DEG SE pch -0.004 0.004 0.014 0.012 0.016 -0.014 -0.016 -0.012 0.003 0.015 0.013 -0.016 -0.013 -0.016 -0.016 -0.016 -0.016 -0.017 -0.016 -0.016 -0.013 -0.016 -0.016 -0.016 -0.016 -0.017 -0.016 -0.016 -0.016 -0.016 -0.016 -0.017 -0.016 -0.017 -0.016 <li< td=""><td>-0.910 9.910 0.915 0.460 1.370 -0.915 -0.460 0.000 2.361 3.271 3.731 0.460 1.370 -0.460 1.370 -0.460 1.370 -0.460 0.900 2.361 -0.910 -0.915 -0.915 -0.915 -0.915 -0.915 -0.910 -0.915 -0.460 -0.955 -0.955 -0.460 -0.955 -0.9</td><td>PROF WJOT H 0.0533 0.0533 0.0266</td><td>ELLANT LB SEC B 0.0533 0.0000 0.0266 0.00000 0.00000 0.00000 0.00000 0.000000 0.00000000</td></li<>	-0.910 9.910 0.915 0.460 1.370 -0.915 -0.460 0.000 2.361 3.271 3.731 0.460 1.370 -0.460 1.370 -0.460 1.370 -0.460 0.900 2.361 -0.910 -0.915 -0.915 -0.915 -0.915 -0.915 -0.910 -0.915 -0.460 -0.955 -0.955 -0.460 -0.955 -0.9	PROF WJOT H 0.0533 0.0533 0.0266	ELLANT LB SEC B 0.0533 0.0000 0.0266 0.00000 0.00000 0.00000 0.00000 0.000000 0.00000000
0 123456789011234567890	C M D + 000 + + 000 + + + 00 + + + 00 + - 00 + - 00 + - 00 + + + + + + + + 00 + - 000 + -	TPANS 	0.275 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138	ACCELE SEC 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.000000	RATIONS + ROTAT rol -2.280 3.226 8.086 10.365 -9.226 10.365 -9.226 0.000 -0.944 1.336 9.422 8.086 10.365 -9.030 -0.365 -9.030 -0.365 -8.086 0.000 -1.336	 DEG SE pch -0.004 0.014 0.012 0.016 -0.016 -0.012 0.003 0.015 0.015 0.015 0.016 -0.013 -0.016 -0.013 -0.016 -0.012 0.016 -0.012 0.000 -0.003 	-0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271 3.731 0.460 1.370 -0.460 1.370 -0.460 0.460 0.460 -0.460 0.900 -3.271	PROF WJOT H 0.0533 0.0533 0.0266	ELLANT LB SEC B 0.0533 0.0000 0.0266 0.0
0 123456789011234567890. 111234567890.	CMD + 00 0+0 ++00 0+0 ++00 ++00 +-00 +++++ 0+0+++++ +-0+0 +-0	TPANS 0.0000 0.00000 0.0000 0.0000 0.00000 0.00000 0.00000000	0.275 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.	ACCELE SEC) 2 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS + ROTAT rol -2.230 3.226 S.086 10.365 -9.226 -9.226 -0.365 -9.030 -0.944 1.336 9.422 8.086 10.365 -9.030 -10.365 -9.030 -10.365 -9.036 0.000 -1.336 0.944	 DEG SE pch 0.004 0.004 0.014 0.016 0.016 0.016 0.012 0.000 0.001 0.003 0.012 0.012 0.012 0.013 0.012 0.012 0.012 0.012 0.012 0.012 0.012 0.012 0.012 0.003 0.001 0.003 0.001 	-0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271 3.731 0.460 1.370 -0.460 1.370 -0.460 0.000 2.361 3.271 -1.370 -0.460 0.000 -3.271 -2.361	PROF WIDT H 0.0533 0.0533 0.0266	ELLANT LB SEC. B 0.0533 0.0200 0.0266 0.
$\begin{array}{c} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 0 \\ 1 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 0 \\ 1 \\ 1 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1$	C M D + 00 0+00 ++00 ++00 +-00 +-00 +-00 +-0++ +-++ 0++++ -0 00 00+-	TPANS 	0.275 0.275 0.275 0.000 0.138 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.0000 0.138 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.00000 0.00000 0.000000 0.00000000	ACCELE SEC 9.0000 9.000 9.000 9.00000 9.0000 9.0000 9.0000 9.00000 9.00000 9.00000 9.00000000	RATIONS + ROTAT rol -2.280 9.226 8.086 10.365 -9.226 -10.365 -9.086 0.000 -0.944 1.336 9.422 8.086 10.365 -9.030 -10.365 -8.086 0.000 -1.336 0.944 9.030	(DEG) SE pch -0.004 0.004 0.014 0.012 0.016 -0.014 -0.012 0.000 -0.001 0.003 0.015 0.012 0.000 -0.013 -0.016 -0.013 -0.016 -0.013 -0.016 -0.013 -0.016 -0.012 0.006 -0.013 -0.016 -0.012 0.016 -0.012 0.001 0.016 -0.012 0.001 0.012 0.001 0.012 0.001 0.001 0.012 0.001 0.0001 0.0001 0.0001 0.001 0.001 0.001 0.0001 0.0001 0.001	-0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 2.361 3.271 3.731 0.460 2.361 3.271 3.730 -0.900 -1.370 -0.460 0.000 2.361 -1.370 -0.460 0.000 -1.370 -0.901 -1.370 -1.390 -1.3	PROF WIDT H 0.0533 0.0533 0.0266	ELLANT LB SEC B 0.0533 0.0533 0.0266 0.0
0 12345678901123456789012 11123456789012222	C M D + - 000 + + + 000 + + + 00 + + + 00 + 00 + - 00 + + + + + + + + + + + + + + + 00 + - 00 +	TPANS 	L FT SEC 0.275 0.275 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0	ACCELE SEC 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.0000 0.000000	RATIONS + ROTAT rol -2.280 3.226 8.086 10.365 -9.226 -0.365 -9.026 0.000 -0.944 1.336 9.422 3.086 10.365 -9.030 -0.365 -9.030 -0.365 0.000 -1.336 0.944 9.030 8.086	 DEG SE pch 0.004 0.014 0.012 0.016 0.016 0.016 0.012 0.000 0.003 0.015 0.015 0.015 0.015 0.016 0.013 0.013 0.013 0.013 0.013 0.014 0.013 0.012 	-0.910 910 0.915 0.460 1.370 -0.915 1.370 -0.460 0.000 2.361 3.731 0.460 1.370 1.370 -0.460 0.000 -0.460 0.460 -	PROF WJOT H 0.0533 0.0533 0.0266	ELLANT LB SEC - B 0.0533 0.0000 0.0266 0
$\begin{array}{c} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 0 \\ 1 \\ 1 \\ 1 \\ 2 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1$	C M D + 000 + + 000 + + + 00 + + + 00 + - 00 0 +	TPANS 	0.275 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138	ACCELE SEC 2 0.0000 0.000 0.00000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.0000 0.00000 0.000000	RATIONS + ROTAT rol -2.230 3.226 S.086 10.365 -9.226 -0.365 -9.226 0.000 -0.944 1.336 9.422 3.086 10.365 -9.030 -10.365 -9.036 0.000 -1.336 0.944 9.030 8.086 10.365	 DEG SE pch 0.004 0.014 0.012 0.016 0.016 0.012 0.003 0.015 0.015 0.012 0.016 0.012 0.016 0.012 0.016 0.012 0.013 0.012 0.012 0.013 0.012 0.013 0.012 0.013 0.012 0.013 0.012 0.014 0.012 <l< td=""><td>-0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271 3.731 0.460 1.370 -0.460 0.000 -3.271 -2.361 -1.901 -2.361 -1.370 -0.460 0.000 -3.271 -2.361 -1.370</td><td>PROF WJUT H 0.0533 0.0533 0.0266</td><td>ELLANT LB SEC. B 0.0533 0.0200 0.0266 0.</td></l<>	-0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271 3.731 0.460 1.370 -0.460 0.000 -3.271 -2.361 -1.901 -2.361 -1.370 -0.460 0.000 -3.271 -2.361 -1.370	PROF WJUT H 0.0533 0.0533 0.0266	ELLANT LB SEC. B 0.0533 0.0200 0.0266 0.
0 1234567390123456789012222	C M D + 000 + + + 00 + + + 00 + 00 + 00 + - 00 0 +	TPANS 	0.275 0.275 0.275 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.138 -0.138 0.000 0.138 -0.14	ACCELE SEC 2 0.0000 0.000 0.00000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.0000 0.00000 0.00000 0.00000 0.00000 0.000000	RATIONS + ROTAT rol -2.230 3.226 5.086 10.365 -9.226 -9.226 -9.226 0.086 10.365 -8.086 0.000 -0.944 1.336 9.422 8.086 10.365 -9.030 -1.336 0.944 9.030 8.086 10.365 -9.422	 DEC SE pch 0.004 0.014 0.012 0.016 0.016 0.012 0.016 0.012 0.000 0.012 0.001 0.013 0.012 0.012 0.016 0.012 0.012 0.012 0.012 0.013 0.013 0.013 0.013 0.016 0.013 0.016 0.013 0.016 0.013 0.016 0.015 	-0.910 0.910 0.910 0.915 0.460 1.370 -0.915 -1.370 -0.460 0.000 2.361 3.271 3.731 -1.370 -0.460 1.370 1.901 -1.370 -0.460 0.000 -3.271 -2.361 -1.901 0.460 -3.731	PROF WIDT H 0.0533 0.0533 0.0266	ELLANT LB SEC. B 0.0533 0.0286 0.
0 1234567890123456789012345	C M D + - 00 + + - 00 + + + - 00 + 00 + - 00 	TPANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.000000	L FT SEC 0.275 0.275 0.000 0.138 0.138 0.138 0.138 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.000 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.000 0.138 0.138 0.138 0.000 0.138 0.138 0.000 0.138	ACCELE SEC 2 0.0000 0.00000 0.0000 0.0000 0.0000 0.000000	RATIONS + ROTAT rol -2.280 2.280 9.226 8.086 10.365 -9.226 -0.365 -8.086 0.000 -0.944 1.336 9.422 8.086 10.365 -9.030 -1.336 0.944 9.030 8.086 10.365 -9.422 -1.0.365	 DEG: SE pch -0.004 0.014 0.012 0.016 -0.016 -0.012 0.003 0.015 0.013 0.016 -0.013 0.016 -0.013 0.016 -0.013 0.016 -0.013 0.016 -0.013 0.016 -0.013 0.012 0.003 0.015 0.016 -0.013 0.012 0.013 0.012 0.013 0.012 0.013 0.012 0.013 0.012 0.013 0.012 0.014 0.015 	-0.910 910 0.910 0.915 0.460 1.370 -0.460 0.000 2.361 3.731 0.460 1.370 -0.460 1.370 -0.460 1.370 -0.460 1.370 -0.460 1.370 -0.460 0.000 -1.370 -0.460 0.000 -3.271 -2.361 -1.370 -0.460 0.3731 -1.370 -0.460 -3.271 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370 -1.370	PROF WJOT H 0.0533 0.0533 0.0256 0.0266	ELLANT LB SEC - B 0.0533 0.0000 0.0266 0

*X, Y, and Z refer to translations along the respective axes. p,y, and r stand for pitch, yaw, and roll, respectively.

Table XV (cont.)

Simulation Results--Solo MMU/Primary Control Mode

	CMD	· · · · · · · · ·	******	+ ACCELE	PATIONS +	******	******	PPOP	ELLANT
		TRANSL	FT/SE	C SECV	ROTAT	DEG. SE	CZSECV	ылот	I B SEC
c	Crp	X	· · · · · ·	z	rol	nch	0.86	A	E F
				-		pen	, 		-
t	+00	ด. ดดด	0.000	0.275	0.045	0.446	0 005	0.0533	0 0533
5	-00	0.000	0.000	-0.275	-0 045	-0 145	-0.005	0.0533	0.0500
2	a+0	0.000	0 000	0 000	0.049	0.440	0.000	a aaaa	0.0000
4		0.000	0.000	0.000	5 921	0.000	0.000	0.0000	0.0000
-		0.000	0.000	-0.130	5.751	0.232	0.000	0.0200	0.0200
-		0.000	0.000	-0.138	5.000	-0.214	0.584	0.0266	0.0266
2	0-0	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
	+-0	0.000	0.000	0.138	-7.886	0.214	-0.584	0.0266	0.0266
8	0	0.000	0.000	-0.138	-5,931	-0.232	-0.588	0.0266	0.0266
. 9	00+	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
10	+0+	0.000	0.000	0.138	0.025	2.045	0.003	0.0266	0.0266
11	-0+	0.000	0.000	-0.138	-0.019	1.600	-0.001	0.0266	0.0266
12	9++	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
13	+++	0.000	0.000	0.138	0.025	2.045	0.003	0.0266	0.0266
14	-++	0.000	0.000	-0.138	-0.019	1.600	-0.001	0.0266	0.0266
15	0-+	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
16	+-+	0.000	0.000	0.138	0.025	2.045	0.003	0.0266	0.0266
17	+	0.000	0.000	-0.138	-0.019	1.600	-0.001	0.0266	0.0266
18	00-	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
19	+0-	9.000	0.000	0.138	0.019	-1.600	0.001	0.0266	0.0266
20	-0-	0.000	0.000	-0.138	-0.025	-2.045	-0 003	0.0266	0.0200
21		0.000	0.000	8.888	0 000	0 000	0.000	0.0200	0.0200
22		0 000	0.000	a 170	0.000	-1 500	0.000	0.0000	0.0000
22		0.000	0.000	-9 120	-0.025	-1.000	-0.001	0.0200	0.0200
23	9	0.000	0.000	-9.138	-0.023	-2.045	-0.003	0.0200	0.0205
24	0	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
20	+	0.000	0.000	0.138	0.019	-1.600	0.001	0.0266	0.0266
20		0.000	0.000	-0.138	-0.025	-2.045	-0.003	0.0200	0.0266
	CMD	******	******	ACCELE	RATIONS **	******	******	PROPI	ELLANT
	CMD	******** TRANSL	********	ACCELE	RATIONS ++ Rotat	******** (DEG/SE	****** C/SEC)	PROPI MDOT	ELLANT (LB SEC)
c	(MD	******** TRANSL 3	····FT/SEC	RECELE	RATIONS ++ Rotat rol	(DEG/SE ∞ch	****** C/SEC) vau	PROPI MDOT A	ELLANT (LB SEC+ B
с	CMD rpy	******** TRANSL X	******** • FT/SEC Y	ACCELE SECT Z	RATIONS ++ Rotat rol	€###¥¥## (DEG∕SE pch	****** C/SEC) yaw	PROP 1 1007 1007	ELLANT (LB SEC) B
C 1	(MD rpy +00	******** TRANSL 3	. + FT∕SEC Y 0.000	ACCELE SEC Z a.000	RATIONS ++ ROTAT rol 9,226	(DEG/SE pch 0.014	******* C/SEC) yaw 0.915	PROPI WDOT A 0-0533	ELLANT (LB SEC) B 0.0000
C 1 2	(MD rpy +00 -00	******** TRANSL 2 0.000 0.000	. • FT∠SEC Y 0.000 0.200	ACCELE SEC: Z 0.000 0.000	RATIONS ++ ROTAT ro1 9.226 -9.226	(DEG/SE pch 0.014 -0.014	****** C/SEC) yaw 0.915 -0.915	PROP WDOT A 0.0533 0.0900	ELLANT (LB SEC) B 0.0000 0.0533
C 1 2 3	011) 1111 1111 1111 1111 1111 1111 1111	+++++++ ТRANSL 2.000 0.000 0.000	. • FT∠SEC Y 0.000 0.000 0.000	ACCELE SEC Z 0.000 0.000 0.000	RATIONS +- ROTAT ro1 9.226 -9.226 0 014	(DEG/SE pch 0.014 -0.014 3 506	+++++++ C/SEC) yaw 0.915 -0.915 a aas	PROP WDOT A 0.0533 0.0000 0.0533	ELLANT (LB SEC) B 0.0000 0.0533 0.0000
0 1 2 3	CMD rpv 900+ 96- 940	TRANSL 3.000 0.000 0.000 0.000	0.000 0.000 0.000 0.000	ACCELE SEC 2 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol 9.226 -9.226 0.014 9.249	(DEG/SE pch 0.014 -0.014 8.506	****** C/SEC) yaw 0.915 -0.915 0.005 0.919	PROP MDOT A 0.0533 0.0000 0.0533 0.1045	ELLANT (LB SEC) 8 0.0000 0.0533 0.0000
01234	0m0 van 00+ 0+0 0+0	TRANSL 3 0.000 0.000 0.000 0.000 0.000	0.000 0.000 0.000 0.000 0.000 0.000	ACCELE SEC 2 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol 9.226 -9.226 0.014 9.240 -9.210	0.014 -0.014 3.506 0.520	******* C-SEC) yaw 0.915 -0.915 0.005 0.919	PROP MDOT A 0.0533 0.0000 0.0533 0.1065	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0000 0.0000
0 12345	0m0 90+ 90+ 90+ 90+ 90+ 90+ 90+	TRANSL 2.000 0.000 0.000 0.000 0.000 0.000	0.000 0.000 0.000 0.000 0.000 0.000 0.000	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS ++ ROTAT rol 9.226 -9.226 0.014 9.240 -9.212	(DEG/SE pch 0.014 -0.014 8.506 8.520 8.492 2.50-	C/SEC) yaw 0.915 -0.915 0.005 0.919 -0.910	PROP MDOT P 0.0533 0.0000 0.0533 0.1065 0.0533	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0000 0.0533
0 1234567	0m) 90+ 90+ 90+ 90+ 90+ 90+ 90+ 90- 90-	TRANSL 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	• FT / SEC 9.000 9.000 9.000 9.000 9.000 9.000 9.000	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014	0.014 -0.014 -0.014 8.520 8.520 8.492 -3.506	C/SEC) yaw 0.915 -0.915 0.005 0.919 -0.910 -0.005	PROP MDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000	ELLANT (LB SEC) 0.0000 0.0533 0.0000 0.0000 0.0533 0.0533 0.0533
0 1234567.	CMD 900+ 940 9+0 9+0 9-0 9-0 9-0	TRANSL 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	• FT / SEC 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS ++ ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212	0.014 -0.	C/SEC) yww 0.915 -0.915 0.005 0.919 -0.910 -0.005 0.910	PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533	ELLANT (LB SEC) 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533
0 123456784	000+0 000+0 00+0 00+0 00+0 00-0	TRANSL 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.000 9.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240	(DEG/SE pch 0.014 -0.014 8.506 8.492 -8.506 -8.492 -8.520	C/SEC) yaw 0.915 -0.915 0.005 0.919 -0.910 -0.910 -0.919 -0.919	PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000	ELLANT (LB SEC) 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.1055
0 123456789	00 - 0 00 - 0 00 - 0 0 - 0 0 0 - 0 0 - 0 0 - 0 0	TRANSL 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	 FT / SEC Y 0.000 <l< td=""><td>ACCELE SEC' Z 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000</td><td>RATIONS + ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586</td><td>(DEG/SE pch 0.014 -0.014 8.506 8.520 8.492 -8.520 -8.520 0.003</td><td>C/SEC) yaw 0.915 -0.915 0.905 0.919 -0.910 -0.910 -0.919 8.418</td><td>PROP WDOT A 0.00533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533</td><td>ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0000 0.0533 0.0533 0.1065 0.0000</td></l<>	ACCELE SEC' Z 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586	(DEG/SE pch 0.014 -0.014 8.506 8.520 8.492 -8.520 -8.520 0.003	C/SEC) yaw 0.915 -0.915 0.905 0.919 -0.910 -0.910 -0.919 8.418	PROP WDOT A 0.00533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0000 0.0533 0.0533 0.1065 0.0000
0 1234567890	00 - 0 00 - 0 0+0 0+0 0++ 0-0 00 00	TRANSL 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	• FT < SEC 9.000 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.000000 0.00000000	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS ++ ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008	0.014 -0.014 -0.014 8.506 8.520 8.492 -8.506 -8.492 -8.520 0.003 0.018	C SEC) yaw 0.915 -0.915 0.005 0.919 -0.910 -0.910 -0.919 8.418 12.149	PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799	ELLANT (LB SEC) 0.0000 0.0533 0.0000 0.0000 0.0533 0.0533 0.0533 0.0533 0.0553 0.0000 0.0266
0 1234567890 101	000 4 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	TRANSL 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	• FT / SEC 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444	0.014 -0.014 -0.014 3.520 8.520 8.492 -8.520 -8.492 -8.520 0.003 0.013 -0.010	C SEC) yaw 0.915 -0.915 0.915 0.919 -0.910 -0.910 -0.910 -0.919 8.418 12.149 10.319	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799	ELLANT (LB SEC) 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0553 0.0000 0.0266 0.0266
0 1234567890 1112	000 000 000 000 000 000 000 000 000 00	TRANSL 3.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	• FT / SEC 9.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS ++ ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600	0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -5.520 8.492 -8.520 0.003 0.018 -0.010 8.509	C SEC) y SW 0.915 -0.915 0.005 0.919 -0.910 -0.005 0.910 -0.919 8.418 12.149 10.319 8.422	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799 0.0266	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.1065 0.0000 0.0266 0.0266 0.0266
0 123456789011123	CMD 960 960 940 940 940 940 940 940 940 940 940 94	TRANSL 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	 FT < SEC Y 0.000 	ACCELE SEC 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol 9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022	<pre> (DEG/SE pch 0.014 -0.014 3.506 8.520 8.492 -8.520 0.003 0.013 -0.010 8.524 </pre>	C SEC) yaw 0.915 -0.915 0.005 0.919 -0.910 -0.910 -0.910 -0.919 8.418 12.149 10.319 8.422 12.153	PROP WDOT A 0.0533 0.0000 0.0533 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799 0.0266 0.0533	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.1065 0.0000 0.0266 0.0266 0.02533
0 123456789011234	CMD + 000 0+0 0+0 0+0 0+0 0++0 0++0 0++0 0	TRANSL 3.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	 FT < SEC Y 0.000 	ACCELE SEC' Z 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS + ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430	(DEG/SE pch -0.014 8.506 8.520 8.492 -8.506 -8.492 -8.520 0.003 0.018 -0.010 8.529 8.524 8.496	C SEC) yaw 0.915 -0.915 0.005 0.919 -0.005 0.910 -0.005 0.910 -0.910 8.418 12.149 10.319 8.422 12.153 10.324	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799 0.0799 0.0266 0.0533 0.0533 0.0533	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.02533 0.0533 0.0533
0 1234567890112345	000 000 000 000 000 000 000 000 000 00	TRANSL 3.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	 FT / SEC Y 0.000 	ACCELE SEC: Z 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +4 ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572	(DEG/SE pch 0.014 -0.014 8.520 8.492 -8.506 -8.492 -8.520 0.003 0.018 -0.010 8.524 8.496 -8.503	C SEC) yaw 0.915 -0.915 0.919 -0.910 -0.910 -0.910 -0.910 8.418 12.149 10.319 8.422 12.153 10.324 8.413	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0253 0.0799 0.02533 0.0533 0.0533 0.0533 0.0266	ELLANT (LB SEC) 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0266
0 1234567890123456	C MD 9000000000000000000000000000000000000	TRANSL 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	• FT / SEC 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000	ACCELE SEC: Z 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS +- ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -0.014 9.212 -0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994	0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -0.014 -0.003 0.013 -0.010 9.509 8.524 8.503 -8.488	C SEC) () SW 0.915 -0.915 0.005 0.919 -0.910 -0.005 0.910 -0.919 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799 0.0799 0.0799 0.0799 0.0266 0.0533 0.05533 0.05553 0.05553 0.05553 0.05555 0.05555 0.05555 0.05555 0.055555 0.055555 0.055555 0.055555 0.0555555 0.0555555 0.0555555 0.05555555 0.05555555 0.05555555555	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.1065 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533
0 12345678901234567	CMD + - 0 - + 0 - + 0 - + - + - 0 - 0 - 0 -	TRANSL 3.000 0.000	 FT < SEC Y 0.000 	ACCELE SEC 2 0.000	RATIONS ** ROTAT rol 9.226 9.226 0.014 9.240 -9.212 -9.214 9.212 -9.240 0.586 10.008 -8.444 8.600 10.022 -8.430 0.572 9.994 -8.458	<pre> (DEG/SE pch 0.014 -0.014 3.506 8.520 8.492 -8.520 0.003 0.013 -0.010 8.524 8.496 -8.503 8.524 8.496 -8.503 -8.516 </pre>	C SEC) yaw 0.915 -0.915 0.005 0.919 -0.910 -0.910 -0.910 -0.919 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 10.314	PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0799 0.0799 0.0799 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0263 0.0533 0.0533 0.0533	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.1065 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533
0 123456789012345678	CMD + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 0 0	TRANSL 3.000 0.0000 0.0000 0.0000 0.0000 0.000000	 FT < SEC Y 0.000 	ACCELE SEC' Z 0.000	RATIONS ** ROTAT rol 9.226 9.226 0.014 9.212 -9.212 -9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -0.586	(DEG/SE pch 0.014 3.506 8.520 8.492 -8.506 8.492 -8.500 0.003 0.018 -0.010 8.524 8.496 -8.503 -8.488 8.496 -8.503 -8.516 -0.003	C SEC) yaw 0.915 0.915 0.905 0.919 -0.910 -0.005 0.919 -0.910 -0.005 0.919 8.418 12.149 10.319 12.153 10.324 8.413 12.144 10.314 -8.418	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799 0.0799 0.0799 0.0266 0.0533 0.0000 0.0533 0.0266 0.0533 0.00000 0.0533 0.0266 0.0533 0.00000 0.0533 0.0266 0.0533 0.000000 0.0533 0.0000000000000000000000000000000000	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0256 0.02533 0.0533 0.0533 0.0533 0.0533 0.0533
0 1234567890123456789	0 - + 0 - + 0 - + 0 - + 0 - + 0 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 -	TRANSL 3.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.000000	 FT/SEC Q.000 Q.000	ACCELE SEC 2 0.000	RATIONS + ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -8.444	 (DEG/SE pch 0.014 -0.014 3.506 8.492 -8.506 -8.492 -8.520 0.003 0.018 -0.010 8.524 8.496 -8.503 -8.503 -8.488 -8.503 -8.503 -8.488 -8.503 -8.503 -8.488 -9.003 0.010 	C SEC) yaw 0.915 -0.915 0.919 -0.910 -0.910 -0.910 -0.910 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 10.314 -8.418 -10.319	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.02533 0.0799 0.02533 0.02533 0.0533 0.0266 0.0533 0.0533 0.0533 0.0266 0.0533 0.0266	ELLANT (LB SEC) 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.05533 0.055533 0.055533 0.055533 0.055533 0.055533 0.055533 0.055533 0.055533 0.055555 0.055555 0.055555 0.055555 0.0555555 0.0555555555 0.05555555555
0 12345678901234567890	C MD 4 - 0 - 1 - 0 - 1 - 0 - 1 - 0 - 1 - 0 - 1 - 0 - 1 - 0 - 0	TRANSL 0.000	 FT - SEC Q Q	ACCELE SEC 2 0.0000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS +- ROTAT rol 9.226 0.014 9.212 -0.0586 10.022 -8.430 0.572 9.994 -8.458 -0.586 8.444 -0.586 -0.586 -0.586 -0.022 -0.586 -0.022 -0.0586 -0.022 -0.0586 -0.022 -0.0586 -0.022 -0.0586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.022 -0.586 -0.0586 -0.572 -0.586 -0.5	<pre></pre>	C SEC) y w 0.915 -0.915 0.915 0.919 -0.910 -0.910 -0.910 -0.910 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 10.314 -8.418 -12.149	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799 0.0799 0.0266 0.0533 0.0266 0.0533 0.0000 0.0533 0.0266 0.0266 0.0266	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.10655 0.02666 0.02666 0.02666 0.02666 0.02666 0.02666 0.02666 0.02666 0.02533 0.05333 0.055555 0.055555 0.0555555 0.05555555555
0 1234567890111111111122	C MD + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 +	TRANSL 0.000	 FT / SEC Y 0.000 <l< td=""><td>ACCELE SEC 2 0.0000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000</td><td>RATIONS ** ROTAT rol 9.226 9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -0.586 8.444 -10.008 -0.522</td><td> (DEG/SE pch 0.014 -0.014 3.506 8.520 8.520 8.520 8.520 0.014 8.520 8.520 9.003 0.010 8.524 8.496 -8.503 0.010 8.524 8.496 -8.503 0.010 8.516 -0.003 0.010 -0.103 0.010 -0.103 0.010 -0.103 0.010 -0.103 -0.010 <</td><td>C SEC) yaw 0.915 0.915 0.919 -0.910 -0.910 -0.910 -0.910 -0.919 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 10.314 -8.418 -10.319 -2.149 -2.144 -3.145 -3.145</td><td>PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0200 0.0533 0.0799 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0266 0.02533 0.0000 0.0533 0.0266 0.0266</td><td>ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.10655 0.02666 0.0533 0.05533 0.05553 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.0555555 0.0555555 0.0555555 0.055555555 0.05555555555</td></l<>	ACCELE SEC 2 0.0000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS ** ROTAT rol 9.226 9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -0.586 8.444 -10.008 -0.522	 (DEG/SE pch 0.014 -0.014 3.506 8.520 8.520 8.520 8.520 0.014 8.520 8.520 9.003 0.010 8.524 8.496 -8.503 0.010 8.524 8.496 -8.503 0.010 8.516 -0.003 0.010 -0.103 0.010 -0.103 0.010 -0.103 0.010 -0.103 -0.010 <	C SEC) yaw 0.915 0.915 0.919 -0.910 -0.910 -0.910 -0.910 -0.919 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 10.314 -8.418 -10.319 -2.149 -2.144 -3.145 -3.145	PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0200 0.0533 0.0799 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0266 0.02533 0.0000 0.0533 0.0266 0.0266	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.10655 0.02666 0.0533 0.05533 0.05553 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.055555 0.0555555 0.0555555 0.0555555 0.055555555 0.05555555555
0 1234567890123456789012	C M D + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + + + 0 + - 0 + + + +	TRANSL 3.000 0.0000 0.000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	 FT / SEC Y 0.000 <l< td=""><td>ACCELE SEC' 2 . 300 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000</td><td>RATIONS + ROTAT rol 9.226 9.226 0.014 9.240 -9.212 -0.014 9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -0.586 8.444 -10.008 -0.572 8.458</td><td>(DEG/SE pch 0.014 3.506 8.520 8.492 -3.506 8.492 -3.506 9.003 0.018 -0.010 8.524 8.496 -8.509 8.524 8.496 -8.503 -8.509 8.524 8.496 -8.503 -8.509 8.524 8.496 -8.509 8.524 8.506 8.509 8.524 8.496 -8.509 8.525 8.509 8.524 8.509 8.525 8.509 8.525 8.509 8.525 8.509 8.526 8.520 8.525 8.520 8.525 8.520 8.525 8.520 8.525 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.55555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.55555 8.55555 8.5555 8.5555 8.5555 8.5555 8.55555 8.55555 8.5555 8.5555 8.5555 8.5555 8.55555 8.55555 8.55555 8.5555 8.5555 8.5555 8.55555 8.55555 8.55555 8.55555 8.555555 8.55555 8.55555 8.55555555</td><td>C SEC) yaw 0.915 -0.915 0.005 0.919 -0.910 -0.005 0.910 -0.005 0.919 8.418 12.149 10.319 -2.153 10.324 8.413 12.144 10.314 -8.418 -10.314 -12.149 -3.14 -3</td><td>PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0263 0.0266</td><td>ELLANT (LB SEC - B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0256 0.02533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0799 0.0799 0.0266 0.0799 0.0266 0.0799 0.0799 0.0533</td></l<>	ACCELE SEC' 2 . 300 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS + ROTAT rol 9.226 9.226 0.014 9.240 -9.212 -0.014 9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -0.586 8.444 -10.008 -0.572 8.458	(DEG/SE pch 0.014 3.506 8.520 8.492 -3.506 8.492 -3.506 9.003 0.018 -0.010 8.524 8.496 -8.509 8.524 8.496 -8.503 -8.509 8.524 8.496 -8.503 -8.509 8.524 8.496 -8.509 8.524 8.506 8.509 8.524 8.496 -8.509 8.525 8.509 8.524 8.509 8.525 8.509 8.525 8.509 8.525 8.509 8.526 8.520 8.525 8.520 8.525 8.520 8.525 8.520 8.525 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.55555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.5555 8.55555 8.55555 8.5555 8.5555 8.5555 8.5555 8.55555 8.55555 8.5555 8.5555 8.5555 8.5555 8.55555 8.55555 8.55555 8.5555 8.5555 8.5555 8.55555 8.55555 8.55555 8.55555 8.555555 8.55555 8.55555 8.55555555	C SEC) yaw 0.915 -0.915 0.005 0.919 -0.910 -0.005 0.910 -0.005 0.919 8.418 12.149 10.319 -2.153 10.324 8.413 12.144 10.314 -8.418 -10.314 -12.149 -3.14 -3	PROP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0263 0.0266	ELLANT (LB SEC - B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0256 0.02533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0799 0.0799 0.0266 0.0799 0.0266 0.0799 0.0799 0.0533
0 12345678901234567890123	MD + 000000000000000000000000000000000000	TRANSL 3.000 0.0000 0.0000 0.0000 0.0000 0.000000	 FT / SEC Y 0.000 <l< td=""><td>ACCELE SEC 2 0.0000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000</td><td>RATIONS + ROTAT rol 9.226 9.226 0.014 9.212 -9.212 -9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 8.444 -10.008 -0.572 8.458 -0.572 -9.240 -9.240 -9.240 -8.458 -0.572 -9.245 -9.458 -0.572 -9.458 -0.572 -9.458 -0.572</td><td> (DEG/SE pch 0.014 -0.014 3.506 8.520 8.492 -8.506 -8.492 -8.520 0.003 0.018 -8.524 8.496 -8.503 -8.5488 -8.516 -0.003 0.018 -8.503 -8.516 -0.018 8.503 8.488 </td><td>C SEC) yaw 0.915 -0.915 0.919 -0.910 -0.910 -0.910 -0.910 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 -8.418 -10.319 -2.9413 -3.919 -3.919 -0.910 -0.314 -8.413 12.144 -8.418 -12.144 -8.418 -12.149 -12.149 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144</td><td>PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.02533 0.0266 0.0266 0.02533 0.0266 0.0266 0.0266 0.0266 0.02533 0.0266 0.0266 0.0266 0.02533 0.02533 0.0266 0.02533 0.0266 0.02533 0.0266 0.02533 0.0266 0.02533 0.02533 0.0266 0.02533 0.02533 0.02533 0.0266 0.02533 0.</td><td>ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.02533 0.0533 0.0533 0.0533 0.0799 0.0799 0.0799 0.02533 0.0533</td></l<>	ACCELE SEC 2 0.0000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS + ROTAT rol 9.226 9.226 0.014 9.212 -9.212 -9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 8.444 -10.008 -0.572 8.458 -0.572 -9.240 -9.240 -9.240 -8.458 -0.572 -9.245 -9.458 -0.572 -9.458 -0.572 -9.458 -0.572	 (DEG/SE pch 0.014 -0.014 3.506 8.520 8.492 -8.506 -8.492 -8.520 0.003 0.018 -8.524 8.496 -8.503 -8.5488 -8.516 -0.003 0.018 -8.503 -8.516 -0.018 8.503 8.488 	C SEC) yaw 0.915 -0.915 0.919 -0.910 -0.910 -0.910 -0.910 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 -8.418 -10.319 -2.9413 -3.919 -3.919 -0.910 -0.314 -8.413 12.144 -8.418 -12.144 -8.418 -12.149 -12.149 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144 -12.144	PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.02533 0.0266 0.0266 0.02533 0.0266 0.0266 0.0266 0.0266 0.02533 0.0266 0.0266 0.0266 0.02533 0.02533 0.0266 0.02533 0.0266 0.02533 0.0266 0.02533 0.0266 0.02533 0.02533 0.0266 0.02533 0.02533 0.02533 0.0266 0.02533 0.	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.02533 0.0533 0.0533 0.0533 0.0799 0.0799 0.0799 0.02533 0.0533
0 123456789012345678901234	C MD V 0000000000000000000000000000000000	TRANSL 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	 FT - SEC Q Q	ACCELE SEC 2 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS + ROTAT rol 9.226 -9.226 0.014 9.240 -9.212 -0.014 9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -8.444 -10.008 -0.572 8.458 -9.994 -0.572	· · · · · · · · (DEG / SE pch 0.014 -0.014 8.506 8.492 -8.506 -8.492 0.013 -0.010 8.524 8.524 8.524 -8.503 -8.488 -8.503 0.010 8.526 -8.488 -8.503 0.010 8.516 -0.018 8.516 -0.018 8.516 -0.018 -	C SEC) y w 0.915 -0.915 0.915 0.915 0.919 -0.910 -0.910 -0.910 -0.910 12.149 10.319 8.413 12.144 10.314 -12.149 -9.413 -10.314 -12.149 -9.413 -10.314 -12.149 -9.413 -10.314 -12.149 -9.413 -10.314 -12.149 -9.413 -10.314 -12.149 -9.413 -10.314 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149 -9.413 -12.149	PROP WDOT A 0.0533 0.0000 0.0533 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0266 0.0533 0.0266	ELLANT (LB SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.1065 0.0266 0.0266 0.0266 0.0266 0.02533 0.05533 0.05533 0.0266 0.0533 0.05555 0.055555 0.05555555555555555
0 1234567890123456789012345	C M D Y 000000000000000000000000000000000	TRANSL 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	 FT - SEC Y 0.000 <l< td=""><td>ACCELE SEC 2 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000</td><td>RATIONS ** ROTAT rol 9.226 9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -0.586 8.444 -10.008 -0.572 8.458 -0.572 8.458 -0.600 -9.212 -9.240 -9.212 -9.240 -8.430 0.572 -8.458 -0.572 -9.994 -0.600 -9.20 -0.600 -9.212 -9.240 -9.212 -9.240 -9.212 -9.240 -8.458 -0.572 -9.994 -0.600 -9.225 -9.994 -0.600 -9.225 -9.994 -0.600 -9.225 -9.240 -9.240 -9.212 -9.240 -9.240 -9.240 -9.212 -9.240 -8.444 -0.600 -8.458 -0.572 -9.994 -0.600 -9.225 -9.994 -0.600 -9.225 -9.240 -9.240 -9.240 -9.240 -9.240 -9.240 -9.240 -8.458 -0.572 -9.994 -0.572 -9.994 -9.2458 -9.994 -0.572 -9.994 -9.2458 -9.994 -9.458 -9.994 -9.2458 -9.994 -9.2458 -9.994 -9.2458 -9.994 -9.2458 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.99488 -9.99488 -9.9948 -</td><td><pre> (DEG/SE pch 0.014 -0.014 3.506 8.520 8.492 -8.520 0.003 0.010 8.524 8.496 -8.503 8.516 -0.018 8.503 8.516 -0.018 8.503 8.516 9.516 8.503 9.516 9.516 9.524 </pre></td><td>C SEC) yaw 0.915 0.915 0.925 0.919 -0.910 -0.910 -0.910 -0.919 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 10.314 -8.418 -10.314 -8.418 -10.314 -8.413 -9.9414 -9.9414 -9.9414 -9.9414</td><td>PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0200 0.0533 0.0799 0.0533 0.0266 0.0266</td><td>ELLANT 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0533 0.10655 0.02666 0.0533 0.05533 0.05555 0.055555 0.055555 0.055555 0.0555555 0.05555555 0.05555555 0.05555555555</td></l<>	ACCELE SEC 2 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS ** ROTAT rol 9.226 9.226 0.014 9.240 -9.212 -0.014 9.212 -9.240 0.586 10.008 -8.444 0.600 10.022 -8.430 0.572 9.994 -8.458 -0.586 8.444 -10.008 -0.572 8.458 -0.572 8.458 -0.600 -9.212 -9.240 -9.212 -9.240 -8.430 0.572 -8.458 -0.572 -9.994 -0.600 -9.20 -0.600 -9.212 -9.240 -9.212 -9.240 -9.212 -9.240 -8.458 -0.572 -9.994 -0.600 -9.225 -9.994 -0.600 -9.225 -9.994 -0.600 -9.225 -9.240 -9.240 -9.212 -9.240 -9.240 -9.240 -9.212 -9.240 -8.444 -0.600 -8.458 -0.572 -9.994 -0.600 -9.225 -9.994 -0.600 -9.225 -9.240 -9.240 -9.240 -9.240 -9.240 -9.240 -9.240 -8.458 -0.572 -9.994 -0.572 -9.994 -9.2458 -9.994 -0.572 -9.994 -9.2458 -9.994 -9.458 -9.994 -9.2458 -9.994 -9.2458 -9.994 -9.2458 -9.994 -9.2458 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.2578 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.994 -9.5788 -9.99488 -9.99488 -9.9948 -	<pre> (DEG/SE pch 0.014 -0.014 3.506 8.520 8.492 -8.520 0.003 0.010 8.524 8.496 -8.503 8.516 -0.018 8.503 8.516 -0.018 8.503 8.516 9.516 8.503 9.516 9.516 9.524 </pre>	C SEC) yaw 0.915 0.915 0.925 0.919 -0.910 -0.910 -0.910 -0.919 8.418 12.149 10.319 8.422 12.153 10.324 8.413 12.144 10.314 -8.418 -10.314 -8.418 -10.314 -8.413 -9.9414 -9.9414 -9.9414 -9.9414	PROP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0200 0.0533 0.0799 0.0533 0.0266 0.0266	ELLANT 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0533 0.10655 0.02666 0.0533 0.05533 0.05555 0.055555 0.055555 0.055555 0.0555555 0.05555555 0.05555555 0.05555555555

Table XV (cont.)

Simulation Results--Solo MMU/Primary Control Mode

Translationa	l Acceleration	
Commanded Translation	Resulting Actual Accelerations (ft/sec ²)	Specific Propellant Consumption Rate (lbs/ft/sec)
+ X	.246	.390
+ Y	.240	.400
+ Z	.270	.397
Rotational Ac	cceleration	
Commanded Rotation	Resulting Actual Acceleration (deg/sec ²)	Specific Propellant Consumption Rate (lbs/deg/sec)
+X (roll)	9.079	.009
+Y (pitch)	8.506	.007
	8 270	.010

Table XVI

Simulation Results--IRV/Primary Control Mode

PART 1--RESPONSE MATRIX

	€MD [●]	******	******	+ ACCELER	PATIONS +		******	PROPI	ELLANT
		TRANS	L FT SE	C 38C	POTAT	- DEG SE	C SEC /	NDOT	LB BECH
¢	Kp⊙.	.:	7	2	rol	pch	い書所	A	E
t	+88	0.210	0 000	A 000	-0.001	0 333	-0 002	0 0522	0 0522
2	-00	-0.191	0.000	0.000	-0.001	-0.343	0.007	0.0000	0.0000
2	0+0	0 005	-0.000	0.000	-0.020	0.040	-0.000	0.0500	0.0000
د د	++0	0.000	0.000 0.000	0.004 0.004	0.020 0 009	2.072	-0.120	0.0000	0.0000
Ē	-+0	-0.105	0.000	0.000	0.007	4 713	-0.003	0.0200	0.0200
2	0.0	-0.074	0.000	0.000	0.009	2.010	0.004	0.0200	0.0266
2	6-0	0.004	-0.002	-0.004	-0.035	-2.048	-0.108	0.0000	0.0533
	+-0	0.105	0.000	0.000	-0.010	-2.040	-0.005	0.0266	0.0266
् ्र	0	-0.075	0.000	-0.007	-0.010	-2.000	0.003	0.0200	0.0200
	00+	0.005	-0.003	0.004	0.404	-0.164	1.473	0.0533	0.0000
10	+0+	0.105	0.000	9.000	0.433	0.167	1.596	0.0266	0.0255
11	-0+	-0.095	-0.005	0.000	0.378	-0.171	1.369	0.0266	0.0266
14	9++	0.005	-0.003	0.004	0.413	2.043	1.473	0.0266	0.0266
13	+++	0.110	-0.003	0.004	0.413	2.209	1.470	0.0799	0.0266
14	-++	-0.090	-0.002	0.004	0.416	1.871	1.496	0.0266	0.0799
15	0-+	0.004	-0.002	-0.004	0.398	-2.047	1.491	0.0266	0.0266
16	+-+	0.110	-0.002	-0.004	0.397	-1.881	1.487	0.0266	0.0799
17	+	-0.091	-0.003	-0.003	0.394	-2.219	1.475	0.0799	0.0266
18	00-	0.005	0.003	0.004	-0.404	-0.165	-1.473	0.0000	0.0533
19	+0-	0.105	0.000	0.000	-0.433	0.166	-1.604	0.0266	0.0266
2.Q	-9-	-0.095	0.005	0.000	-0.379	-0.172	-1.362	0.0266	0.0266
21	5-	0.005	0.003	0.004	-0.395	2.042	-1.472	0.0266	0.0266
22	++-	0.110	0.003	0.004	-0.395	2.208	-1.476	0.0266	0.0799
23	-+-	-0.090	0.002	0.004	-0.399	1.870	-1.488	0.0799	0.0266
24	0	0.004	0.002	-0.004	-0.418	-2.048	-1.493	0.0266	0.0266
25	+	0.110	0.002	-0.004	-0.418	-1.882	-1.497	0.0799	0.0266
26		-0.091	0.003	-0.003	-0.415	-2.220	-1.470	0.0266	0.0799
				0005151	DOTIONO .				
	CMD	******	*******	+ ACCELER	RATIONS +	*******	******	PROPI VDOT	ELLANT
	CMD	TPANS	L FT 5E	+ ACCELER	PATIONS + Potat	DEG SE	******* C/SEC)	PROPI NDOT	ELLANT
C	CMD Vew	TPANS	L FT 5E	+ ACCELEN C/SEC+ Z	RATIONS + ROTAT rol	DEG SE pch	******* С/SEC) Уви	PROPI Ndot A	ELLANT (LB BEC) B
C 1	CMD 7r44 +00	TPANS X 0.000	0.210	+ ACCELER C/ SEC (Z 0.000	ATIONS + ROTAT rol -2.052	DEG SE pch -0.002	C/SEC) (/aw -3.125	PROPI NDOT A 0.0533	ELLANT (LB 3EC) B 0.0523
C 1 2	CMD 7844 +00 -00	TFANS 2 0.000 0.000	0.210 -0.210	+ ACCELER C- SEC (Z 0.000 0.000	ATIONS + ROTAT rol -2.052 2.052	DEG SE pch -0.002 0.002	-3.125 3.125	PROPI NDOT A 0.0533 0.0533	ELLANT LB 3EC - B 0.0523 0.0533
C 1 2 3	CMD 7844 +00 -00 0+0	TFANS 2 0.000 0.000 0.000	0.210 -0.210 0.000	+ ACCELER C- SEC + Z 0.000 0.000 0.000	ATIONS + ROTAT rol -2.052 2.052 8.182	·DEG SE pch -0.002 0.002 0.009	-3.125 0.676	PROPI NDOT A 0.0533 0.0533 0.0533	ELLANT LB 3EC - B 0.0523 0.0533 0.0000
0 1 2 3 4	CMD 7844 +00 -00 0+0 +40	TFANS 2.000 0.000 0.000 0.000 0.000	0.210 -0.210 -0.210 0.000 0.105	+ ACCELER C, SEC (2 0.000 0.000 0.000 0.000 0.000	RATIONS ◆ ROTAT rol -2.052 2.052 8.182 7.156	DEG SE pch -0.002 0.002 0.009 0.009	-3.125 3.125 0.676 -0.886	PROPI WDOT A 0.0533 0.0533 0.0533 0.0533	ELLANT LB 3EC - B 0.0523 0.0533 0.0000 0.0266
0 12345	CMD 77~~ +00 -00 0+0 ++0 -+0	TPANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000	0.210 -0.210 -0.210 0.000 0.105 -0.105	+ ACCELER C- SEC - Z 0.000 0.000 0.000 0.000 0.000 0.000	RATIONS ◆ ROTAT rol -2.052 2.052 8.182 7.156 9.208	 DEG SE pch -0.002 0.002 0.009 0.008 0.011 	-3.125 3.125 0.676 -0.886 2.239	PROPI NDOT A 0.0533 0.0533 0.0533 0.0266 0.0266	ELLANT ELB SEC - B 0.0523 0.0533 0.0000 0.0266 0.0266
0 120400	CMD 7r +00 -00 0+0 ++0 -+0 0-0	TFANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000	0.210 -0.210 0.000 0.000 0.105 -0.105 0.000	 ACCELER SEC - Z 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 	PATIONS ◆ ROTAT rol -2.052 2.052 8.182 7.156 9.208 -8.182	 DEG SE pch -0.002 0.002 0.003 0.003 0.008 0.011 -0.009 	-3.125 3.125 3.125 0.676 -0.886 2.239 -0.676	PROPI NDOT A 0.0533 0.0533 0.0533 0.0553 0.0266 0.0266 0.0000	ELLANT LB SEC - B 0.0533 0.0503 0.0266 0.0266 0.0533
0 1234567	CMD 7r +00 -00 0+0 ++0 -+0 0-0 +-0	TFANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	L FT SE 7 0.210 -0.210 0.000 0.105 -0.105 0.000 0.105	 ACCELEF SEC Z 0.000 	PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -8.182 -9.208	 DEG SE pch -0.002 0.002 0.009 0.009 0.011 -0.009 -0.001 	-3.125 9.87 0.876 -0.886 2.239 -0.676 -2.239	PROP(WDOT A 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0000 0.0266	ELLANT ELB SEC - B 0.0523 0.0533 0.0000 0.0266 0.0266 0.0533 0.0266
0 1004000.0	CMD +00 -00 0+0 ++0 -+0 0-0 +-0 0	TFANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.210 -0.210 0.000 0.105 -0.105 0.005 0.105 0.105 -0.105	+ ACCELER 2 SEC 1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	PATIONS ← POTAT rol -2.052 2.052 8.182 7.156 9.208 -9.208 r7.156	· DEG SE pch -0.002 0.002 0.009 0.009 0.009 0.011 -0.008 -0.011 -0.008	-3.125 9.676 -0.886 2.239 -0.676 -2.239 0.886	PROPI WDOT A 0.0533 0.0533 0.0533 0.0255 0.0265 0.0265 0.0265 0.0265	ELLANT 0.0533 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266
0 1204007.00	CMD 7844 +000 -000 +00 -+00 00 00 00 0	TFANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.210 -0.210 0.000 0.105 -0.105 0.000 0.105 -0.105 -0.105 0.000	+ ACCELER 2 SEC 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -9.208 -9.208 r7.156 0.000</pre>	 DEG SE pch -0.002 0.002 0.003 0.003 0.003 0.011 -0.003 -0.003 0.008 0.008 0.008 0.008 0.008 	-3.125 3.125 3.125 0.676 -0.886 2.239 -0.676 -2.239 0.886 0.000	PROPI WDOT A 0.0533 0.0533 0.0255 0.0265 0.0265 0.0265 0.0265 0.0265 0.0265	ELLANT 0.0523 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 1234567.000	CMD +80 -00 8+0 ++0 8-0 +-0 0-0 +-0 00+ +0+	TFANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.210 -0.210 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105	+ ACCELER 2 SEC - 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -8.182 -9.208 r7.156 0.000 -0.881</pre>	· DEG SE pch -0.002 0.009 0.009 0.009 0.011 -0.009 -0.011 -0.009 -0.001	-3.125 3.125 0.676 -0.886 2.239 -0.676 -2.239 0.886 -2.239 0.886 -2.239 0.800 -1.027	PROPI WDOT A 0.0533 0.0533 0.0533 0.0255 0.0255 0.0265 0.0265 0.0265 0.0265 0.0265	ELLANT 0.0523 0.0523 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 123456789011	CMD +00 -00 0+0 ++0 0-0 +-0 0-0 +-0 00+ +0 -0+	TFANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.210 -0.210 0.000 0.105 -0.105 0.000 0.105 -0.105 0.005 -0.105 0.105	+ ACCELES C SEC 1 Z 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	PATIONS ← POTAT rol -2.052 2.052 8.182 7.156 9.208 -8.182 -9.208 r7.156 0.000 -0.881 1.171	 DEG SE pch 0.002 0.009 0.008 0.011 0.008 0.011 0.008 0.008 0.008 0.008 0.008 0.001 0.009 0.001 0.001 	<pre>C SEC)</pre>	PROPI WDOT A 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT ALB SEC - B 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 1234567890112	CMD +00 -00 ++0 -+0 0 +-0 +-0 +-0 +-0 +-0	TFANS 2,000 0,000 0,000 0,000 0,000 0,000 0,000 0,000 0,000 0,000 0,000 0,000 0,000	0.210 0.210 0.210 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000	+ ACCELES C SEC 1 2 0.0000 0.000000 0.00000000	PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -9.208 r7.156 0.000 -0.881 1.171 8.327	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 0.008 0.011 -0.008 0.000 -0.001 0.000 -0.001 0.001 0.010		PROPI WDOT A 0.0533 0.0533 0.0256 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT 0.0522 0.0522 0.0523 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 12345678901123	CMD +888 -888 ++88 -+88 -+88 88 88 +88 +	TFANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.210 -0.210 0.000 0.105 -0.105 0.105 -0.105 -0.105 -0.105 0.105 -0.105 0.105 0.105 0.105 0.105	+ ACCELER C SEC 2 0.0000 0.00000 0.00000 0.00000 0.00000000	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -7.156 0.000 -0.881 1.171 8.327 7.156</pre>	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 -0.001 -0.008 0.000 -0.001 0.001 0.001 0.001 0.008	-3.125 3.125 3.125 0.676 -0.886 2.239 -0.676 -2.239 0.886 0.000 -1.027 2.098 2.212 -0.886	PROPH WDOT A 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT 0.0522 0.0522 0.0523 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 123456789011234 111234	CMD +88 -88 -+88 -+8 -+8 8 8 8 8 	TFANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.210 -0.210 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 0.105 0.000 0.105 0.000 0.105	+ ACCELER C SEC 2 0.0000 0.0000000 0.00000 0.000	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -9.208 -9.208 -7.156 0.000 -0.881 1.171 8.327 7.156 9.208</pre>	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 -0.009 -0.009 0.009 0.000 0.000 0.001 0.008 0.008 0.008	-3.125 3.125 3.125 0.676 -0.886 2.239 -0.676 -2.239 0.886 0.000 -1.027 2.098 1.212 -0.886 0.223	PROPH WDOT A 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT 0.0523 0.0533 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 1234567890112345 1112345	CMD +888 -888 -488 -488 -488 -488 -488 -488	TFANS 2,000 0,	0.210 0.210 0.210 0.000 0.105 0.000 0.105 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.0000 0.00000 0.00000 0.00000 0.00000 0.000000 0.00000000	+ ACCELES C SEC C 2 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -9.208 r7.156 0.000 -0.881 1.171 8.327 7.156 9.208 9.208 -8.037	 DEG SE pch 0.002 0.009 0.008 0.011 0.008 0.001 	<pre>C SEC)</pre>	PROPI WDOT A 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT ALB SEC - B 0.0523 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 12345678901123456 111111156	CMD +80 -90 -90 +80 +90 +90 +-0 -90 +-0 -90 +-0 +0+ +8+ -0+ ++0+ -++ -++	TFANS 2,000 0,000	0.210 0.210 0.210 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.0000 0.105 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000000	+ ACCELES C SEC - Z 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.0000 0.0000 0.00000 0.00000	PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -9.208 r7.156 0.000 -0.881 1.171 8.327 7.156 9.208 -8.037 -9.208	 DEG SE pch 0.002 0.003 0.009 0.009 0.009 0.009 0.009 0.001 0.000 0.001 0.001 0.001 0.003 0.003 0.009 0.010 	-3.125 3.125 0.676 -0.886 2.239 -0.6239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 -0.141 -2.239	PROPI WDOT A 0.0533 0.0533 0.0256 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT B B SEC - B 0.0523 0.0000 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266
0 123456789011234567 1111111111111111	CMD +80 -80 -80 +80 +80 -90 +90 +90 +90 +90 +90 +10 +10 +10 +10 +10 +10 +10 +10 +10 +1	TFANS 2,000 0,000	0.210 0.210 0.210 0.000 0.105 0.	+ ACCELES C SEC - Z 0.0000 0.00000 0.00000 0.0000 0.00000 0.00000 0.00000 0.00000000	PATIONS ← POTAT rol -2.052 2.052 8.182 7.156 9.208 -7.156 0.000 -0.881 1.171 8.327 7.156 9.208 -8.037 -9.208 -8.037 -9.208 -7.156	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 0.009 0.011 -0.008 0.001 0.008 0.010 0.008 0.011 -0.009 -0.011 -0.009 -0.011 -0.009	-3.125 3.125 0.676 -0.886 2.239 -0.6239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 -0.141 -2.239 -0.141 -2.239 0.886	PROPI WDOT A 0.0533 0.05533 0.0256 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT 0.0522 0.0522 0.0523 0.0000 0.0266
0 1234567800112345678	CMD +888 -888 +888 -888 -888 -888 -888 -88	TFANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000	0.210 -0.210 0.000 0.105 -0.105 -0.105 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 -0.105 -0.105 0.000 0.105 -0.000 -0.105 -0.105 -0.000 -0.105 -0.000 -0.105 -0.000 -0.105 -0.000 -0.105 -0.000 -0.105 -0.000 -0.105 -0.000 -0.105 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000 -0.0000	+ ACCELES 2 SEC - 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000	PATIONS ◆ POTAT rol -2.052 2.052 3.182 7.156 9.208 -7.156 0.000 -0.881 1.171 8.327 7.156 9.208 -8.037 -9.208 -9.208 -8.037 -9.208 -8.037 -9.208 -8.037 -9.208 -8.037 -9.208 -8.037 -9.208 -8.037 -9.208 -9.208 -8.037 -9.208 -9.208 -8.037 -9.208 -9.208 -9.208 -9.208 -9.208 -8.037 -9.208 -9.208 -9.208 -9.208 -8.037 -9.208 -9.208 -9.208 -9.208 -8.037 -9.208 -9.208 -9.208 -9.208 -9.208 -9.208 -9.208 -8.037 -9.208 -9.2	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 -0.001 -0.008 0.000 0.001 0.009 0.011 -0.009 -0.011 -0.009 -0.011 -0.009 -0.011 -0.009	-3.125 3.125 3.125 0.676 -0.886 2.239 -0.676 -2.239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 -0.141 -2.239 0.886 2.239 -0.141	PROPH WDOT A 0.0533 0.0533 0.0266	ELLANT 0.0533 0.0533 0.0000 0.0266 0.00000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.00000 0.000000 0.00000000
0 1234567890123456789	CMD +80 -00 ++0 -+0 -+0 0 +-0 +-0 +0+ +0+ +0	TFANS 2.000 0.0000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	0.210 -0.210 0.000 0.105 -0.105 0.105 -0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105	+ ACCELER C SEC 0.0000 0.0000 0.000 0.00000 0.00000 0.00000 0.000000 0.00000 0.00000000	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -8.182 -9.208 -7.156 0.000 -0.881 1.171 8.327 7.156 9.208 -8.007 -9.208 -7.156 0.000 -1.121</pre>	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 -0.011 -0.008 0.001 0.008 0.001 0.009 -0.011 -0.009 -0.011 -0.009 -0.001	-3.125 3.125 3.125 0.676 -0.886 2.239 -0.676 -2.239 0.886 0.000 -1.027 2.098 1.212 -0.886 0.200 -1.027 2.098 1.212 -0.886 0.239 -0.141 -2.239 0.886 0.800 -2.998	PROPH WDOT A 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT ALB SEC B 0.0533 0.0000 0.0266 0.
0 123456789011234567890	CMD +00 0+0 +00 0-0 0-0 +-0 0 0 +-0 +-0	TFANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0	0.210 0.210 0.210 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 -0.105 0.000 0.105 -	+ ACCELES C SEC - Z 0.000	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -9.208 -7.156 0.000 -0.881 1.171 8.327 7.156 9.208 -8.037 -9.208 -7.156 9.208 -7.156 0.000 -1.171 a</pre>	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 -0.011 -0.008 0.000 0.000 0.000 0.000 0.009 -0.011 -0.008 0.010 0.009 -0.001 -0.009 -0.001 -0.009	-3.125 3.125 0.676 -0.886 2.239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 0.886 2.239 0.886 2.239 0.141 -2.239 0.886 0.000 -1.411 -2.239 0.886 0.000 -1.027	PROPI WDOT A 0.0533 0.0533 0.0255 0.0265 0.0265 0.0265 0.0265 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT ALB SEC - B 0.0503 0.0000 0.0266
0 12345678901234567890.	CMD +80 -90 -90 ++0 ++0 +-0 +-0 +-0 +-0 +-0 ++0 +++ +-++ +0 +-+ +0 0 +-0 0 -	TFANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0		+ ACCELES C SEC - Z 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -7.156 0.000 -0.881 1.171 8.327 7.156 9.208 -8.037 -9.208 -9.208 -9.208 -0.881 1.171 8.000 -1.171 8.327</pre>	· DEG SE pch -0.002 0.009 0.009 0.009 0.008 0.011 -0.008 0.000 -0.001 0.009 0.000 0.008 0.011 -0.008 0.011 -0.008 0.001 -0.001 0.000 -0.001 0.001	-3.125 3.125 0.676 -0.886 2.239 -0.6239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 -0.141 -2.239 0.886 0.000 -1.41 -2.098 1.027	PROPI WDOT A 0.0533 0.0533 0.0256 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT B B SEC - B 0.0522 0.0523 0.0000 0.0266
0 1234567890123456789010	CMD +00 ++00 ++0 0-0 ++0 0-0 +-0 +-0 +-0 ++++ +-++ +-++ +0 +-+ +0 +-+ +0 +-+ +0 +-+ +0 +-+ +0 0 ++0 0 0 +-0 +0 0 +0 0 -0 +0 0 -0 +0 0 -0 +0 0 -0 +0 0 -0 +0 -0 +0 -0 -0 +0 -0 +0 -0 -0 +0 -0 +0 -0 +0 -0 +0 -0 -0 +0 -0 -0 +0 -0 -0 +0 -0 -0 -0 +0 -0 -0 -0 -0 +0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0 -0	TFANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0	0.210 -0.210 0.210 0.200 0.105 -0.105 0.105 -0.105 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 -0.105 0.000 0.105 -0.105 -0.105 0.000 0.105 -0.105 -0.105 -0.105 0.000 0.105 -0.105	+ ACCELES C SEC) 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -7.156 0.000 -0.881 1.171 8.037 -9.208 -7.156 0.000 -1.171 0.881 8.037 -7.55</pre>	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 0.009 -0.001 -0.008 0.001 0.000 0.009 -0.011 -0.009 -0.011 -0.009 -0.011 -0.009 -0.001 0.000 0.001 0.001 0.001 0.009	-3.125 3.125 3.125 9.676 -0.886 2.239 -0.676 -2.239 0.886 0.000 -1.027 2.098 0.886 0.000 -1.212 -0.886 2.239 -0.141 -2.239 0.886 0.000 -2.098 1.027 0.141 -2.239 0.886 0.000 -2.098 1.027 0.141 -2.239	PROPI WDOT A 0.0533 0.0533 0.0256 0.0266	ELLANT 0.0522 0.0522 0.0523 0.0000 0.0266
0 12345678901234567890123	CMD +889 -848 +489 -448 -448 -448 -448 -448 +484 +484 +484	TFANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000	0.210 0.210 0.210 0.000 0.105 0.000 0.105 0.105 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.0000 0.0000 0.00000 0.00000 0.00000 0.000	+ ACCELER C SEC - C SEC - C SEC - C - C - C - C - C - C - C -	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -9.208 -7.156 0.000 -0.881 1.171 8.037 -9.208 -7.156 0.000 -1.171 0.881 8.037 7.150</pre>	· DEG SE pch -0.002 0.009 0.009 0.009 -0.001 -0.008 0.000 -0.001 0.009 -0.001 -0.009 -0.001 -0.009 -0.001 -0.009 -0.001 0.009 -0.001 0.009 -0.001 0.009 -0.001	-3.125 3.125 3.125 0.676 -0.886 2.239 -0.676 -2.239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 -0.141 -2.239 0.886 2.239 -0.141 -2.239 0.898 1.027 0.141 -0.898	PROPH WDOT A 0.0533 0.0533 0.0255 0.0265 0.0265 0.0265 0.0266	ELLANT ALB SEC - B 0.0523 0.0266
0 123456780012345678901233	CMD +00 0+0 +00 0-0 0-0 +-0 0 0 +-0 +-0	TFANS 2.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000	- FT SE 0.210 -0.210 0.000 0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0	+ ACCELES C SEC - Z 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000	PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -8.182 -9.208 r7.156 0.000 -0.881 1.171 8.327 7.156 9.208 -7.156 9.208 -7.156 0.000 -1.171 0.881 8.037 7.156 9.208	DEG SE pch -0.002 0.009 0.009 0.009 0.009 0.009 -0.011 -0.008 0.000 0.008 0.010 0.009 -0.011 -0.009 0.009 -0.011 -0.009 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.009	-3.125 3.125 0.676 -0.886 2.239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 0.141 -2.239 0.886 0.000 1.212 -0.886 2.239 0.886 0.000 1.212 -0.886 2.239 0.886 0.000 -1.027 0.141 -0.886 2.239	PROPI WDOT A 0.0533 0.0533 0.0255 0.0265 0.0265 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT ALB SEC - B 0.05233 0.0000 0.0266
0 1204567890120456789012244	CMD +80 -90 +90 +90 +90 +90 +90 +90 +90 +90 +90 +	TFANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000	L FT SE 0.210 0.210 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 0.0000 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.0000000 0.00000000	+ ACCELES C SEC - 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -7.156 0.000 -0.881 1.171 8.327 7.156 9.208 -7.156 9.208 -7.156 9.208 -7.156 0.000 -1.171 8.037 7.156 9.208 -7.156 -7.156 -7.208 -</pre>	· DEG SE pch -0.002 0.003 0.009 0.009 0.009 -0.001 -0.009 -0.001 0.000 0.001 0.008 0.001 -0.008 0.001 0.009 -0.001 0.009 -0.001 0.009 -0.001 0.009 0.001 0.009 0.001 0.009	-3.125 3.125 0.676 -0.886 2.239 -0.686 2.239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 0.886 2.239 -0.141 -2.239 0.886 0.000 -1.027 0.141 -0.886 2.239 -0.141 -0.886 2.239 -0.141 -0.886	PROPH WDOT A 0.0533 0.0533 0.0533 0.0256 0.0266	ELLANT ALB SEC - B 0.0503 0.0000 0.0255
0 100456789012045678901224456	CMD +80 -80 +80 +80 +80 +80 +80 +80 +80 +80 +80 +	TFANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000		+ ACCELES C SEC - 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0	<pre>PATIONS ◆ POTAT rol -2.052 2.052 8.182 7.156 9.208 -7.156 0.000 -0.881 1.171 8.037 -7.156 0.208 -7.156 9.208 -8.037 -9.208 -7.156 0.000 -1.171 0.881 8.037 7.156 9.208 -7.156 9.208 -7.156 9.208 -7.156 9.208 -8.037 -9.208 -7.156 9.208 -7.156 -8.037 -9.208 -7.156 -8.037 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 -7.156 -9.208 </pre>	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 0.009 0.001 -0.001 0.008 0.001 0.009 0.011 -0.009 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.002 0.001 0.002 0.002 0.002 0.002 0.002 0.002 0.002 0.002 0.002 0.003 0.001 0.003 0.003 0.003 0.001 0.003 0.003 0.001 0.003 0.001 0.003 0.003 0.001 0.003 0.003 0.003 0.001 0.003 0.003 0.001 0.003 0.003 0.001 0.003 0.003 0.001 0.003 0.	-3.125 3.125 0.676 -0.886 2.239 -0.6239 0.886 0.000 -1.027 2.098 1.212 -0.886 2.239 -0.141 -2.239 -0.141 -2.239 -0.141 -2.239 -0.141 -2.239 -0.141 -2.239 -0.141 -2.239 -0.141 -2.239 -0.141 -2.239 -2.239	PROPI WDOT A 0.0533 0.0533 0.0533 0.0256 0.0266	ELLANT 0.0522 0.0522 0.0523 0.0000 0.0266
0 1204567.0001204567.000120456	CMD +00 +00 ++0 0-0 ++0 0-0 +-0 00+ +0+ +0+	TFANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000	0.210 0.210 0.200 0.105 0.	+ ACCELES C SEC 2 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0	PATIONS + POTAT rol -2.052 2.052 8.182 7.156 9.208 -7.156 0.000 -0.881 1.171 8.037 -9.208 -7.156 0.000 -1.171 0.881 8.037 -9.208 -7.156 0.000 -1.171 0.881 8.037 -9.208 -7.156 0.000 -1.171 0.881 8.037 -9.208 -7.156 0.000 -1.171 0.881 -3.208 -7.156 0.000 -1.171 0.881 -3.208 -7.156 -7.156 -7.	· DEG SE pch -0.002 0.009 0.009 0.009 0.009 0.009 0.001 -0.009 -0.001 0.009 0.009 -0.011 -0.009 -0.011 -0.009 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.009 0.001 0.009	-3.125 3.125 3.125 9.676 -0.886 2.239 -0.6239 0.886 0.000 -1.027 2.098 0.886 0.000 -1.027 2.098 1.212 -0.886 0.000 -2.098 1.027 0.141 -2.239 0.886 0.000 -2.098 1.027 0.141 -2.239 0.886 0.000 -2.098 1.027 0.141 -2.239 0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 1.027 0.141 -0.886 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.039 0.886 0.000 -2.039 0.886 0.000 -2.239 0.886 0.000 -2.239 0.886 0.000 -2.239 0.886 0.000 -2.239 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.886 0.000 -2.098 0.000 -2.098 0.886 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.000 -2.098 0.0000 -2.098 0.0000 -2.098 0.0000 -2.098 0.0000 -2.098 0.0000 -2.0000 -2.0000 -2.0000 -2.0000 -2.00000 -2.00000 -2.00000 -2.00000 -2.0000000000	PROPI WDOT A 0.0533 0.0533 0.0256 0.0266	ELLANT 0.0522 0.0522 0.0523 0.0000 0.0266

*X, Y, and Z refer to translations along the respective axes. p,y, and r stand for pitch, yaw, and roll, respectively.

	OMD	******	******	+ ACCELE	PATIONS +	*******	******	PROP	ELLANT
		TRANS	L FT SE	C SEC >	POTAT	VDEG.SE	C SEC	NDOT	LE SEC
¢	Σrp	2	÷.	Z	rol	pch	Υ ≌ω	Ĥ	E
1	+00	0.000	0.000	0.210	0.037	2.671	0.003	0.0533	0.0533
ż	-00	0.000	0.000	-0.210	-0.037	-2.671	-0.003	0.0533	0.0533
3	0+0	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
4	++0	0.000	0.000	0.105	5.259	1.342	0.435	0.0266	0.0266
5	-+0	0.000	0.000	-0.105	5.222	-1.329	0.432	0.0266	0.0266
6	0-0	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
7	+-0	0.000	0.000	0.105	-5.222	1.329	-0.432	0.0266	0.0266
8	0	0.000	0.000	-0.105	-5.259	-1.342	-0.435	0.0266	0.0266
9	00+	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
10	+0+	0.000	0.000	0.105	0.021	1.808	0.002	0.0266	0.0266
11	-0+	0.000	0.000	-0.105	-0.017	-0.863	-0.001	0.0266	0.0266
12	0++	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
13	+++	0.000	0.000	0.105	0.021	1.808	0.002	0.0266	0.0266
14	-++	0.000	0.000	-0.105	-0.017	-0.863	-0.001	0.0266	0.0266
15	0-+	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
16	+-+	0.000	0.000	0.105	0.021	1.808	0.002	0.0266	0.0266
17	+	0.000	0.000	-0.105	-0.017	-0.863	-0.001	0.0266	0.0266
18	00-	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
19	+0-	0.000	0.000	0.105	0.017	0.863	0.001	0.0266	0.0266
20	-0-	0.000	0.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
21	Ø+-	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
22	++-	0.000	0.000	0.105	0.017	0.863	0.001	0.0266	0.0266
23	-+-	0.000	9.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
24	0	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
25	+	0.000	0.000	0.105	0.017	0.863	0.001	0.0266	0.0266
26		0.000	0.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
	CMD	******* TRANSI	******* L (FT SE	+ ACCELER	ATIONS ** Rotat	******* • DEG- SE	******* C/SEC/	РРОР(Мрот –	ELLANT (LB/SEC+
с	CMB rpy	******* TRANSI X	******* L (FT 'SE Y	← ACCELER C/SEC> Z	ATIONS ** Rotat rot	CDEG SE	******* C/SEC/ yau	РРОР(WDOT - R	ELLANT (LB/SEC+ B
C	смв пру	TRANSI X	******* L (FT SE 7	← ACCELER C.SEC> Z	ATIONS ** Rûtat roî	CDEG-SE pch	***** * С∕SEСл уаы	РРОР(WDOT - A	ELLANT (LB/SEC+ B
C 1	CMD rpy +00	******** Transi X 0.000	L (FT SE 7 0.000	 ACCELER C. SEC > Z 0.000 	ATIONS ** Rotat roi 8.182	DEG SE pch 0.009	+*+++++ C∕SEC/ yaw 0.676	PPOP6 WDOT R 0.0533	ELLANT (LB+SEC+ B 0.0000
C 1 2	CMD rpy +00 -00	TRANSI X 0.000 0.000	L (FT SE 7 0.000 0.000	 ACCELER C. SEC.> Z 0.000 0.000 	ATIONS ** ROTAT ro! 8.182 -8.182	CDEG-SE pch 0.009 -0.009	******* C/SEC/ yaw 0.676 -0.676	FPOP WDOT R 0.0533 0.0000	ELLANT (LB: SEC + B 0.0000 0.0533
C 1 2 3	CMD npy +00 -00 0+0	TRANSI X 0.000 0.000 0.005	L (FT SE 7 0.000 0.000 -0.003	 ACCELER C. SEC.> Z 0.000 0.000 0.000 0.004 	ATIONS ** Rotat ro! 8.182 -8.182 -0.020	DEG SE pch 0.009 -0.009 2.042	******* C/SEC/ yaw 0.676 -0.676 -0.126	FFOF WDOT R 0.0533 0.0000 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000
C 1 2 3 4	CMD rpy +00 -00 0+0 +00	TRANSI X 0.000 0.000 0.005 0.005	-0.003 -0.003	 ACCELER SEC → Z 0.000 0.000 0.004 0.004 	ATIONS ** ROTAT roi 8.182 -8.182 -0.020 8.162	0.009 -0.009 2.042 2.052	******* C/SEC/ yaw 0.676 -0.676 -0.126 0.550	PPOP WDOT A 0.0533 0.0000 0.0533 0.1065	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0000
C 1 2 3 4 5	CMD +00 -00 0+0 ++0 -+0	TRANSI X 0.000 0.000 0.005 0.005 0.005	0.000 0.000 0.000 -0.003 -0.003 -0.003 -0.003	 ACCELER SEC Z 0.000 0.000 0.004 0.004 0.004 0.004 0.004 	ATIONS ** ROTAT rol 8.182 -8.182 -0.020 8.162 -3.202	DEG SE pch 0.009 -0.009 2.042 2.052 2.033	******* C/SEC/ yaw 0.676 -0.676 -0.126 0.550 -0.303	PPOP WDOT A 0.0533 0.0000 0.0533 0.1065 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0000 0.0000 0.0533
C 1 2 3 4 5 6	CMD +00 -00 0+0 ++0 -+0 0-0	TRANSI X 0.000 0.000 0.005 0.005 0.005 0.005 0.005	0.000 0.000 -0.003 -0.003 -0.003 -0.003 -0.002	+ ACCELEF C.SEC) Z 0.000 0.004 0.004 0.004 0.004 -0.004	(ATIONS ** ROTAT rol 8.182 -8.182 -8.182 0.020 8.162 -3.202 -0.035	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048	******* C/SEC/ Valu 0.676 -0.676 -0.126 0.550 -0.303 -0.108	PPOP WDUT A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533
0 1234567.	CMD +00 -00 0+0 ++0 -+0 0-0 +-0	TRANSI X 0.000 0.005 0.005 0.005 0.005 0.005 0.004 0.004	0.000 0.000 -0.003 -0.003 -0.002 -0.002 -0.002	 ACCELEF SEC -> Z 0.000 0.004 0.004 0.004 -0.004 -0.004 	ATIONS ** ROTAT rol -3.182 -0.020 8.162 -3.202 -0.035 8.147	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.038	******* C/SEC/ Valu 0.676 -0.676 -0.126 0.550 -0.303 -0.109 0.563	FF0F6 WD0T A 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533
0 12345678	CMD + 89 - 89 - 49 - 49 - 49 - 49 - 49 - 49 - 49 - 4	TRANSI X 0.000 0.000 0.005 0.005 0.005 0.005 0.005 0.004 0.004 0.004	0.000 0.000 -0.003 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002	 ACCELEF SEC > Z 0.000 0.004 0.	ATIONS ** ROTAT roi 8.182 -8.182 -0.020 8.162 -3.202 -0.035 8.147 -3.217	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.038 -2.048 -2.035	+++++++ C/SEC/ VaW 0.676 -0.676 -0.126 0.550 -0.108 0.568 -0.735	FF0F6 WD0T - R 0.0533 0.0000 0.0533 0.106533 0.0533 0.0000 0.0533 0.0000	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0000 0.0533 0.0533 0.0533 0.0533
0 123456789	CMD +00 -00 ++00 ++0 0 +-0 +-0 +-0	TRANSI 2.999 0.999 0.909 0.905 0.905 0.905 0.904 0.904 0.904 0.904	0.000 0.000 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.002 -0.003	 ← ACCELEF C SEC > Z 0.000 0.004 	ATIONS ** ROTAT roi 8.182 -8.182 -0.020 8.162 -3.202 -0.035 8.147 -3.217 0.404	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.038 -2.057 -0.164	••••••• C/SEC/ Vaw 0.676 -0.676 -0.126 0.550 -0.303 -0.108 0.568 -0.735 1.473	FF0F6 WD0T - R 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.05533 0.0553
0 1234567890 10	CMD + 00 - 00 - + 0 - + 0 - + 0 0 0 + - 0 0 + - 0 0 + - 0	TRANSI X 0.000 0.005 0.005 0.005 0.005 0.005 0.004 0.004 0.004 0.004 0.004	0.000 -0.003 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003	 ACCELEF SEC) Z 0.000 0.004 0.0	ATIONS ** ROTAT rol 8.182 -8.182 -0.020 8.162 -3.202 -0.035 8.147 -8.217 0.404 8.731	0.009 -0.009 -0.009 2.042 2.052 2.033 -2.048 -2.038 -2.037 -0.164 -0.154	••••••• ••••••• ••••••	FF0F8 WD0T R 0.0533 0.0000 0.0533 0.1065 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0553 0.0000 0.0266
C 123456789011	CMD + 99 + 98 + + 98 + + 98 + + 98 + - 98 - 98 - 98 - 98 - 98 - 98 - 98 - 98	TRANSI X 0.000 0.000 0.005 0.005 0.005 0.005 0.004 0.004 0.004 0.005 0.005 0.005 0.005	0.000 0.000 0.000 -0.003 -0.003 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003	 ACCELEF SEC) Z 0.000 0.004 0.0	RTIONS ** ROTAT rol 8.182 -8.182 -8.182 -8.202 -8.202 -9.035 8.147 -8.217 0.404 8.731 -7.633	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.037 -0.164 -0.154 -0.173	******* C>SEC> Valu 0.676 -0.126 0.550 -0.303 -0.108 0.568 0.568 -0.735 1.473 2.684 1.332	FP0P6 WD0T A 0.0533 0.0000 0.0533 0.05533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0553 0.0000 0.0266 0.0266
C 12345678901122	CMD + 000 + -000 + + 000 + + + 00 + - 00 - 00	TRANSI X 0.000 0.005 0.005 0.005 0.005 0.004 0.004 0.004 0.004 0.005 0.005 0.005 0.005 0.005	0.000 0.000 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003	 ACCELEF SEC) Z 0.000 0.000 0.004 0.0	(ATIONS ** ROTAT rol 8.182 -8.182 -8.182 -8.020 8.162 -8.202 -0.035 8.147 -3.217 0.404 8.731 -7.633 0.413 0.413	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.038 -2.057 -0.164 -0.154 -0.173 2.043	******* C/SEC/ VaW 0.676 -0.676 -0.126 0.550 -0.303 -0.108 0.563 -0.735 1.473 2.684 1.332 1.473	FPOP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0799 0.0799 0.0799	ELLANT (LB, SEC) B 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266
C 12345678901123	CMD + 000 + -000 + + + 00 +00 +00 +00 + -00 + -00 -00 + -00 + -00 -00 + -00 -00 + 00 + -00 + 00 + 00 + 00 + 00 + 00 + 00 + 00 + 00 + 	TRANSI X 0.000 0.005 0.005 0.005 0.005 0.004 0.004 0.004 0.004 0.004 0.004 0.005 0.005 0.005 0.005	0.000 0.000 -0.003 -0.003 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003	 ACCELEF SEC -) Z 0.000 0.004 0	ATIONS ** ROTAT rol 8.182 -8.182 -0.020 8.162 -3.202 -0.035 8.147 -3.217 0.404 8.731 -7.633 0.413 8.740	DEG SE pch 0.009 -0.009 2.042 2.033 -2.048 -2.033 -2.048 -2.033 -2.048 -2.057 -0.164 -0.154 -0.154 -0.154	******* C/SEC/ Valu 0.676 -0.676 -0.126 0.550 -0.108 0.568 -0.735 1.473 2.684 1.332 1.473 2.685	FF0F6 WD0T A 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0739 0.0739 0.0739 0.0265 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.05533 0.05533 0.0266 0.0266 0.0266 0.0266 0.0266
C 1234567890112345	C M D + 000 + -0+0 + -0-0 + -00 + -00 + -00 + -00 + -00 + -00 + -0 + -	TRANSI X 0.000 0.005 0.005 0.005 0.005 0.005 0.004 0.004 0.004 0.004 0.004 0.004 0.005 0.005 0.005 0.005 0.005	0.000 0.000 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003	 ACCELEF SEC) 2 0.000 0.004 0.0	ATIONS ** ROTAT rol 8.182 -8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 -0.020 -0.025 8.147 -3.217 0.404 8.731 -7.633 0.413 8.740 -7.624	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.033 -2.057 -0.164 -0.154 -0.173 2.043 2.052 2.033	<pre>******* C > SEC ></pre>	FF0F6 WD0T A 0.0533 0.0000 0.0533 0.0533 0.0533 0.0500 0.0533 0.0500 0.0533 0.0799 0.0799 0.0265 0.0533 0.0533 0.0533 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0000 0.0533 0.0533 0.0533 0.1065 0.0266 0.0533 0.0533 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.055555 0.055555 0.055555 0.055555 0.0555555 0.05555555555
C 12345678901123456	CMD +000 ++000 +++00 +++00 +++00 +-00 +++++ +-00 ++++++++	TRANSI X 0.900 0.900 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905	0.000 0.000 -0.003 -0.003 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003	 ACCELEF SEC Z 0.000 0.004 	ATIONS ** ROTAT rol 8.182 -8.182 -0.020 8.162 -3.202 -0.035 8.147 -3.217 0.404 8.731 -7.633 0.413 8.740 -7.624 0.398	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.038 -2.048 -0.154 -0.154 -0.154 -0.154 2.043 2.052 2.033 -2.043 2.043	******* C/SEC/ VaW 0.676 -0.676 -0.126 0.550 -0.108 0.568 -0.735 1.473 2.685 1.332 1.473 2.685 1.332 1.491	FF0F6 WD0T A 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0739 0.0739 0.0739 0.0265 0.0533 0.0265 0.0533 0.0265 0.0533 0.0265	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0266
C 123456789011234567	C M D + 000 0 + + 00 0 + + 00 + - + + + + + + + + + + + + + + + + + +	TRANSI 2.900 0.900 0.905 0.905 0.905 0.905 0.904 0.904 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905	0.000 0.000 0.003 -0.003 -0.003 -0.002 -0.002 -0.003 -0.002 -	 ACCELEF SEC) Z 0.000 0.004 0.0	CATIONS *** ROTAT rol 8.182 -8.182 -8.182 -8.202 -8.202 -3.202 -0.035 8.147 -3.217 0.404 8.731 -7.633 0.413 3.740 -7.624 0.398 8.725 -7.624	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.038 -2.057 -0.164 -0.154 -0.154 -0.173 2.043 2.052 2.033 -2.047 -2.038 -2.037	<pre>******* C > SEC ></pre>	FP0P6 WD0T A 0.0533 0.0000 0.0533 0.05533 0.05533 0.05533 0.05533 0.0739 0.05533 0.0739 0.05533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533	ELLANT (LB, SEC) B 0.0000 0.0000 0.0000 0.0533 0.0533 0.0533 0.0533 0.0553 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0533 0.0533 0.055533 0.055535 0.055555 0.0555555555555555555555555
0 1234567890112345679	C M D + 000 + + 000 + + + 00 + - 00 +	TRANSI X 0.000 0.005 0.005 0.005 0.005 0.005 0.004 0.004 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005	0.000 0.000 0.003 -0.003 -0.003 -0.002 -0.002 -0.003 -0.004 -0.00	 ACCELEF SEC) Z 0.000 0.000 0.004 0.0	(ATIONS ** ROTAT rol 8.182 -8.182 -8.182 -8.202 -0.035 8.147 -3.217 0.404 3.731 -7.633 0.413 3.740 -7.624 0.398 8.725 -7.639 -7.639	DEG SE pch 0.009 -0.009 2.042 2.033 -2.048 -2.033 -2.048 -2.033 -2.043 2.052 2.033 -2.043 2.052 2.033 -2.047 -2.033 -2.047 -2.039 -2.057 -2.035 -2.057 -2.057 -2.057 -2.057	****** C-SEC- -9.676 -0.676 -0.126 0.550 -0.108 0.568 -0.108 0.568 -0.735 1.473 2.684 1.332 1.473 2.685 1.491 2.703 1.350 -1.473	FP0P6 WD0T A 0.0533 0.0000 0.0533 0.05533 0.05533 0.05533 0.05533 0.0799 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.05533 0.055555 0.055555 0.0555555555555555
0 12345678901123456789	C m p 9000 + -0000 + +0000 + +0000 + +0000 + +0000 + + + +	TRANSI X 0.990 0.900 0.905 0.905 0.905 0.904 0.904 0.904 0.904 0.905	0.000 0.000 0.000 0.003 -0.003 -0.002 -0.002 -0.003 -0.002 -0.003 -0.002	+ ACCELEF C-SEC) Z 0.000 0.000 0.004 -0.004 -0.004 -0.004 -0.004 0.004	<pre>(ATIONS **</pre>	DEG SE pch 0.009 -0.009 2.042 2.033 -2.048 -2.033 -2.048 -2.033 -2.054 -0.154 -0.154 -0.154 -0.154 -2.033 2.052 2.033 -2.047 -2.038 -2.052 -2.038 -2.052 -2.038 -2.055 -0.155 -0.155 -0.155 -2.055 -2.055 -2.055 -2.055 -0.155 -0.155 -0.155 -2.055 -2.055 -2.055 -2.055 -2.055 -0.155 -0.155 -2.055 -2.055 -2.055 -2.055 -2.055 -0.155 -2.0555 -2.05555 -2.0555 -2.0555 -2.0555 -2.0	******* C/SEC/ Valu 0.676 -0.676 -0.126 0.550 -0.108 0.568 -0.735 1.473 2.685 1.332 1.473 1.353 2.703 1.350 -1.272	FPOP WDOT A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0533 0.0799 0.0799 0.0799 0.0265 0.0533 0.0533 0.0265 0.0533 0.0553 0.05553 0.05553 0.05553 0.05553 0.05553 0.05553 0.05555 0.05555 0.05555 0.055555 0.055555 0.055555555	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.05533 0.0533 0.055555 0.0555555 0.055555555555555
0 1234567890111134567890	C m p 0000 + -0+0000 + +0000+++++++++++	TRANSI 3.999 9.999 9.995 9.995 9.995 9.995 9.994 9.994 9.994 9.994 9.994 9.995	0.000 0.000 0.000 -0.003 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.002 -0.003 -0.002 -0.00	 ACCELEF SEC) Z 0.000 0.000 0.004 0.0	ATIONS ** ROTAT rol 8.182 -8.182 -0.020 8.162 -3.202 -0.035 8.147 -3.217 0.404 8.731 -7.633 0.413 3.740 -7.624 0.398 8.725 -7.639 -0.404 7.633 -7.639	DEG SE pch 0.009 -0.009 2.042 2.033 -2.048 -2.033 -2.048 -2.033 -2.047 -0.154 -0.173 2.043 2.052 2.038 -2.047 -2.047 -2.0	******* C/SEC/ Valu 0.676 -0.676 -0.126 0.550 -0.108 0.568 -0.735 1.473 2.685 1.332 1.473 2.685 1.3391 2.703 1.350 -1.473 2.525	FF0F6 WD0T A 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0739 0.0739 0.0739 0.0733 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.05533 0.05533 0.05533 0.05533 0.05533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.05533 0.05553 0.055555 0.055555 0.0555555555555555
0 12345678901111345673901	C M D + 000 + + 000 + + + + 00 + - 00 + 00 + - 000 + - 000 + - 000 + - 00 + - 00 + - 00 + - 00 + - 00 + - 00 +	TRANSI 0.900 0.900 0.905	0.000 0.000 -0.003 -0.003 -0.002 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.002 -0.002 -0.002 -0.002 -0.003 0.003 0.003 0.003 0.003	 ACCELEF SEC) Z 000 004 004<td>ATIONS ** ROTAT rol 8.182 -8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.147 -0.404 7.633 -0.639 -0.633 -0.633 -0.639 -0.633 -0.633 -0.639 -0.633 -0.633 -0.633 -0.639 -0.633 -0.535 -0.655 -0.655 -0</td><td>DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.033 -2.048 -2.033 -2.047 2.043 2.057 -0.154 -0.154 -2.033 -2.043 2.043 2.043 2.033 -2.045 -2.035 -2.045 -2.038 -2.057 -2.038 -2.057 -2.042 2.038 -2.057 -2.042 -2.042 2.042 2.042 2.043 2.043 2.043 2.043 2.043 2.043 2.044 2.043 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.04444 2.04444 2.04444 2.044444 2.04444444444</td><td>******* C/SEC/ Valu 0.676 -0.676 -0.126 0.550 -0.108 0.568 -0.785 1.473 2.685 1.332 1.473 2.685 1.350 -1.473 -1.350 -1.473 -2.685 -1.472</td><td>FF0F6 WD0T A 0.0533 0.0000 0.0533 0.0533 0.0200 0.0533 0.0200 0.0533 0.0739 0.0265 0.0533 0.0739 0.0265 0.0533 0.0265 0.0533 0.05533 0.05533 0.05533 0.05533 0.05533 0.0255 0.0255 0.0255</td><td>ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.055555 0.055555 0.055555 0.055555 0.0555555 0.0555555 0.05555555555</td>	ATIONS ** ROTAT rol 8.182 -8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.182 -0.020 8.147 -0.404 7.633 -0.639 -0.633 -0.633 -0.639 -0.633 -0.633 -0.639 -0.633 -0.633 -0.633 -0.639 -0.633 -0.535 -0.655 -0.655 -0	DEG SE pch 0.009 -0.009 2.042 2.052 2.033 -2.048 -2.033 -2.048 -2.033 -2.047 2.043 2.057 -0.154 -0.154 -2.033 -2.043 2.043 2.043 2.033 -2.045 -2.035 -2.045 -2.038 -2.057 -2.038 -2.057 -2.042 2.038 -2.057 -2.042 -2.042 2.042 2.042 2.043 2.043 2.043 2.043 2.043 2.043 2.044 2.043 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.0444 2.04444 2.04444 2.04444 2.044444 2.04444444444	******* C/SEC/ Valu 0.676 -0.676 -0.126 0.550 -0.108 0.568 -0.785 1.473 2.685 1.332 1.473 2.685 1.350 -1.473 -1.350 -1.473 -2.685 -1.472	FF0F6 WD0T A 0.0533 0.0000 0.0533 0.0533 0.0200 0.0533 0.0200 0.0533 0.0739 0.0265 0.0533 0.0739 0.0265 0.0533 0.0265 0.0533 0.05533 0.05533 0.05533 0.05533 0.05533 0.0255 0.0255 0.0255	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.05555 0.055555 0.055555 0.055555 0.055555 0.0555555 0.0555555 0.05555555555
1234567890123456739012222	C M D V + - 0 + 0 - 0 - 0 + + + + + + +	TRANSI 0.900 0.900 0.905 0.905 0.905 0.905 0.904 0.904 0.904 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905 0.905	0.000 0.000 0.003 -0.003 -0.003 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.002 -0.002 -0.002 -0.003 -0.002 -0.002 -0.003 -0.003 -0.003 -0.002 -0.002 -0.003 -0.003 -0.003 -0.002 -0.003 -	 ACCELEF SEC) Z 0.000 0.004 0.0	<pre>CATIONS ***</pre>	DEG SE pch 0.009 -0.009 2.042 2.033 -2.038 -2.038 -2.038 -2.037 -0.164 -0.154 -0.154 -0.154 -2.033 -2.047 -2.033 -2.033 -2.037 -0.165 -0.155 -0.155 -0.174 2.041	****** C SEC yau 0.676 -0.676 -0.126 0.550 -0.303 -0.108 0.5655 1.473 2.682 1.475 1.332 1.491 2.705 -1.352 -1.332 -1.471	FP0P6 WD0T A 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0739 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.05533 0.05533 0.05533 0.0266 0.0266 0.0266 0.0266	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.055533 0.055555 0.0555555 0.055555555555555
0 12345678901234567890123 1111111111112223	C M D V + 000 000 + + + 000 + - 000 + - 000 + + + +	TRANSI 0.000 0.0005 0.005 0.005 0.005 0.005 0.005 0.004 0.004 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005	0.000 0.000 0.003 -0.003 -0.003 -0.002 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 0.003 0.003 0.003 0.003 0.003 0.003	 ACCELEF SEC) Z 0.000 0.000 0.004 0.0	<pre>(ATIONS ***</pre>	DEG SE pch 0.009 -0.042 2.033 -2.042 2.033 -2.042 2.033 -2.042 2.033 -2.042 2.033 -2.042 2.033 -2.042 2.033 -2.043 2.042 2.033 -2.044 -0.154 -0.154 -0.155 -0.165 -0.165 -0.174 2.042 2.032	<pre>******* C > SEC ></pre>	PP0P4 WD0T A 0.0533 0.0000 0.0533 0.05533 0.05533 0.05533 0.0799 0.0266 0.0533 0.05533 0.05533 0.05533 0.05533 0.05533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0265 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0799 0.0266 0.0799 0.0266 0.0533 0.0799 0.0533 0.0533
0 123456789012345673901234	C M D Y 00000+++0000++000000000000000000000	TRANSI 0.000 0.0005 0.005 0.005 0.005 0.005 0.004 0.004 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005	6.000 0.000 0.000 0.003 -0.003 -0.003 -0.002 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 0.003	 ACCELEF SEC) Z 0.000 0.004 	<pre>(ATIONS *** ROTAT rol 8.182 -0.020 9.182 -0.020 8.182 -0.020 -0.035 8.147 -0.202 -0.035 8.147 -3.217 -3.217 0.413 9.740 4.731 -7.633 9.740 8.725 -7.639 8.725 -7.639 -0.404 7.633 -9.731 -0.395 -7.642 -0.395 -0.418</pre>	DEG: SE pch 0.009 -0.009 2.042 2.033 -2.048 -2.033 -2.048 -2.033 -2.048 -2.033 -2.048 -2.033 -2.048 -2.052 -0.164 -0.154 -0.155 -2.043 2.057 -0.165 -0.174 2.042 2.032 -2.048	******* C SEC / Vau 0.676 -0.676 -0.126 0.503 -0.108 0.568 -0.735 1.473 2.685 1.331 2.703 1.357 1.373 -1.335 -1.473 -1.335 -1.473 -1.331 -2.6834 -1.493	FP0P6 WD0T A 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0000 0.0533 0.0533 0.0739 0.0739 0.0739 0.0733 0.0266 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0799 0.0266 0.0533 0.0533 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0565 0.0266 0.0565 0.0266 0.0565 0.0566 0.0573 0.0556 0.05566 0.05566 0.05566 0.05566 0.05566 0.05566 0.05566 0
0 1234567890123456789012345	C m p y + -0+ -0 + -0+ + + + + + +	TRANSI 0.000 0.005 0.005 0.005 0.005 0.005 0.004 0.004 0.005	6.000 0.000 0.000 0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.003 -0.002 -0.002 -0.002 -0.002 0.003 0	 ACCELEF SEC) Z 0.000 0.004 0.0	<pre>(ATIONS **</pre>	DEG SE pch 0.009 -0.009 2.042 2.033 -2.048 -2.033 -2.048 -2.033 -2.048 -2.033 -2.044 -0.154 -0.154 -0.154 -0.155 -2.033 -2.047 -2.038 -2.038 -2.0357 -0.165 -0.155 -0.155 -0.1551 2.0348 -2.0347 -2.0348 -2.0347 -2.0342 -2.0347 -2.0347 -2.0347 -2.0342 -2.0347 -2.0342 -2.0342 -2.0342 -2.0342 -2.03444 -2.0344 -2.0344 -2.0344 -2.03444 -2.03444 -2.03444 -2.03444 -2.03444 -2.03444 -2.034444 -2.034444 -2.034444444 -2.0444444444444444444444444444444444444	******* C SEC / Valu 0.676 -0.676 -0.126 0.503 -0.108 0.568 -0.735 1.473 2.685 1.331 2.703 1.353 -1.473 -1.385 -1.472 -1.331 -2.684 -1.352	FPOP WDOT A 0.0533 0.0000 0.0533 0.0553 0.0000 0.0533 0.0000 0.0533 0.0265 0.0533 0.0265 0.0533 0.0265 0.0255 0.0255 0.0255 0.0255 0.0255 0.0253 0.0255 0.0255 0.0255 0.0533	ELLANT (LB, SEC) B 0.0000 0.0533 0.0000 0.0533 0.0533 0.0533 0.0533 0.0266 0.0266 0.0266 0.0266 0.0533 0.0553 0.05553 0.05553 0.05555 0.05555 0.055555 0.055555 0.055555 0.0555555 0.05555555555

Simulation Results--IRV/Primary Control Mode

Simulation Results--IRV/Primary Control Mode

PART 2--ACTUAL ACCELERATIONS

Translational Acceleration

Translationa	I Acceleration					
Commanded Translation	Resulting Accelerations (ft/sec ²)	Specific Propellant Consumption Rate (lbs/ft/sec)				
+ X	.198	.511				
-x	176	.568				
+Y	.114	.937				
+ Z	.136	.807				

Rotational Acceleration

Commanded Rotation	Resulting Actual Acceleration (deg/sec ²)	Specific Propellant Consumption Rate (lbs/deg/sec)
+X (roll)	7.801	.057
+Y (pitch)	2.024	.030
+Z (yaw)	1.413	.049
AAH maintained control law li	d all uncommanded rota	ational rates within

Table XVII

Simulation Results--IRV/Backup Control Mode

PART 1--RESPONSE MATRIX

	⊂m⊅®	******		+ ACCELE	PATIONS +	*******	******	PROF	ELLANT
		TRANS	SL (FT/SE	C SEC -	POTAT	• DEG SE	CASECA	WDOT	LB SEC
¢	.:ipУ	К	Υ	Z	rol	pch	9 a 0	Ĥ	E
1	+80	0.105	6.000	0.000	-0.000	Ø. 166	-0 004	a aaga	0 0522
2	-00	-0.095	0.000	0.000	0.003	-0.172	0.004	0.0000	0.0000
3	n+0	0.005	0.003	0.000	0.039	2.042	0.023	0.0000	0.0555
4	++0	0.005	0.003	ด. กัดส	a. 638	2.042	0 127	a aaaa	0.0000
5	-+0	0.005	0.000	0.004	0.000	2.042	0.127	0.0000	0.0000
	a_a	0.005	-0.000	-0.004	0.030	-2.042	0.127	0.0000	0.0033
ž	a	0.004	-0.002	-0.004	-0.035	-2.040	-0.108	0.0000	0.0000
	0	0.004	-0.002	-0.004	-0.035	-2.048	-0.108	0.0000	0.0033
3	004	0.004	-0.002	-0.004	-0.035	-2.043	-0.108	0.0000	0.0533
10	+00+	0.004	-0.002	-0.004	0.407	0.159	1.492	0.0000	0.0533
11	-0+	0.004	-0.002	-0.004	0.407	0.109	1.492	0.0000	0.0533
44	-0-	0.004	-0.002	-0.004	0.407	0.159	1.492	0.0000	6.0533
14	9 ++	0.005	0.003	0.004	0.038	2.042	0.127	0.0000	0.0533
13	+++	0.073	0.000	0.000	0.221	1.137	0.798	0.0000	0.0266
14	-++	-0.043	0.000	0.000	0.224	1.015	0.821	0.0000	0.0799
15	8-+	0.004	-0.002	-0.004	-0.035	-2.048	-0.108	0.0000	0.0533
16	+-+	0.057	-0.002	-0.004	0.186	-0.861	0.690	0.0000	0.0799
17	+	-0.048	-0.002	-0.004	0.186	-1.027	0.694	0.0000	0.0266
18	00-	0.005	0.003	0.004	-0.404	-0.165	-1.473	0.0000	0.0533
19	+0-	0.005	0.003	0.004	-0.404	-0.165	-1.473	0.0000	0.0533
20	-0-	0.005	0.003	0.004	-0.404	-0.165	-1.473	0.0000	0.0533
21	8+-	0.005	0.003	0.004	0.038	2.042	0.127	0.0000	0.0533
22	++-	0.053	0.003	0.004	-0.133	1.022	-0.675	0.0000	0.0799
23	-+-	-0.047	0.003	0.004	-0.183	0.856	-0.671	0.0000	0.0266
24	0	0.004	-0.002	-0.004	-0.035	-2.048	-0.108	0.0000	0.0533
25	+	0.053	0.000	0.000	-0.221	-1.020	-0.802	0.0000	0.0266
26		-0.043	0.000	0.000	-0.218	-1.192	-0.779	0.0000	0.0799
	CMD				SATIONS .				
	CMD	******	*******	+ ACCELE	RATIONS +	******	******	PPOP	ELLANT
	CMD	******* TPANS		+ ACCELE	RATIONS + Potat	Degase	******* C/SEC+	PPOP WDOT	ELLANT ·LB SEC ·
¢	CMD VCr	TPANS C	5L + FT SE 7	+ ACCELE C. SEC) Z	PATIONS ★ ROTAT rol	DEG/SE pch	******* C/SEC+ yaw	РРОР Ирот А	ELLANT ·LB SEC · B
C 1	(MD 72r +00	TPANS 3	6L + FT SE 7 0.105	* ACCELE C. SEC > 2 0.000	RATIONS + ROTAT rol -1.026	•DEG∼SE pch ≁0.001	******* C2SEC+ yaw -1.563	РРОР ИДОТ А 9.0000	ELLANT -LB SEC - B 0.0533
C 1 2	(MD VCr +00 -00	TPANS () 0.000 0.000	6L +FT SE 7 0.105 -0.105	 ACCELE SEC → Z 0.000 0.000 	ATIONS * ROTAT rol -1.026 1.026	•DEG-SE pch +0.001 0.001	C-SEC - yaw -1.563 1.563	PPOP WDOT A 0.0000 0.0000	ELLANT *LB SEC+ B 0.0533 0.0533
C 123	(MD 70r +00 -00 0+0	TPANS 2 0.000 0.000 0.000	6L + FT SE 7 -0.105 -0.105 0.000	 ACCELEI SEC > 2 0.000 0.000 0.000 0.105 	ATIONS * ROTAT rol -1.026 1.026 0.019	• DEG -SE pch -0.001 0.001 1.336	-1.563 0.901	PPOP WDOT A 0.0000 0.0000 0.0000	ELLANT *LB SEC+ B 0.0533 0.0533 0.0533
C 1 2 3 4	(MD 70r +00 -00 0+0 +00	TPANS 2.000 0.000 0.000 0.000 0.000	6L + FT SE 7 -0.105 -0.105 0.000 0.105	 ↔ ACCELEI C: SEC 2 0.000 0.000 0.000 0.105 0.105 	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007	• DEG - SE pch -0.001 0.001 1.336 1.334	-1.563 0.001 -1.561	PPOP WDOT A 0.0000 0.0000 0.0000 0.0000	ELLANT *LB SEC+ B 0.0533 0.0533 0.0533 0.0533 0.1065
0 12345	CMD 70r +00 -00 0+0 ++0 -+0	TPANS 2.000 8.000 8.000 8.000 9.000 9.000	0.105 -0.105 -0.105 0.000 0.105 -0.105	 ACCELEI SEC 2 0.000 0.000 0.105 0.105 0.105 0.105 	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.004	(DEG/SE pch -0.001 0.001 1.335 1.334 1.337	-1.563 -1.563 1.563 0.001 -1.561 1.564	PPOP WDOT A 9.0000 9.0000 9.0000 9.0000 9.0000	ELLANT • LB SEC • B 0.0533 0.0533 0.0533 0.1065 0.1065
0 120450	CMD 70r +90 -90 9+0 ++0 -+0 9-0	TPANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000	5L FT SE 7 -0.105 -0.000 0.000 0.105 -0.105 0.000	 ACCELEI SEC 2 0.000 0.000 0.105 0.105 0.105 0.105 0.105 	 ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 	· DEG/SE pch -0.001 0.001 1.336 1.334 1.337 -1.336	-1.563 -1.563 1.563 0.001 -1.561 1.564 -0.001	PPOP WDOT A 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000	ELLANT - LB SEC - - B - 0.0533 - 0.0533 - 0.0533 - 0.0533 - 0.0553 - 0.0553
5 40M410101-	CMD VCr +00 -00 0+0 ++0 -+0 0-0 +-0	TPANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	5L • FT SE 7 -0.105 -0.105 0.000 0.105 -0.105 0.105 0.105	+ ACCELE C SEC - Z 0.000 0.105 0.105 0.105 -0.105 -0.105	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044	 DEG/SE pch -0.001 0.001 1.336 1.337 -1.336 -1.337 	-1.563 9.801 -1.563 0.001 -1.564 -0.001 -1.564	PPOP WDOT A 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000	ELLANT -LB SEC - B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065
0 100100100	CMD 70r +00 -00 9+0 ++0 -+0 0-0 +-0 0	TPANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	6L • FT SE 9.105 -0.105 0.000 0.105 -0.105 -0.105 0.000 0.105 -0.105 -0.105	 ACCELEI SEC > 2 0.000 0.000 105 0.105 0.105 -0.105 -0.105 -0.105 	ATIONS ← POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007	(DEG/SE pch -0.001 1.336 1.334 1.337 -1.337 -1.337	-1.563 -1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 1.564	PPOP WDOT A 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	ELLANT *LB SEC+ B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065
0 1004907.00	CMD 70r +00 -00 9+0 ++0 0-0 +-0 +-0 -0 +-0 00+	TPANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.105 -0.105 0.000 0.105 -0.105 -0.105 0.000 0.105 -0.105 -0.105 0.000	 ACCELEI SEC > 2 0.000 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105 0.000 	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182	(DEG/SE pch -0.001 1.336 1.334 1.337 -1.336 -1.337 -1.334 0.009	-1.563 -1.563 1.563 0.001 -1.564 -0.001 -1.564 1.564 0.676	PPOP WDOT A 9.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	ELLANT *LB SEC+ B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 1234557898	CMD +00 -00 0+0 ++0 0 +-0 +-0 +-0 00+ +0+	TPANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	6L - FT SE -0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105	+ ACCELEI C. SEC) 2 0.000 0.000 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.000	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215	<pre></pre>	-1.563 -1.563 1.563 0.001 -1.564 -0.001 -1.564 1.564 1.561 0.676 -1.130	PPOP WDOT A 9.0000 9.0000 0.0000 0.0000 0.0000 0.0000 9.0000 9.0000 9.0000 9.0000 9.0000	ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 1234567899011 11	CMD +00 -00 0+0 ++0 -+0 0-0 +-0 +-0 +-0 +0 +-0 -0+ +0+ -0+	TPANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	6L • FT 5E 7 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.005 0.005 0.105 0.005 0.105 0.005 0.105	 ACCELEI SEC > 2 0.000 0.000 0.005 0.105 0.105 0.105 -0.105 -0.105 0.005 0.000 0.000 0.000 	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.256	<pre></pre>	-1.563 1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 1.564 0.676 -1.130	PPOP WDOT A 9.0000 9.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 12345578990112	CMD VCr +00 0+0 ++0 +-0 +-0 +-0 00+ +0+ +0+ 0++	TPANS 	6L • FT SE 7 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 -0.105 -0.105	 ACCELEI SEC > 2 0.000 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.000 	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 2.24	<pre> (DEG/SE pch -0.001 0.001 1.336 1.334 1.337 -1.337 -1.337 -1.334 0.009 0.005 0.007 1.345 </pre>	-1.563 .563 0.001 -1.561 1.564 -0.001 -1.564 1.564 1.564 1.564 1.564 1.566 -1.130 1.396 6.279	PPOP WDOT A 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000	ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 123455789011123	CMD +00 -00 ++0 ++0 ++0 +-0 +-0 +-0 +0+ +0+	TPANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	6L • FT SE 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.105 0.000 0.105 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.105 0.0000 0.00000 0.00000 0.00000 0.0000 0.00000 0.00000000	 ACCELEI SEC > 2 0.000 0.000 105 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.0	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 8.201 9.201	(DEG/SE pch -0.001 1.336 1.334 1.337 -1.337 -1.337 -1.337 0.009 0.005 0.007 1.345	-1.563 1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 1.564 1.566 1.566 0.676 -1.130 1.996 0.678	PPOP WDOT A 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000	ELLANT *LB SEC + B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 123455789011234	CMD +00 -00 +00 +00 +00 +00 +00 +00 +00 +00	TPANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	6L - FT SE -0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.000 0.0000 0.00000 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.000000 0.00000000	+ ACCELEI C. SEC) 2 0.000 0.000 0.105 0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.105 0.105 0.000 0.000 0.105 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.005 0.105 0.105 0.000 0.000 0.000 0.105 0.105 0.000 0.000 0.105 0.105 0.000 0.000 0.105 0.105 0.105 0.000 0.000 0.105 0.10	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 8.201 8.201 9.201	(DEG/SE pch -0.001 1.336 1.334 1.337 -1.336 -1.337 -1.334 0.009 0.005 0.007 1.345 1.345	-1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 1.564 1.564 1.566 1.130 1.996 0.678 0.678 0.678	PPOP WDOT A 9.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	ELLANT *LB SEC+ B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 1234557.890112345	CMD VCr +00 -00 0+0 ++0 0-0 +-0 -00 +00 +-0 -00 +00 +	TPANS 	GL - FT SE -0.105 -0.105 -0.105 -0.105 -0.105 -0.105 -0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.105 -0.105 0.0000 0.00000 0.00000 0.00000 0.00000 0.0000000 0.00000 0.00000 0.00000 0.00000000	 ACCELEI SEC > 2 0.000 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.000 0.005 0.105 0.105 0.000 0.005 0.105 	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 8.201 8.201 3.201 3.201	<pre> DEG/SE pch -0.001 0.001 1.336 1.334 1.337 -1.336 -1.337 -1.334 0.009 0.005 1.345 1.345 1.345 1.345 </pre>	-1.563 -1.563 0.001 -1.561 1.564 -0.064 -1.564 1.564 1.564 0.676 -1.130 1.996 0.6788 0.67888 0.67888 0.67888 0.678888 0.67888888888888888888888888888888888888	0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	ELLANT LB SEC B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 12345578901123455	CMD VCr +00 0+0 +-0 0-0 +-0 +-0 +-0 +-0 00+ +0+ +	TPANS 	6L • FT 5E 9.105 -0.105 0.000 0.105 -0.105 0.105 -0.105 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 0.000 0.105 -0.105 0.000 0.000 0.0000 0.000 0.000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.0000000 0.00000000	 ACCELEI SEC > 2 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.000 <l< td=""><td>ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 8.201 8.201 8.201 8.163 2.62</td><td><pre> (DEG > SE pch -0.001 0.001 1.336 1.337 -1.337 -1.337 -1.334 0.009 0.005 1.345 1.345 1.345 -1.326 </pre></td><td>-1.563 .563 0.001 -1.561 1.564 -0.001 -1.564 1.564 1.564 1.564 0.676 -1.130 1.996 0.678 0.678 0.678 0.678 0.678 0.673</td><td>PPOP WDOT A 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000</td><td>ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065</td></l<>	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 8.201 8.201 8.201 8.163 2.62	<pre> (DEG > SE pch -0.001 0.001 1.336 1.337 -1.337 -1.337 -1.334 0.009 0.005 1.345 1.345 1.345 -1.326 </pre>	-1.563 .563 0.001 -1.561 1.564 -0.001 -1.564 1.564 1.564 1.564 0.676 -1.130 1.996 0.678 0.678 0.678 0.678 0.678 0.673	PPOP WDOT A 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000	ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 1234557.89011234557	CMD VCr +00 0+0 +00 +-0 0-0 00+ +00 +-0 00+ +0+ +	TPANS 	6L • FT SE 0.105 0.105 0.000 0.105 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.105 0.000 0.105 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000000	+ ACCELEI C SEC) Z 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.105 0.105 -0.105 -0.105 -0.105 -0.105	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.044 1.025 6.256 8.201 8.201 8.201 8.201 8.163 8.163 8.163	<pre> (DEG > SE pch -0.001 0.001 1.336 1.334 1.337 -1.337 -1.334 0.009 0.005 0.007 1.345 1.345 1.345 -1.326</pre>	-1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 -0.001 -1.564 1.564 1.564 1.564 1.564 0.676 -1.130 1.996 0.678 0.678 0.675 0.675	PPOP WDOT A 9.0000 9.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065
0 1234567890112345670 1112345670	CMD VCr +00 0+0 +00 0-0 0-0 +00 +00 +00	TPANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0	6L • FT SE 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 0.000 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.000000 0.00000000	+ ACCELEI C SEC) 2 0.000 0.000 0.105 0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.105 0.105 -	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 8.201 8.201 8.201 8.163 8.163 8.163	(DEG/SE pch -0.001 0.001 1.336 1.334 1.337 -1.337 -1.337 -1.337 0.009 0.005 0.007 1.345 1.345 1.345 1.326 -1.326 -1.326	-1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 1.564 1.564 1.566 1.566 1.566 0.676 0.678 0.678 0.675 0.675	PPOP WDOT A 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000 9.0000	ELLANT * LB SEC + B 0.0533 0.0533 0.1065
0 1234557890123455780	CMD VCr +00 -00 0+0 ++0 0-0 -0-0 00+ +-0 00+ +0+ -0+ +++ 0++ -0+ 0++ -0+ 0++ -0+ 0-0 0+0 -00 0-0 0-	TPANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0	L FT SE 0.105 0.000 0.105 0.000 0.105 0.105 0.000 0.105 0.105 0.105 0.000 0.105 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000000	 ACCELEI SEC Z 0.000 0.000 0.105 0.105 0.105 0.105 0.105 0.000 0.000 0.000 0.000 0.005 0.105 0.200 	ATIONS + POTAT rol -1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.256 8.201 8.201 8.201 8.201 8.163 3.163 -6.192	<pre> DEG > SE pch -0.001 0.001 1.336 1.334 1.337 -1.336 -1.337 -1.334 0.005 0.007 1.345 1.345 1.345 1.345 1.326 -1.326 -1.326 -0.007 </pre>	-1.563 0.001 -1.563 0.001 -1.564 1.564 1.564 1.564 1.564 1.566 -1.130 0.678 0.678 0.678 0.675 0.675 0.675 -0.675	00994 0.0000	ELLANT LE SEC B 0.0533 0.0533 0.1065 0.1
0 123455789011234567890	CMD VCr +00 0+0 ++0 0-0 +-0 0 00+ +0+ +0+	TPANS 	L FT SE 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000000	+ ACCELEI C SEC) 2 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.105 -	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.007 3.182 4.215 6.266 8.201 8.163 8.163 8.182 -6.266	<pre> DEG > SE pch -0.001 0.001 1.336 1.337 -1.337 -1.334 0.009 0.007 1.345 1.345 1.326 -1.326 -1.326 -0.009 -0.007 </pre>	-1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 1.564 1.564 1.564 1.564 0.676 -1.130 0.678 0.678 0.675 0.675 0.675 -0.676 -1.996	00994 0.0000	ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.056
0 123456789011234567890. 111134567890.	CMD VCr +00 0+0 +00 0+0 +-0 00+ +00 +-0 00+ +0+ +	TPANS 	6L • FT SE 0.105 0.105 0.000 0.105 0.000 0.105 0.105 0.105 0.105 0.105 0.000 0.000 0.000 0.000 0.000 0.000 0.105 -0.105 0.000 0.000 0.000 0.105 -0.105 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.0000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.0000 0.000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000000	+ ACCELEI C SEC) Z 0.000 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.000 0.105 -0.005 -0.005	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.007 3.182 4.215 6.266 8.201 8.201 8.201 8.163 8.163 -6.266 -4.215	<pre> DEG > SE pch -0.001 0.001 1.336 1.334 1.337 -1.337 -1.334 0.009 0.005 1.345 1.345 1.345 1.345 1.326 -1</pre>	-1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 -0.001 -1.564 1.564 1.564 1.564 1.564 1.566 1.130 1.996 0.678 0.675 0.675 0.675 -0.676 -1.996 1.130	POP WDOT A 9.0000 9.0000 0.0000	ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.055 0
0 123455789012345578901	CMD VCr +00 0+0 +00 0+0 +-0 00+ +0+ -0+ 00+ +0+ -0+ 0+- 00- +0- 00- +0- 00- -00 00- 00+ 00+	TPANS C.000 C.	6L • FT SE 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.000 0.000 0.000 0.000 0.105 -0.105 0.000 0.105 -0.105 0.000 0.000 0.105 -0.105 0.000 0.000 0.105 -0.105 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.105 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000000	+ ACCELEI C SEC) 2 0.000 0.000 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.105 -0.000 -0.0000 -0.000 -0.000 -0.000 -0.000 -0.0000 -0.0000 -0.0000 -0.0	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 8.201 8.201 8.261 8.201 8.163 8.163 8.163 8.163 -4.215 -8.163	<pre> (DEG/SE pch -0.001 0.001 1.336 1.334 1.337 -1.337 -1.337 -1.334 0.009 0.005 0.007 1.345 1.345 1.345 -1.326 -</pre>	-1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 -0.001 1.564 -0.676 -1.130 0.676 0.678 0.675 0.675 0.675 0.675 0.675 0.675 0.675 0.675	PPOP WDOT A 9.0000	ELLANT * LB SEC + B 0.0533 0.0533 0.1065
0 123456789011234567890122 111111567890122	CMD VCr +00 -00 0+0 ++0 0-0 -0-0 00+ +-0 -0+ +0+ +0+ +0+ +-+ 0++ +0+ +0+ +0+ +0+	TPANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0	L FT SE 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000000	+ ACCELEI C SEC - Z 0.000 0.105 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.105 0.105	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.226 8.201 8.201 8.201 8.201 8.201 8.163 8.163 -8.163 -8.163 -8.163	<pre> DEG > SE pch -0.001 0.001 1.336 1.334 1.337 -1.337 -1.334 0.005 0.007 1.345 1.345 1.345 1.326 -1.326 -0.007 -0.005 1.326 1.326 1.326 </pre>	-1.563 0.001 -1.563 0.001 -1.564 1.564 1.564 1.564 1.564 1.564 1.566 -1.130 0.678 0.675 0.675 0.675 -0.675 -0.675 -0.675 -0.675	P094 H004 A 9.0000 9.0000 0.0000	ELLANT LE SEC B 0.0533 0.0533 0.1065 0.106 0.1065 0.1065 0.1065 0.1065 0.1065 0.1065 0.10
0 1234567890112345678901223 11113456789012223	CMD VCr +00 0+0 ++0 0-0 +-0 -0+ 0++ -0+ 0++ -0+ +0+ +	TPANS 	L FT SE 0.105 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.105 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.00000 0.00000000	+ ACCELEI C SEC) Z 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.000 0.105 0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.000 0.105 0.105 0.000 0.000 0.105 0	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.007 3.182 4.215 6.266 8.201 8.163 -8.163 -8.163 -8.163 -8.163	<pre> DEG > SE pch -0.001 0.001 1.336 1.334 1.337 -1.337 -1.334 0.009 0.005 1.345 1.345 1.326 -1.326 -1.326 -0.009 -0.005 1.326 1.326 1.326 1.326 1.326 </pre>	-1.563 1.563 0.001 -1.561 1.564 -0.064 1.564 1.564 1.564 1.564 0.676 -1.130 0.678 0.678 0.675 0.675 -0.675 -0.675 -0.675 -0.675	00000 0.0000	ELLANT - LB SEC - B 0.0533 0.0533 0.1065 0.055 0.055 0.055 0.055 0.055 0.055 0.055
0 128456789012345678901234	CMD VCr +00 0+0 +00 0+0 +-0 00+ +0+ +0+	TPANS 	L FT SE 0.105 0.105 0.000 0.105 0.000 0.105 0.105 0.105 0.105 0.000 0.105 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.000000 0.00000000	+ ACCELEI C SEC) 2 0.000 0.105 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.000 0.105 -0.105	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.007 8.104 4.215 6.266 8.201 8.201 8.163 8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.201	<pre> (DEG - SE</pre>	-1.563 -1.563 0.001 -1.561 1.564 -0.001 -1.564 1.564 1.564 1.564 1.564 1.564 0.678 0.678 0.678 0.675 0.675 -0	 POP WDOT A 9.0000 9.0000 0.0000 	ELLANT - LB SEC - B 0.0533 0.0533 0.1065
0 12345578901234557890123455	CMD VCr +00 0+0 +00 0+0 +-0 00+ +0+ +0+	TPANS 	6L FT SE 0.105 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.105 0.000 0.105 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000000	+ ACCELEI C SEC) 2 0.000 0.105 0.105 0.105 0.105 -0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 -0.105 0.105	ATIONS + POTAT rol -1.026 1.026 0.019 -1.007 1.044 -0.019 -1.044 1.007 3.182 4.215 6.266 8.201 8.163 8.163 -4.215 -8.163 -8.163 -8.163 -8.163 -8.163 -8.201 -8.201	<pre> (DEG > SE pch -0.001 0.001 1.336 1.337 -1.337 -1.337 -1.337 0.009 0.005 1.345 1.345 1.326 -1.326 -1.326 -1.326 1.32 1.326</pre>	-1.563 1.563 0.001 -1.561 1.564 -0.001 -1.564 -0.001 1.564 -0.676 -1.130 0.676 0.675 0.675 0.675 0.675 -0.675 -0.675 -0.675 -0.675 -0.675 -0.675	 POP WDOT A 9.0000 9.0000 0.0000 	ELLANT - LB SEC - B 0.0533 0.0533 0.1065
0 12345578901234557890123455	CMD VCr +00 -00 0+0 +-0 0-0 +-0 0-0 +-0 0-0 +-0 0++ -0+ +-+ 0++ +-+ 0-+ +-+ 0 0+- 0 0-	TPANS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.00000 0.000	L FT SE 0.105 0.000 0.105 0.000 0.105 0.000 0.105 0.005 0.105 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.0000000 0.00000000	+ ACCELEI C SEC - Z 0.000 0.105 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.000 0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.000 0.000 0.105 -0.105 -0.105 0.105 -0.10	ATIONS * POTAT rol -1.026 0.019 -1.007 1.044 -0.044 1.007 3.182 4.215 6.266 8.201 8.201 8.201 8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.163 -8.201 -3.201 -3.201	<pre> DEG-SE pch -0.001 1.336 1.334 1.337 -1.337 -1.337 -1.334 0.005 0.007 1.345 1.345 1.345 1.326 -1.326 -1.326 -1.326 1.326 1.326 1.326 1.326 1.326 1.326 1.326 1.325 1.345</pre>	-1.563 0.001 -1.563 0.001 -1.564 1.564 1.564 1.564 1.564 1.564 1.566 -1.564 0.678 0.675 0.675 0.675 -0.675 -0.675 -0.675 -0.673 -0.673 -0.675 -0.675 -0.675 -0.673 -0.675 -0.555 -0.555 -0	 P094 WD01 A WD01 A WD00 <li< td=""><td>ELLANT LE SEC B 0.0533 0.0533 0.1065 0.106 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.0</td></li<>	ELLANT LE SEC B 0.0533 0.0533 0.1065 0.106 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.0

p,y, and r stand for pitch, yaw, and roll, respectively.

Table XVII (cont.)

		Simula	ition R	lesults	sIRV/I	Backup	Contro	ol Mode	
	CMD	******	******	· ACCELER	RATIONS +	******	******	PPOF	ELLANT
		TRANSI	LIFTISE	C SEC /	POTAT	OEG SE	CSEC	WDOT	LB SEC -
C.	npo	X	ï	Z	rol	pen	9 3 0	н	в
1	+00	0.000	0.000	0.000	8.192	0.009	0.676	0.0000	0.0533
Ē	-00	0.000	0.000	0.000	-8.182	-0.009	-0.676	0.0000	0.0533
3	0+0	0.005	0.003	0.004	0.038	2.042	0.127	0.0000	0.0533
4	++0	0.005	0.003	0.004	8.220	2.052	0.304	0.0000	0.1065
5	-+0	0.005	0.003	0.004	-3.144	2.033	-0.549	0.0000	0.1065
Ē	0-0	0.004	-0.002	-0.004	-0.035	-2.048	-0.108	0.0000	0.0533
-	+-0	0.004	-0.002	-0.004	8.147	-2.038	0.568	0.0000	0.1055
3	0	0.004	-0.002	-0.004	-8.217	-2.057	-0.785	9.0000	0.1065
g	<u>аа</u> +	0.004	-0.002	-9.004	0.407	0.159	1.492	0.0000	0.0533
1.4	+9+	0 004	-0 002	-0.004	8.589	0.169	2.168	0.0000	0.1065
11	-0+	0.004	-0.002	-0.004	-7.775	0.150	9.916	9-9999	0.1065
12	 0.⊥.∔	0.004 0.004	0.002	0.004	A 838	2 942	9 127	a aaaa	0.1000
13	***	0.000	0.000	0.004	8.220	2.052	9.804	A 00000	0.1065
14		0.005	0.000	0.004	-9 144	2 933	-0 549	a aaaa	0.1005
1.4	0-++	0.005	-0.000	-0.004	-0.177	-2.000	-0.042	a aaaa	0.1000
10	6	0.004	-0.002	-0.00-	-0.033 3 147	-2.070	-0.100	0.0000	0.0000
10		0.004	-0.002	-0.004	9.14/ -9 317	~2.030	0.000 -0 705	0.0000	0.1005
10		0.004	-0.002	-0.004	-0.417	-2.007	-0.700	0.0000	0.1000
18	66-	0.005	0.003	0.004	-0.404	-0.165	-1.473	0.0000	0.0033
19	+10-	0.005	0.003	0.004	(.(/8	-0.155	-0.797	0.0000	0.1065
20	-0-	0.005	0.003	0.004	-8.586	-0.174	-2.149	0.0000	0.1065
21	0+-	0.005	0.003	0.004	0.038	2.042	0.127	0.0000	0.0533
22	++-	0.005	0.003	0.004	8.220	2.052	0.804	0.0000	0.1065
23	-+-	0.005	0.003	0.004	-8.144	2.033	-0.549	0.0000	0.1065
24	0	0.004	-0.002	-0.004	-0.035	-2.048	-0.108	0.0000	0.0533
25	+	0.004	-0.002	-0.004	8.147	-2.038	0.568	0.0000	0.1065
26		0.004	-0.002	-0.004	-8.217	-2.057	-0.785	0.0000	0.1065
DA	7 11		T. ACCE	TERATT	ONC				
					.01.0		<u>_</u>		
Tra	ansl	ational	Accel	eratic	n				
Tra	ansl	ational	Accel	eratic	n				
Tra Cor	ansl nman	ational ded	Accel Resul	eratic ting A	on Actual	Spec	ific P	ropella	int
Tra Con Tra	ansl nman ansl	ational ded ation	Accel Resul Accel	eratic ting A eratic	on Actual ons	Spec	ific P sumpti	ropella on Rate	int
Tra Con Tra	ansl nman ansl	ational ded ation	Accel Resul Accel	eratic ting A eratic	on Actual ons	Spec Cor	ific P sumpti	ropella on Rate	int 2
Tra Con Tra	ansl nman ansl	ational ded ation	Accel Resul Accel (ft/s	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	cific P sumpti s/ft/se	ropella on Rate ec)	int 2
Tra Con Tra +X	nman ansl	ational ded ation	Accel Resul Accel (ft/s	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	sific P sumpti s/ft/se	ropella on Rate ec)	int 2
Tra Con Tra +X	nman ansl	ational ded ation	Accel Resul Accel (ft/s .100	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	ific P sumpti s/ft/se	ropella on Rate ec)	int 2
Tra Con Tra +X	ansl nman ansl	ational ded ation	Accel Resul Accel (ft/s .100	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	sific P sumpti s/ft/se .544	ropella on Rate ec)	int 2
Tra Con Tra +X -X	ansl nman ansl	ational ded ation	Accel Resul Accel (ft/s .100 090	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	ific P sumpti s/ft/se .544 .620	ropella on Rate ec)	int
Tra Con Tra +X -X	ansl nman ansl	ational ded ation	Accel Resul Accel (ft/s .100 090	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	ific P sumpti s/ft/se .544 .620	ropella on Rate ec)	int
Tra Con Tra +X -X	ansl nman ansl	ational ded ation	Accel Resul Accel (ft/s .100 090	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	sific P sumpti s/ft/se .544 .620	ropella on Rate ec)	int 2
Tra Con Tra +X -X +Y	ansl mman ansl	ational ded ation	Accel Resul Accel (ft/s .100 090 .102	eratic ting A eratic sec ²)	on Actual ons	Spec Cor (1b	sific P sumpti s/ft/se .544 .620 .167	ropella on Rate ec)	int
Tra Con Tra +X -X +Y	ansl mman ansl	ational ded ation	Accel Resul Accel (ft/s .100 090 .102	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	ific P sumpti s/ft/se .544 .620 .167	ropella on Rate ec)	int
Tra Con Tra +X -X +Y +Z	ansl nman ansl	ational ded ation	Accel Resul Accel (ft/s .100 090 .102 .102	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	ific P sumpti s/ft/se .544 .620 .167 .892	ropella on Rate ec)	int
Tra Con Tra +X -X +Y +Z	ansl nman ansl	ational ded ation	Accel Resul Accel (ft/s .100 090 .102 .102	eratic ting P eratic ec ²)	on Actual ons	Spec Cor (1b	ific P sumpti s/ft/se .544 .620 .167 .892	ropella on Rate ec)	int
Tra Con Tra +X -X +Y +Z	ansl nman ansl	ational ded ation	Accel Resul Accel (ft/s .100 090 .102 .102	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	ific P sumpti s/ft/se .544 .620 .167 .892	ropella on Rate ec)	int
Tra Con Tra +X -X +Y +Z Ro	ansl mman ansl	ational ded ation onal Ac	Accel Resul Accel (ft/s .100 090 .102 .102 :celera	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	sific P sumpti s/ft/se .544 .620 .167 .892	oropella on Rate ec)	int
Tra Con Tra +X +X +Y +Z Ro	ansl mman ansl tati	ational ded ation onal Ac	Accel Resul Accel (ft/s .100 090 .102 .102 :celera	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b	sific P sumpti s/ft/se .544 .620 .167 .892	Propella on Rate	ant
Tra Con Tra +X +X +Y +Z Ro Con	ansl mman ansl tati	ational ded ation onal Ac ded	Accel Resul Accel (ft/s .100 090 .102 .102 :celera Result	eratic ting P eratic ec2) tion	on Actual ons	Spec Cor (1b	ific P sumpti s/ft/se .544 .620 .167 .892 cific I	Propella Propella	ant
Tra Con Tra +X -X +Y +Z Ro Con Ro	ansl mman ansl tati	ational ded ation onal Ac ded on	Accel Resul Accel (ft/s .100 090 .102 .102 .102 :celera Result Accele	ting Action	on Actual ons	Spec Cor (1b	sific P sumpti s/ft/se .544 .620 .167 .892 cific I nsumpt	Propella Propella	ant
Tra Con Tra +X +X +Y +Z Ro ⁻ Con Ro ⁻	ansl nman ansl tati nman tati	ational ded ation onal Ac ded on	Accel Resul Accel (ft/s .100 090 .102 .102 :celera Result Accele (deg/s	eratic ting A eratic ec ²)	on Actual ons	Spec Cor (1b 1 Spec Cor	cific P sumpti s/ft/se .544 .620 .167 .892 cific I nsumpti lbs/dec	Propella Propella ion Rate	ant
Tra Con Tra +X -X +Y +Z Ro Con Ro	tati nman tati	ational ded ation onal Ac ded on	Accel Resul Accel (ft/s .100 090 .102 .102 :celera Result Accele (deg/s	eratic ting A eratic sec ²)	on Actual ons :tual	Spec Cor (1b 1 Spec Cor	cific P sumpti s/ft/se .544 .620 .167 .892 cific I nsumpti lbs/dee	Propella on Rate ec) Propella ion Rate g/sec)	ant e
Tra Con Tra +X +X +Y +Z Ro [•] Con Ro [•]	ansl mman ansl tati mman tati	ational ded ation onal Ac ded on	Accel Resul Accel (ft/s .100 090 .102 .102 :celera Accele (deg/s	ting Action	on Actual ons	Spec Cor (1b 1 Spec Cor	cific P sumpti s/ft/se .544 .620 .167 .892 cific I nsumpti lbs/dec	Propella Propella g/sec)	ant e
Tra Con Tra +X +X +Y +Z Ro Con Ro -	tati nman tati (ro	ational ded ation onal Ac ded on 11)	Accel Resul Accel (ft/s .100 090 .102 .102 :celera Accele (deg/s 7.717	ting P eratic eratic ec2)	on Actual ons tual	Spec Cor (1b 1 Spec Cor (sific P sumpti s/ft/se .544 .620 .167 .892 cific I nsumpti lbs/dec .025	Propella Propella ion Rate	ant e
Tra Con Tra +X +X +Y +Z Ro Con Ro -	tati nman tati (ro	ational ded ation onal Ac ded on 11)	Accel Resul Accel (ft/s .100 090 .102 .102 :celera Result Accele (deg/s 7.717	ting Action	on Actual ons tual	Spec Cor (1b	sific P isumpti s/ft/se .544 .620 .167 .892 cific I nsumpti lbs/dee .025	Propella Propella ion Rate	ant e
Tra Con Tra +X +X +Y +Z Ro Con Ro	tati mman tati (ro	ational ded ation onal Ac ded on 11)	Accel Resul Accel (ft/s .100 090 .102 .102 .102 :celera Result Accele (deg/s 7.717	eratic ting A eratic sec ²)	on Actual ons	Spec Cor (1b 1 Spec Cor	cific P sumpti s/ft/se .544 .620 .167 .892 cific I nsumpti lbs/dec .025	Propella on Rate ec) Propella ion Rate g/sec)	ant e
Tra Con Tra +X +X +Y +Z Ro Con Ro - +X +Y	tati nman tati (ro (pi	ational ded ation onal Ac ded on 11) tch)	Accel Resul Accel (ft/s .100 090 .102 .102 .102 :celera Accele (deg/s 7.717 2.030	eratic ting A eratic sec ²)	on Actual ons	Spec Cor (1b 1 Spec Co: (cific P sumpti s/ft/se .544 .620 .167 .892 cific I nsumpti lbs/dec .025 .030	Propella Propella g/sec)	ant e
Tra Con Tra +X -X +Y +Z Ro ⁻ Con Ro ⁻ +X +Y	tati mman tati (ro (pi	ational ded ation onal Ac ded on 11) tch)	Accel Result Accel (ft/s .100 090 .102 .102 :celera Result Accele (deg/s 7.717 2.030	eratic ting A eratic sec ²)	on Actual ons	Spec Cor (1b	sific P isumpti s/ft/se .544 .620 .167 .892 cific I nsumpti lbs/dec .025 .030	Propella Propella g/sec)	ant e

Table XVIII

Simulation Results--IRV/Satellite Stabilization Control Mode

PA	RT]	LRESPC	NSE MA	TRIX					
	CMD	******	********	ACCELER	PATIONS ★+	*******	******	FROPE	LLANT
		TPANSL	. (FT/SEC	ZSECH	ROTAT	 DEG SEC	SEC	ивот -	LE SEC
C.	Cipital Cipital	X	7	Ζ	rol	pch	γ e ω	A	B
		0.210	a	a aaa	-0.001	0.333	-0.003	0.0533	0.0533
-	-00	-0.210	0.000	0.000	-0.001	-0.343	0.007	0.0533	0.0533
ŝ.	-00	-0.121	0.000	0.000	a aaa	a aaa	0.000	0.0000	0.0000
3	0+0	0.000	0.000	0.000	-0 001	0.000	-0 002	0.0533	0.0533
4	++0	0.210	0.000	0.000	-0.001	-0 242	0.000	0.0533	0.0533
2	-+0	-0.171	0.000	0.000	0.001	0.040	0.000	0.0000	0.0000
6	0-0	0.000	0.000	0.000	-0.000	0.000	-0.000	0.0000	0.0533
7.	+-0	0.210	0.000	0.000	-0.001	0.333	-0.003	0.0555	a a533
8	0	-0.191	0.000	0.000	-0.001	-0.343	0.007	0.0100	a aaaa
9	90+	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
0	+0+	0.210	0.000	0.000	-0.001	0.333	-0.000	0.00000	0.0500
1	-0+	-0.191	0.000	0.000	-0.001	-13.343	0.007	0.0000	0.0333
2	Ø++	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
3	+++	0.210	0.000	0.000	-0.001	0.333	-0.008	0.0533	0.0033
4	-++	-0.191	0.000	0.000	-0.001	-0.343	0.007	0.0533	0.0533
5	0-+	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
16	+-+	0.210	0.000	0.000	-0.001	0.333	-0.008	0.0533	0.0533
17	+	-0.191	0.000	0.000	-0.001	-0.343	0.007	0.0533	0.0533
18	00-	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
19	+0-	0.210	0.000	0.000	-0.001	0.333	-0.008	0.0533	0.0533
20	-0-	-0.191	0.000	0.000	-0.001	-0.343	0.007	0.0533	0.0533
21	0+-	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
22	++-	0.210	0.000	0.000	-0.001	0.333	-0.008	0.0533	0.0533
23	-+-	-0.191	0.000	0.000	-0.001	-0.343	0.007	0.0533	0.0533
24	A	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
25	÷	0.210	0.000	0.000	-0.001	0.333	-0.008	0.0533	0.0533
26		-0.191	0.000	0.000	-0.001	-0.343	0.007	0.0533	0.0533
		•••••						0000	ELL ANT
	CMD	******	********	ACCELE	HILUNS +	********	*******		1.6 167.
		TRANSL	, (FT-SEU	SEC)	RUTHT	UEG SE	JOEL/	0 I U U U	- LB- 5E-C-
C.	Sr 9		Y .	4	rol	pen	λam		Đ
	+00	0 000	a 21 0	0 000	-2.052	-0.002	-3,125	0.0533	0.0533
1	- 20	a aaa	-0.210	a aaa	2.052	0.002	3.125	0.0533	0.0533
-	-00	0.000	0.210	a aaa	16 364	a a 19	1.353	0.0533	0.0533
5	0+0	0.000	0.000	0.000	7 184	0.009	-0.002	0.0266	0.0266
4	++0	0.000	0.100	0.000	9 200	0.000	2.229	0.0200	0.0266
2	-+6	0.000	-0.105	0.000	7.200	-0.011	2,232	0.0200	0.0533
2	0-0	9.000	0.000	0.000	-10.364	-0.017	-2.229	0.0000	0.0266
7	+-0	0.000	0.105	0.000	-7.208	-0.011	-2.237	0.0200	0.0200
8	0	0.000	-0.105	0.000	-1.136	-0.008	U.000 7 AGO	0.0200	0.0200
9	00+	0.000	-0.105	0.000	1.1/1	0.001	2.078	0.0200	0.0200
10	+0+	0.000	0.000	9.000	0.290	0.000	1.070	0.0333 0.0355	0.0000
11	-0+	0.000	-0.105	0.000	1.171	0.001	2.098	0.0200	0.0200
12	Ø++	0.000	-0.105	0.000	9.353	0.011	2.774	0.0200	0.0777
13	+++	0.000	0.000	0.000	8.327	0.010	1.212	0.0266	0.0200
14	-++	0.000	-0.105	0.000	9.353	0.011	2.774	0.0266	0.0779
15	0-+	0.000	-0.105	0.000	-7.011	-0.008	1.422	0.0799	0.0266
16	+-+	0.000	0.000	0.000	-8.037	-0.009	-0.141	0.0265	0.0266
17	+	0.000	-0.105	0.000	-7.011	-0.008	1.422	0.0799	0.0266
18	99-	0.000	0.105	0.000	-1.171	-0.001	-2.098	0.0266	0.0266
19	+0-	0.000	0.105	0.000	-1.171	-0.001	-2.098	0.0266	0.0266
20	-0-	0.000	0.000	0.000	-0.290	-0.000	-1.070	0.0533	0.0533
21	0+-	0.000	0.105	0.000	7.011	0.008	-1.422	0.0266	0.0799
22	++-	0.000	0.105	0.000	7.011	0.008	-1.422	0.0266	0.0799
23	-+-	0.000	0.000	0.000	8.037	0.009	0.141	0.0265	0.0266
24	0	0.000	0.105	0.000	-9.353	-0.011	-2.774	0.0799	0.0266
25	+	0.000	0.105	0.000	-9.353	-0.011	-2.774	0.0799	0.0266
26		0.000	0.000	0.000	-8.327	-0.010	-1.212	0.0266	0.0266
	••			~ +~			ng the	reenart	ive a
x	~	3 D C 7	STOT T		1310110				

X, Y, and Z refer to translations along the respective axes. p,y, and r stand for pitch, yaw, and roll, respectively.

Simulation Results--IRV/Satellite Stabilization Control Mode

	CMD	******	*******	+ ACCELE	RETIONS +	*******	*******	PROP	FLIANT
	•	TRANS	L (ET/SE	C (SEC)	ROTAT	(DEG/SE	C/SEC)	ылот	(18.SEC)
С	Zrp	×		2	rol	pch	17 a w	A	B
-	- ,-			_	-		,		-
1	+00	0.000	0.000	0.210	0.037	2.671	0.003	0.0533	0.0533
2	-00	0.000	0.000	-0.210	-0.037	-2.671	-0.003	0.0533	0.0533
3	0+0	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
4	++0	0.000	0.000	0.210	0.037	2.671	0.003	0.0533	0.0533
5	-+0	0.000	0.000	-0.210	-0.037	-2.671	-0.003	0.0533	0.0533
6	0-0	0.000	0.000	0.000	0.000	0.000	0.000	0.0000	0.0000
7	+-0	0.000	0.000	0.210	0.037	2.671	0.003	0.0533	0.0533
8	0	0.000	0.000	-0.210	-0.037	-2.671	-0.003	0.0533	0.0533
9	00+	0.000	0.000	0.105	0.021	1.803	0.002	0.0266	0.0266
10	+0+	0.000	0.000	0.105	0.021	1.808	0.002	0.0266	0.0266
11	-0+	0.000	0.000	0.000	0.004	0.946	0.000	0.0533	0.0533
12	0++	0.000	0.000	0.105	0.021	1.808	0.002	0.0266	0.0266
13	+++	0.000	0.000	0.105	0.021	1.803	0.002	0.0266	0.0266
14	-++	0.000	0.000	0.000	0.004	0.946	0.000	0.0533	0.0533
15	0-+	0.000	0.000	0.105	0.021	1.808	0.002	0.0266	0.0266
16	+-+	0.000	0.000	0.105	0.021	1.808	0.002	0.0266	0.0266
17	+	0.000	0.000	0.000	0.004	0.946	0.000	0.0533	0.0533
18	00-	0.000	0.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
19	+0-	0.000	0.000	0.000	-0.004	-0.946	-0.000	0.0533	0.0533
20	-0-	0.000	0.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
21	0+-	0.000	0.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
22	++-	0.000	0.000	0.000	-0.004	-0.946	-0.000	0.0533	0.0533
23	-+-	0.000	0.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
24	0	9.000	0.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
25	+	、 900	0.000	0.000	-0.004	-0.946	-0.000	0.0533	0.0533
26		0.000	0.000	-0.105	-0.021	-1.808	-0.002	0.0266	0.0266
	CMD	******* TRANS	********	* ACCELE C/SEC)	RATIONS +	*******	*******	PROF WDOT	ELLANT
c	CMD	******* TRANS	******** L • FT SE	* ACCELE C/SEC) 7	RATIONS + POTAT rol	• DEG -SE	******* C/SEC)	PROF WDOT	ELLANT • LB 'SEC •
¢	CMD ripii	******* TRANS ::	******** L + FT : SE 7	* ACCELE C/SEC) Z	RATIONS + ROTAT rol	·DEG SE pch	****** C/SEC) yaw	PROF WDOT A	ELLANT • LB 'SEC • B
C 1	CMD r p +00	******* TRANS :: 0.000	******** L • FT • SE 7 0.000	+ ACCELE C/SEC) Z 0.000	RATIONS + POTAT rol 16.364	• DEG ~5E pch 0.019	****** C/SEC) yaw 1.353	PROF WDOT A 0.0533	ELLANT • LB 'SEC • B 0.0533
0 1 2	CMD rp++ +00 -00	******* Trans :: 0.000 0.090	L · FT ·SE 7 9.000 9.000	* ACCELE C/SEC) Z 0.000 0.000	RATIONS * POTAT rol 16.364 -16.364	• DEG -SE pch 0.019 -0.019	******* C-SEC) yaw 1.353 +1.353	PROF WDOT A 0.0533 0.0533	ELLANT • LB 'SEC • B 0.0533 0.0533
0 1 2 3	CMD rp** +00 -00 0+0	******* Trans :: 0.000 0.000 0.000	L · FT ·SE 7 9.000 0.000 0.000	* ACCELE C/SEC) 2 0.000 0.000 0.105	RATIONS + FOTAT rol 16.364 -16.364 8.021	• DEG -SE pch 0.019 -0.019 1.308	****** C-SEC) yaw 1.353 ~1.353 0.002	PROF WDOT A 0.0533 0.0533 0.0555	ELLANT +LB+SEC+ B 0.0533 0.0533 0.0553
0 1 2 3 4	CMD rp" +00 -00 0+0 ++0	******* TRANS :: 0.000 0.000 0.000 0.000	0.000 0.000 0.000 0.000 0.000 0.000	* ACCELE C>SEC) 2 0.000 0.000 0.105 0.105	PATIONS + FOTAT rol 16.364 -16.364 0.021 16.384	• DEG SE pch 0.019 -0.019 1.308 1.827	****** C>SEC) yaw 1.353 ~1.353 0.002 1.354	PROF WDOT A 0.0533 0.0533 0.0265 0.0265	ELLANT · LB 'SEC · B 0.0533 0.0533 0.0266 0.0266
0 12345	CMD +00 -00 0+0 ++0 -+0	******* TRANS :: 0.000 0.000 0.000 0.000 0.000	0.000 0.000 0.000 0.000 0.000 0.000 0.000	* ACCELE C/SEC) 2 0.000 0.000 0.105 0.105 0.105	RATIONS + FOTAT rol 16.364 -16.364 0.021 16.384 -16.343	• DEG SE pch 0.019 -0.019 1.308 1.308 1.789	C/SEC) yaw 1.353 -1.353 0.002 1.354 -1.351	PROF WDOT A 0.0533 0.0533 0.0265 0.0799 0.0799	ELLANT · LB 'SEC - B 0.0533 0.0533 0.0266 0.0799 0.0799
0 123456	CMD +00 +00 0+0 ++0 -+0 0-0	****** TRANS :: 0.000 0.000 0.000 0.000 0.000	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	* ACCELE (/SEC) 2 0.000 0.000 0.105 0.105 0.105 -0.105	RATIONS * FOTAT rol 16.364 -16.364 0.021 16.384 -16.343 -0.021	• DEG - SE pch 0.019 -0.019 1.308 1.827 1.789 -1.808	******* C-SEC) yaw 1.353 -1.353 0.002 1.354 -1.351 -0.002	PROF WDOT A 0.0533 0.0533 0.0266 0.0799 0.0799	ELLANT · LB 'SEC - B 0.0533 0.0533 0.0266 0.0799 0.0266
0 1434551	CMD +00 +00 0+0 ++0 -+0 0-0 +-0	TRANS :: 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	 ACCELE C>SEC> 2 0.000 0.000 0.105 0.105 0.105 -0.105 	PATIONS * FOTAT rol -16.364 0.021 16.384 -16.343 -0.021 16.343	 DEG > 5E pch 0.019 0.019 1.808 1.827 1.789 -1.789 	C-SEC) yaw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.351	PROF WDOT A 0.0533 0.0265 0.0799 0.0265 0.0799 0.0266 0.0799	ELLANT - LB-SEC - B 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799
0 1404000000	CMD +00 -00 ++0 ++0 -+0 0-0 +-0 0	TRANS :: 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	D.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	<pre>* ACCELE C SEC) 2 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105</pre>	PATIONS * FOTAT rol -16.364 0.021 16.384 -16.343 -0.021 16.343 -0.821 -16.384	• DEG -SE pch -0.019 1.308 1.827 1.789 -1.808 -1.789 -1.827	C SEC) yaw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.351 -1.354	PROF NDOT A 0.0533 0.05533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0799	ELLANT LB-SEC - B 0.0533 0.0533 0.0266 0.0266 0.0799 0.0266 0.0799 0.0269 0.0799
0 1234556588	CMD +00 -00 ++0 ++0 -+0 0-0 +-0 +-0 00+	****** TRANS :: 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000		 ACCELE SEC) 2 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105 0.000 	PATIONS * FOTAT rol 16.364 -16.364 0.021 16.384 -16.343 -0.021 16.343 -16.384 1.171	 DEG SE pch 0.019 0.019 1.808 1.789 1.808 1.789 1.808 0.001 	<pre>******* C>SEC)</pre>	PROF WDOT A 0.0533 0.0265 0.0265 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266	ELLANT LB-SEC - B 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266
0 1234567890	CMD +00 +00 ++0 ++0 0-0 +-0 0 +00 +00 +00	****** TRANS 2.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	L FT SE 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000 9.000	* ACCELE C/SEC) 2 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000	PATIONS * FOTAT rol 16.364 -16.364 0.021 16.384 -0.021 16.343 -16.384 -16.384 1.171 9.353	 DEG 'SE pch 0.019 0.019 1.308 1.808 1.789 1.808 1.789 1.808 0.011 	******* C>SEC) yaw 1.353 +1.353 -1.354 -1.351 -0.002 1.351 -1.351 -1.351 2.098 2.774	PROF WDOT A 0.0533 0.0253 0.0265 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266	ELLANT LB-SEC - B 0.0533 0.0253 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799
0 123456789011	CMD +00 0+0 +00 +00 +00 +00 +-00 00+ +00 00+ +00 +-00 +00+ +00+	TRANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 -0.105 -0.105	 ACCELE CSEC) 2 0.000 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.000 0.000 	RATIONS + FOTAT rol 16.364 -16.364 0.021 16.343 -0.021 16.343 -16.384 1.171 9.353 -7.011	 DEG SE pch 0.019 0.019 1.308 1.827 1.789 1.898 1.789 1.827 0.001 0.011 0.008 	******* C>SEC) yaw 1.353 -1.353 0.002 1.351 -1.351 -0.002 1.351 -1.354 2.098 2.774 1.422	PROF WDOT A 0.0533 0.0263 0.0263 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0299	ELLANT - LB -SEC - B 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266
0 12345678901112	CMD +00 +00 ++00 ++00 +-00 +-00 +-00 +00 +0	TRANS 	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 -0.105 -0.105 -0.105	 ACCELE C SEC) 2 0.000 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.000 0.000 0.000 0.000 0.105 	RATIONS * FOTAT rol 16.364 -16.364 0.021 16.384 -16.343 -0.021 16.384 1.171 9.353 -7.011 1.191	· DEG SE pch -0.019 1.308 1.827 1.789 -1.808 -1.789 -1.827 0.001 0.011 -0.008 1.810	C SEC) y W 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.351 -1.354 2.098 2.774 1.422 2.100	PROF WDOT A 0.0533 0.0265 0.0799 0.0265 0.0799 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0265 0.0265 0.0265 0.0265	ELLANT LB-SEC - B 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0266
0 123456789011123	C MD + 00 - 00 + 00 - 00 - 00 + 00 + 00 + 00	TRANS 	D.000 0.0000 0.000000	<pre>* ACCELE C SEC) Z 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.105 0.105</pre>	PATIONS * FOTAT rol 16.364 -16.364 -16.384 -16.343 -0.021 16.343 -0.021 16.343 -16.343 -16.384 1.171 9.353 -7.011 1.191 9.373	• DEG -5E pch • 0.019 -0.019 1.808 1.827 1.789 -1.808 -1.789 -1.827 0.001 0.011 -0.008 1.819	****** C SEC) y aw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.351 -1.351 -1.351 2.098 2.774 1.422 2.100 2.776	PROF WDOT A 0.0533 0.05533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0265 0.0265 0.0265 0.02533 0.0533	ELLANT LB-SEC - B 0.0533 0.0266 0.0799 0.0266 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0799 0.0266 0.0799 0.0266 0.0265 0.0266 0.0265 0.0255 0.0265 0.0265 0.0265 0.0265 0.0265 0
0 123456789011234	C M D + 00 0 + 00 0 + + 0 0 - 00 + + 0 0 - 00 + - 00 + 0 + + 0 + + + 0 + + +	TRANS 	L FT SE 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 -0.105 -0.105 -0.105 -0.105 -0.105	* ACCELE C SEC) Z 0.000 0.105 0.105 -0.105 -0.105 -0.105 0.105 0.000 0.000 0.000 0.105 0.105 0.105 0.105	PATIONS * FOTAT rol 16.364 -16.364 -0.021 16.384 -16.343 -0.021 16.343 -0.021 16.384 1.171 9.353 -7.011 1.191 9.373 -6.991	DEG SE pch 0.019 -0.019 1.808 -1.789 -1.808 -1.789 -1.808 -1.789 -1.808 1.827 0.001 0.011 -0.008 1.819 1.800	******* C>SEC) yaw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.354 2.098 2.774 1.422 2.100 2.776 1.423	PROF WDOT A 0.0533 0.0265 0.0265 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0253 0.0533 0.1065	ELLANT LB-SEC - B 0.0533 0.0533 0.0266 0.0799 0.0266 0.0533 0.0533
0 1234567890112345	C M D + 000 0++00 +++00 ++00 +-00 +00 +00 +00 +0	****** TRANS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	L FT SE 0.000 0.005 -0.105 -	+ ACCELE C SEC) Z 0.000 0.000 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.000 0.105 0.105 0.105 -0.105	PATIONS * FOTAT rol 16.364 -16.364 0.021 16.384 -16.383 -0.021 16.383 -16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150	 DEG 'SE pch 0.019 0.019 1.308 1.789 1.789 1.808 1.789 1.808 1.810 1.810 1.810 1.810 1.810 1.810 1.800 1.800 	******* C>SEC) yaw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.351 -1.351 2.098 2.774 1.422 2.100 2.776 1.423 2.096	PROF WDOT A 0.0533 0.0265 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.02533 0.0533 0.0533	ELLANT LB 'SEC ' B 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.1065 0.0533 0.0533
0 1234567890123456	C M D + 000 0+00 + +00 + +00 + -00 + 00 + 00	TRANS 0.0000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000000	0.000 0.0000 0.000000	 ACCELE C SEC) Z 0.000 0.105 	PATIONS * FOTAT rol 16.364 -16.364 0.021 16.384 -16.384 -16.384 -16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150 9.332	· DEG - SE pch 0.019 1.808 1.827 1.789 -1.808 -1.789 -1.827 0.001 0.011 0.011 0.008 1.810 1.810 1.810 1.807 -1.798	C SEC) y aw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.351 -1.354 2.098 2.774 1.422 2.100 2.776 1.423 2.096	PROF WDOT A 0.0533 0.0533 0.0265 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.02533 0.0533 0.0533 0.0533	ELLANT LB'SEC - B 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.1065 0.0533 0.1065
0 12345678901234567	C M D + 000 + 000 + + + 00 + + + 00 + - 00 + 00 +	TRANS 	0.000 0.0000 0.000000	 ACCELE SEC) 2 0.000 0.105 	PATIONS * FOTAT rol 16.364 -16.364 -16.384 -16.343 -0.021 16.343 -0.021 16.343 -16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150 9.332 -7.032	• DEG - SE pch 0.019 -0.019 1.308 1.827 1.789 -1.808 -1.827 0.001 0.011 -0.008 1.810 1.810 1.810 1.810 -1.800 -1.807	****** C SEC) y W 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.351 -1.354 2.098 2.774 1.422 2.100 2.776 1.423 2.096 2.773 1.420	PROF WDOT A 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.02533 0.0533 0.1065 0.0533 0.1065	ELLANT LB-SEC - B 0.0533 0.0266 0.0799 0.0266 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0265 0.0265 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.05553 0.05553 0.05553 0.05553 0.05555 0.05555 0.05555 0.05555 0.055555 0.055555 0.055555 0.05555555555
0 1234567890112345678	C MD +0000 +0000 ++++00 +++00 +000 +00 +00	****** TRANS 0.000	- FT SE 0.000 0.005 -0.105	* ACCELE (SEC) 2 0.000 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.000 0.000 0.105 -0.000	PATIONS * FOTAT rol 16.364 -16.364 -16.384 -16.343 -0.021 16.343 -0.021 16.343 -16.343 -16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150 9.332 -7.032 -7.032 -1.171	· DEG - SE pch 0.019 -0.019 1.808 1.827 1.789 -1.809 -1.827 0.001 0.011 -0.008 1.819 1.800 -1.807 -1.789 -1.807 -1.800 -1.807 -1.8000 -1.80000 -1.80000 -1.80000 -1.80000 -1.800000 -1.80000 -1.80000000 -1.800000000 -1.8000000000000000000000000000000000000	****** C SEC) yaw 1.353 0.002 1.354 -1.351 -0.002 1.351 -0.002 1.351 -0.002 2.774 1.420 2.776 1.420 2.776 1.423 2.096 2.776 1.420 2.796 2.726 1.420 2.796 2.726 1.420 2.798	PROF WDOT 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.1065 0.0533 0.1065 0.0533 0.1065 0.0266	ELLANT LB-SEC - B 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.1065 0.0533 0.1065 0.0533 0.1065 0.0533 0.0266
0 12345678901123456789	C MD +0000+++00 +++000+++++++++ 0+000+++++++	****** TRANS 0.000	D.000 0.005 0.005	* ACCELE C SEC) Z 0.000 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.105 0.105 0.105 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.000	PATIONS * FOTAT rol 16.364 -16.364 -16.384 -16.384 -16.343 -0.021 16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150 9.332 -7.032 -1.171 7.011	· DEG - 5E pch 0.019 -0.019 1.808 -1.789 -1.808 -1.789 -1.808 -1.789 -1.807 -1.819 1.800 1.819 1.800 -1.807 -1.798 -1.817 0.001 0.001 0.001	******* C SEC) y aw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.354 2.098 2.774 1.422 2.100 2.776 1.423 2.096 2.773 1.420 2.098 -1.422	PROF WDOT 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0266 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0265	ELLANT LB SEC - B 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.1065 0.0533 0.0533 0.1065 0.0533 0.0539 0.0266 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.05566 0.07999 0.05555 0.05566 0.055555 0.05566 0.0555555 0.05566 0.05566 0.0555555 0.05566 0.0555555 0.0556555555555555555555555555555555555
0 123456789011234567890	C M D + 000 + + 000 + + + 00 + + + 00 + - 00	****** TRANS .: 0.000		+ ACCELE C SEC) Z 0.000 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.105 0.105 -0.105 -0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.000	PATIONS * FOTAT rol 16.364 -16.364 -0.021 16.384 -16.343 -0.021 16.343 -0.021 16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150 9.332 -7.032 -7.011 -9.353	 DEG 5E pch 0.019 0.019 1.308 1.789 1.789 1.789 1.808 1.789 1.827 0.001 0.011 0.008 1.810 1.800 1.807 1.807 1.807 1.807 1.817 0.001 0.011 0.001 0.011 	****** C > SEC) Y aw 1.353 0.002 1.351 -0.002 1.351 -0.002 1.351 -2.098 2.774 1.422 2.100 2.773 1.420 -2.774	PROF WDOT 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.02533 0.0533 0.1065 0.0533 0.1065 0.0266 0.0266 0.0266 0.0266 0.0299	ELLANT LB SEC - B 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.1065 0.0533 0.1065 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.05533 0.0266 0.0799 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0799 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.02799 0.0266 0.02799 0.0266 0.02799 0.0266 0.02799 0.0266 0.02799 0.0266 0.0266 0.02799 0.0266 0.0266 0.02799 0.0266 0.0266 0.0799 0.0266 0.02799 0.0266 0.0266 0.0533 0.1065 0.0533 0.0266 0.0533 0.1065 0.0266 0.0533 0.0266 0.0533 0.1065 0.0266 0.02533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.05533 0.0266 0.0266 0.0266 0.0533 0.0266 0.0266 0.0265 0.0266
0 1234567890112345678901	C M D + 000 + + 000 + + + 000 + + + + + + + +	TRANS 		 ACCELE SEC) 2 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.000 0.000 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.105 0.000 0.105 	PATIONS * FOTAT rol 16.364 -16.364 -16.384 -16.343 -0.021 16.384 -16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150 9.332 -7.012 -7.011 1.150	· DEG 5E pch 0.019 1.303 1.827 1.789 -1.803 -1.803 -1.827 0.001 0.011 1.810 1.810 1.810 1.810 1.810 1.810 -1.798 -1.817 -0.001 0.001 1.807	C SEC) y aw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.354 -1.351 -1.354 2.098 2.776 1.420 2.773 1.420 -2.098 -1.420 -2.096	PROF WDOT 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0799 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533	ELLANT LB'SEC - B 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.1065 0.0533 0.0533 0.0533 0.0533 0.0533 0.0266 0.0799 0.0266 0.0793
0 1234567890123456789012	C m D · · · · · · · · · · · · · · · · · ·	TRANS 		* ACCELE C SEC) Z 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105 -0.105 -0.105 0.105 0.105 0.105 0.000 0.000 0.105 0.000 0.005 0.005 0.005 0.005 0.005 0.000 0.000 0.005 0.005 0.005 0.000 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.005 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.000000	RATIONS * FOTAT rol 16.364 -16.364 -16.384 -16.343 -0.021 16.343 -0.021 16.343 -0.021 16.343 -16.384 1.171 9.353 -7.011 1.150 9.353 -1.150 7.032	· DEG - 5E pch 0.019 1.308 1.827 1.789 -1.808 -1.827 0.001 0.011 -0.008 1.810 1.810 1.810 1.810 1.810 1.817 -1.798 -1.817 -0.001 0.008 -1.817 -0.001 0.008	****** C SEC) y W 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.354 -1.354 2.098 2.774 1.422 2.100 2.776 1.423 2.098 2.773 1.420 -2.098 -1.422 -2.096 -1.420	PROF WDOT 0.0533 0.0533 0.0533 0.0266 0.0799 0.0266 0.0266 0.0266 0.02533 0.0533 0.1065 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.0533	ELLANT LB-SEC - B 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.1065 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0265 0.0533 0.0266 0.0533 0.0265 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0533 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0265 0.0266 0.0265 0.0265 0.0265 0.0265 0.0265 0.0265 0.02533 0.0265 0.02533 0.0266 0.02533 0.0265 0.02533 0.0266 0.02533 0.0266 0.02533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.0533 0.0256 0.05533 0.0256 0.05533 0.0256 0.05533 0.0256 0.05533 0.05553 0.05533 0.05533 0.05533 0.05533 0.05533 0.05533 0.05555 0.05555 0.055555 0.0555555 0.05555555555
0 12345678901234567890123	C MD + 0000 + + + + + + + +	TRANS 	- FT SE 0.000 0.105 -0.105 0.105	* ACCELE C SEC) Z 0.000 0.105 0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.000 0.105 0.105 -0.105 -0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.005 0.005 0.000 0.000 0.000 0.000 0.005 0.005 0.000 0.005 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000 0.000000	PATIONS * FOTAT rol 16.364 -16.364 -16.343 -0.021 16.384 -16.343 -0.021 16.343 -0.021 16.343 -0.021 16.384 1.171 9.353 -7.011 1.150 9.332 -7.032 -1.171 7.011 -9.353 -1.150 -7.032 -3.332	· DEG - SE pch 0.019 -0.019 1.808 -1.789 -1.809 -1.809 -1.827 0.001 0.011 -0.008 1.819 1.800 -1.807 -1.798 -1.807	****** C SEC) y aw 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.354 -1.354 2.098 2.774 1.422 2.1096 2.776 1.423 2.096 2.774 1.422 -2.098 -1.422 -2.098 -1.422 -2.774 -2.098 -1.420 -2.773	PROF WDOT 0.0533 0.0533 0.0533 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.1065 0.0533 0.1065 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0533 0.1065 0.0266 0.0256 0.0533 0.1065 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0533 0.1065 0.0266 0.0533 0.1065 0.0266 0.0533 0.1065 0.0266 0.0533 0.1065 0.0266 0.0533 0.1065 0.0266 0.0533 0.1065 0.0266 0.0533 0.1065 0.0266 0.0533 0.1065 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0533 0.1065 0.0266 0.0266 0.0253 0.0266 0.0266 0.0533 0.1065 0.0266 0.0533 0.1065 0.0553 0.0553 0.0553 0.0553 0.0553 0.0553 0.05555 0.05555 0.05555 0.055555 0.055555 0.05555555555	ELLANT LB-SEC - B 0.0533 0.0533 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.0533 0.1065 0.0533 0.0266 0.0533 0.0266 0.0799 0.0266 0.0533 0.0266 0.0799 0.0266 0.0533 0.0533 0.0533
0 123455789012345578901234	C MD + 0000 + + + + + + + +	TRANS 	L FT SE 0.000 0.105 -0.105 0.105	* ACCELE C SEC) Z 0.000 0.105 0.105 0.105 -0.105 -0.105 0.000 0.000 0.105 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.000000	PATIONS * FOTAT rol 16.364 -16.364 -16.384 -16.343 -0.021 16.384 -16.343 -0.021 16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150 9.332 -7.032 -1.171 -9.353 -1.150 7.032 -3.332 -1.191	· DEG - 5E pch 0.019 -0.019 1.808 -1.789 -1.808 -1.789 -1.808 -1.789 -1.819 1.819 1.800 -1.819 1.800 -1.819 1.800 -1.817 -0.001 1.819 -1.817 -0.001 1.817 -1.810	******* C SEC) y ww 1.353 -1.353 0.002 1.354 -1.351 -0.002 1.354 -1.354 2.098 2.774 1.422 2.100 2.773 1.420 2.774 1.422 2.096 2.774 -2.098 -1.420 -2.774 -2.096 -1.420 -2.773 -2.100	PROF WDOT 0.0533 0.0533 0.0799 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.0266 0.0266 0.02533 0.0533 0.1065 0.0266 0.0266 0.02533 0.106533 0.05333 0.106533 0.106533	ELLANT LB-SEC - B 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.1065 0.0533 0.1065 0.0533 0.1065 0.0533 0.0533
0 1234557890123455789012345	C M D + 000 + + 000 + + 000 + + 000 + + 000 + + + +	****** TRANS 0.000	L FT SE 0.000 0.005 0.1055	* ACCELE C SEC) Z 0.000 0.105 0.105 -0.105 -0.105 -0.105 0.000 0.000 0.105 0.105 0.105 -0.105 -0.105 -0.105 -0.105 -0.105 0.000 0.000 0.105 -0.105 0.105 -0.105 -0.105 -0.105	PATIONS * FOTAT rol 16.364 -16.364 -0.021 16.384 -16.343 -0.021 16.343 -0.021 16.384 1.171 9.353 -7.011 1.191 9.373 -6.991 1.150 9.332 -7.032 -1.171 -9.353 -1.150 7.032 -3.332 -1.191 6.991	· DEG - 5E pch 0.019 1.308 1.827 1.789 -1.808 -1.789 -1.808 1.819 1.819 1.807 -1.819 1.800 -1.817 -0.008 1.817 -1.817 -0.008	******* C SEC) y aw 1.353 0.002 1.354 -1.351 -0.002 1.354 -1.351 -0.002 1.354 2.098 2.774 1.422 2.100 -2.774 -2.096 -1.420 -2.774 -2.096 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.420 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.774 -2.006 -1.422 -2.776 -2.006 -1.422 -2.776 -2.100 -1.423	PROF WDOT 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0266 0.0266 0.0266 0.02533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533 0.0533	ELLANT LB SEC B 0.0533 0.0533 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0799 0.0266 0.0533 0.1065 0.0533 0.0533 0.1065 0.0533 0.1065

100

Table XVIII (cont.)

Simulation Results--IRV/Satellite Stabilization Control Mode

PART 2ACT	UAL ACCELERA	TIONS								
Rotational	Rotational Acceleration									
Commanded Rotation	Accel	eration	Specific Propellant Consumption Rate							
	Rotation (deg/sec ²)	Translation (ft/sec ²)	(IDS/deg/sec)							
+X (roll)	14.701	X =010 Y =040 Z = .040	.029							
+Y (pitch)	1.808	X = .104 Y =002 Z = .014	.030							
+Z (yaw)	1.982	X = .014 Y =102 Z =046	.041							
AAH maintai control law	ned all unco limits.	mmanded rotation	al rates within							

Analysis of Results

いたいための問題がたがたためで見た

<u>Validation</u>. MILMU predicted solo MMU translational acceleration in the +X direction of .246 ft/sec , .240 ft/sec in the +Y direction, and .270 in the +Z direction. Predicted rotational accelerations were 9.079 deg/sec in roll, 8.506 deg/sec in pitch, and 8.270 deg/sec in yaw. Predicted propellant consumption rate was .0266 lbs/sec per thruster. These values generally agree with published MMU performance data of .280 ft/sec translational acceleration along all three axes; rotational accelerations of 9.17 deg/ $\frac{2}{2}$ sec roll, 8.75 deg/sec pitch, and 8.72 deg/sec yaw; and a

propellant consumption rate of .027 lb/sec per thruster (12:9). The agreement between MILMU-predicted performance parameters and published information validated the program and increased confidence in subsequent results.

IRV Stability. Study of the phase plane plots in Appendix D revealed that AAH was able to limit uncommanded rotations to within the control law deadbands, for all translations and rotations and in all control modes except one. While operating in the Backup control mode, during translations along the Y axis, yaw due to the offset mass center was driven beyond the .2 deg/sec rate error deadband and continued to increase as long as a +/- Y translation was commanded. The yaw acceleration was opposite in sign to the translation direction. Upon termination of the Y translation command, however, AAH was able to null all rates and reestablish the IRV within the original attitude deadband. This inability of AAH to maintain a fixed yaw attitude implies that the IRV pilot forced to operate in the Backup mode should limit Y-axis translations to short durations followed by a quiet period to allow AAH to null the resulting yaw attitude error.

<u>IRV Performance</u>. Comparison of Primary Mode (Table XVI, Part 2) runs with the Solo MMU runs (Table XV, Part 2) confirmed the anticipated reduction in translational and rotational acceleration, and increase in specific fuel consumption. Table XIX documents the decrease in IRV performance. IRV translational accelerations along all three axes

Table XIX

Translat	tiona	1 Accel	leratio	on					
Command		Rest Accele (ft)	is	Specific Propellant Consumption Rate (lbs/ft/sec)					
	So MM	10 U II	۶ RV Ch	nange	S M	olo MU	IRV	% Char	nge
+ X	.24	6.19	98 -	-20	.3	90	.511	+31	L
-x	24	61	76 -	-28	.3	90	.568	+4(5
+Y	.24	0.1	14 -	-53	.4	00	.937	+13	34
+ Z	.270 .1		36 -	-50		97	.807	+10)3
Rotation	nal A	ccelera	ation						
Command		Re Acc (c	esultir celerat deg/sec	ig ion 2)		S	pecif Consu (1bs	ic Prop mption s/deg/s	pellant Rate sec)
		Solo MMU	IRV	% Chang	e	S M	olo MU	IRV	۶ Change
+X (roll	1)	9.08	7.80	-14		•	009	.057	+533
+Y (pito	ch)	8.51	2.02	-76		.	007	.030	+329

Solo MMU/IRV Performance Comparison

suffered from the IRV's increased mass; however, Y-and Zaxis translational accelerations were also degraded by the IRV's 12-inch X-axis offset between the center of mass and center of thrust. This offset forced the automatic attitude hold (AAH) control system to modulate the appropriate thrusters' on-times to cancel the significant rotational moments induced by full-on Y- and Z-axis translational commands.

-83

.010

.049

+390

+Z (yaw)

8.27

1.41

IRV rotational accelerations were degraded by the increases in moments of inertia. IRV roll acceleration was reduced only 14 percent, while pitch and yaw accelerations were reduced an average of 80 percent. These results reflect the relatively small increase in IRV Ixx (15 percent) compared to the solo MMU, and the large increases in Iyy and Izz (285 and 435 percent, respectively).

Increases in IRV specific fuel consumption (compared to the solo MMU) resulted from the increases in mass and moments of inertia. However, roll axis specific propellant consumption increased much more than could be accounted for by the increased Ixx. Comparison of the applicable phase plane plots in Appendix D revealed that plume impingement during IRV roll commands caused significantly greater coupled yaw, which was nulled by AAH at the expense of more propellant.

The effect of plume impingement was revealed in Table XVI, Part 2, wherein it was noted that the -X thrusters (which impinge upon the attached PRE) produced 11 percent less acceleration and suffered 11 percent greater specific fuel consumption than the +X thrusters (which do not impinge).

As already mentioned, of the two Backup control modes only the Backup B mode was simulated. The results, however, are also generally applicable to the Backup A mode. As displayed in Table XX, the Backup B control mode provided IRV rotational accelerations equivalent to those in the Primary mode. This was as expected because, as shown in the

Table XX

Translational Acceleration										
Command	Resulting Accelerations (ft/sec ²)					Specific Propellant Consumption Rate (lbs/ft/sec)				
	P	rim	BUB	१ Change		Prim	BUB	۶ Change		
+ X	•	198	.100	-49		.511	.544	+6		
-x	:	176 -	.090	-49		.568	.620	+9		
+Y	•	114	.102	2 -11		.937	1.167	+25		
+ Z	•	136	.102	-25		.807 .8		+11		
Rotational Acceleration										
Command		A	Resulti ccelera (deg/se	ng tion c ²)		Specific Propellant Consumption Rate (lbs/deg/sec)				
		Prim	BUB	% Change		Pri	m BU	% B Change		
+X (roll)	7.80	7.72	+1		.05	7.0	25 -128		
+Y (pitch)		2.02	2.03	0		.03	0.0	30 0		
+Z (yaw)		1.41	1.40	0		.04	9.0	50 +2		

IRV: Primary Control Mode/Backup B Control Mode Performance Comparison

thruster select tables in Appendix A, both modes use two thrusters to produce the necessary moments. Backup mode translational accelerations, however, were significantly degraded because only two thrusters, instead of the normal four, were available for use. Specific propellant consumption remained the same, except for the positive roll command, where a 50 percent decrease occurred from that experienced in the Primary mode. Reference to the applicable phase plane plots (Appendix D) showed that the fuel savings resulted from a decrease in coupled yaw. The reason for this decreased coupled yaw was not clear from the results of the limited number of simulation runs conducted in the Backup mode.

Analysis of the Satellite Stabilization (Sat Stab) mode thruster select logic tables (Appendix A) and the response matrix in Table XVIII (Part 1), revealed that this control mode was not preferred. Sat Stab mode reduces plume impingement on forward mounted payloads by producing rotations without utilizing the forward-firing thrusters. This would be marginally advantageous for the IRV, except that Sat Stab produces yaw and pitch by taking advantage of rotations coupled from translational commands. For example, to obtain a positive yaw, Sat Stab fires two +Y thrusters (L1B and L3A--see Appendix A for thruster positions) which produce a moment about the forward displaced mass center. For the IRV, however, this firing scheme also produced an undesireable -Y translational acceleration of .104 ft/sec . Similar rotation-to-translation coupling was obtained from pitch commands. This was determined to be undesireable because the IRV must be capable of delicate maneuvering to successfully rendezvous with a tumbling stranded orbiter.

Chapter Summary

MILMU simulation was conducted to determine IRV stability and performance. The program was first validated by simulating the solo MMU and comparing the predicted performance to published figures. IRV simulation runs included translational and rotational commands in the Primary, Backup, and Satellite Stabilization modes. Results showed that AAH was capable of limiting uncommanded IRV rotations to within the control law deadbands during all simulated maneuvers and in all control modes, except during Y translations in the Backup control mode. The IRV's increased mass and increased center-of-mass/center-of-thrust offset caused significant reductions in acceleration and increases in specific fuel consumption. Plume impingement, however, was found to be of minor importance. Translational accelerations in the Backup control mode were found to be one-half those in the Primary mode, but rotational accelerations were unaffected. The Satellite Stabilization mode was found to have significant rotational-to-translational coupling which made it undesireable for IRV use.

VI. IRV Operation

Chapter Overview

This chapter answers Research Question 3 by presenting procedures which crewmembers of both stranded and rescue orbiters could implement to effect a successful rescue using the IRV. Only an all-American, orbiter-to-orbiter rescue scenario was studied, but portions of the procedures presented herein would also apply to a U.S.-U.S.S.R. rescue mission.

Preparations

<u>Rescue Orbiter</u>. Within three days of notification, a rescue shuttle would be outfitted with two MMUs, two modified stingers, and the required number of PREs and portable oxygen systems. The rescue orbiter would be launched to rendezvous with the disabled spacecraft, and would take up a stationkeeping position approximately 100 feet away from the stranded orbiter (12:27).

Two rescue astronauts would enter the rescue orbiter's airlock and don their spacesuits. The MMU pilot's spacesuit would be equipped with a Mini-Work Station carrying the modified Probe in a tool caddy, and two adjustable wrist tethers attached to the torso tether rings as explained in Chapter III.

Following depressurization, the IRV pilot would trans-

late via handrails to the Flight Service Station and prepare and don the MMU as described in Chapter II. The other rescue astronaut would disconnect a modified ACD from its carrying bracket and help the IRV pilot attach it to the MMU hand controller arms (11:28). The IRV pilot would then release the IRV from the Flight Support Station and set his course for the stranded orbiter.

<u>Stranded Orbiter</u>. Upon discovery of the emergency situation, the stranded crewmembers would conserve consumables by powering down all unnecessary systems and limiting their activities.

After rendezvous by the rescue orbiter, one stranded astronaut would don his spacesuit, undergo depressurization, and exit into the payload bay so as to be able to aid the approaching IRV pilot. Two non-spacesuited astronauts would don PREs as described in Chapter II. The one astronaut now in the stranded orbiter's cabin who was allocated a spacesuit would act as a PRE "shepherd", and would position the two PREs inside the airlock, attach an air umbilical to each PRE, close the inner hatch, and depressurize the airlock. The PREs would remain in the airlock, connected to air umbilicals, until removed by the spacesuited stranded astronaut for attachment to the IRV.

Rescue Operations

As explained in Chapter I, this scenario assumes that the stranded orbiter is slowly tumbling. MILMU, as imple-

mented on the Hewlett-Packard 9825, was found unsuitable for simulating the complicated maneuvering required to successfully dock with a tumbling target. This was because the graphics screen was updated only once every 7.5 seconds, which was not frequent enough to give the simulation pilot enough information for accurate flying. Consequently, the following approach and docking procedure is presented without the benefit of simulation testing. It is offered as a baseline procedure, subject to modification or abandonment, as justified by follow-on simulation.

The IRV pilot would time his approach so that the stranded orbiter's payload bay rotated into the line of flight just as he arrived. Once established in the payload bay, the IRV pilot could dock with the stranded orbiter in one of two ways. The first method would be to lock his boots into a portable foot restraint (see Appendix B) affixed to the sidewall or the centerline of the payload bay. The second method would be for the IRV pilot to "land" on the forward payload bay bulkhead, as shown in Figure 6.1. He would then attach the free end of the left adjustable wrist tether (the other end being connected to the left torso tether ring) to the vertical handrail above the airlock hatch and shorten it until it held the the IRV firmly against the bulkhead. The thermal protection blanket which covers the bulkhead would serve as a docking fender to prevent damage to the MMU or the orbiter.



Figure 6.1. IRV Attached to Forward Bulkhead of Stranded Orbiter

After docking, the EVA stranded astronaut would open the outer airlock hatch, disconnect one PRE from its air umbilical and remove it from the airlock, and position it for attachment to the modified ACD.

To attach the PRE, the EVA stranded astronaut would extend the 4-foot tether from the MMU pilot's Mini-Work Station so that the tether projected forward out of the modified ACD's "basket", and would attach the tether to the

.÷ .

. . .

PRE's carrying strap. The self-reeling tether's .6 lb of takeup force would slowly retract the PRE into the modified ACD's "basket" and pull the carrying strap within reach of the MMU pilot (18:3.3-3). The MMU pilot would connect the adjustable wrist tether from the right torso tether ring to the carrying strap, and tighten it as necessary to secure the PRE against the modified ACD structure (34). The IRV would then return to the rescue orbiter.

Upon reaching the rescue orbiter's payload bay, the IRV pilot and EVA rescue astronaut would disconnect the PRE and place it in the airlock. The EVA rescue astronaut would attach an air umbilical to the PRE. The IRV pilot would then begin another flight to the stranded orbiter to pick up the next PRE.

After the IRV's departure from the stranded orbiter with the second PRE, the stranded EVA astronaut would close the outer airlock door and the airlock would be pressurized to accept two more PREs. After the second PRE was inserted into the rescue orbiter's airlock it, too, would be pressurized and the PREs removed into the main cabin, where their occupants would egress. The rescue orbiter's airlock would then be depressurized again in preparation for receiving two more PREs. This cycle would be repeated until all PREs were transferred.

IRV Recharging

Definitive IRV endurance figures which take into ac-

count the intense maneuvering necessary for docking with the tumbling orbiter can only be obtained in a real-time, high fidelity simulation, and therefore were beyond the capabilities of MILMU. However, it is certain that the rescue procedure described above would have to be interrupted several times to allow recharging of the MMU's propellant tanks.

When recharging was necessary, the IRV pilot would hand off the PRE to the EVA rescue astronaut, then land on the Flight Support Station's foot restraint platform and lock the MMU into the Flight Support Station's latches as described in Chapter II. To save time, he and the modified ACD would stay attached to the MMU. After depositing the PRE in the airlock, the EVA rescue astronaut would translate to the Flight Support Station, connect the recharging hose, and refuel the MMU's propellant tanks. A full recharge would take approximately five minutes (9:4-23--4-24).

Spacesuited Stranded Astronaut Transfer

The two spacesuited stranded astronauts would be transferred to the rescue orbiter after all PREs had been transported. Procedures for this transfer have been developed and tested by Johnson Space Center's Crew System's Division and the Martin Marietta Aerospace Corporation.

Following the transfer of the last PRE, the modified ACD would be removed from the MMU and returned to its cradle. The Mini-Work Station would also be doffed. The



Figure 6.2. Spacesuited Crewmember Rescue (26:6)

MMU pilot would then return to the stranded orbiter and position himself in front of, but upside down with respect to, a stranded EVA astronaut who would be secured in a portable foot restraint.

The MMU pilot would attach the two adjustable wrist tethers from his torso rings to the victim's torso rings and shorten them to pull the victim securely against the MMU controller arms and the pilot's lower legs. Figure 6.2 shows the resulting configuration. The stranded EVA astronaut would then step out of the foot restraint, and the MMU pilot would fly back to the rescue orbiter. The procedure would be repeated for the second spacesuited stranded astronaut (26:6).

Rogers reports that this method of connecting a spacesuited astronaut to the MMU has been tested in Johnson Space Center's Weightless Environment Training Facility, and found acceptable (26:4). In addition, Martin Marietta's MMU simulator was programmed with the mass properties of this configuration and several simulated rescue scenarios flown. The results of the simulations showed control response to be sluggish but stable (26:7).

Comments

Faster rescue operations could be achieved by simultaneously using two IRVs. Essentially the same procedures as described above could be used.

The proposed rescue procedures assume that the required number of PREs and portable oxygen systems are carried aboard the stranded orbiter. If this were not the case, portable oxygen systems and deflated PREs could be carried to the stranded orbiter by the IRV on its first fly-over. All equipment would be placed inside one PRE, which would be inflated and attached to the modified ACD as already explained. Upon arrival at the stranded orbiter, the PRE would be inserted into the airlock, repressurized, and its contents distributed to the non-spacesuited stranded astronauts. Subsequent procedures would remain unchanged from those already described.

The proposed procedures also assume an operational airlock on the stranded orbiter. Should this not be the

case, two stranded astronauts could don their spacesuits and all others would enter their PREs. The stranded orbiter's entire cabin would then be depressurized and rescue operations conducted through either the airlock hatch or the side hatch. This alternative procedure would require close monitoring of each PRE's remaining oxygen, and possibly cycling the PREs across the two air umbilicals to preclude portable oxygen system exhaustion prior to rescue.

Chapter Summary

Į

This chapter has answered Research Question 3 by proposing procedures for using the IRV to rescue the crew of a stranded space shuttle orbiter. Although approach and docking simulation proved impossible because of MILMU's slow update cycle time, baseline procedures were presented for rescue preparations, rescue operations, and IRV recharging. Alternative procedures were outlined for the simultaneous use of two IRVs, carrying the PREs to a non-equipped stranded orbiter, and rescue operations with a stranded orbiter suffering airlock failure.

VII. Conclusions and Recommendations

Chapter Overview

This chapter presents the three research questions and summarizes the answers as determined by this project. Also presented is a list of recommended follow-on research.

Conclusions

Research Question 1: "What is a mechanically and operationally sound method of attaching the PRE to the MMU, using only minimally modified and available flight-qualified hardware, to arrive at an Interim Rescue Vehicle (IRV)?

<u>Answer</u>: A list of requirements was developed describing a suitable MMU/PRE connecting device. This list included: off-the-shelf components, adequate pilot visibility, ease of use, ease of stowage, lack of critical fits, quick response, crew safety, and adequate IRV performance and stability. The Apogee Kick Motor Capture Device (ACD) was modified and fit tests conducted with the MMU, PRE, and ACD payload bay attachment bracket. These tests revealed that the modified ACD adequately fulfilled all requirements except ease of use, and was inconclusive concerning visibility, stability, and performance.

The ease of use requirement was violated because the PRE carrying strap fell eight inches outside the reach of the MMU pilot. Therefore, it was recommended that the PRE carrying straps be lengthened from their current six to twenty

inches. Furthermore, it was recommended that the IRV pilot be equipped with a hook tool for grappling the PRE handle and pulling it within his grasp. It was shown that this tool could be obtained by modifying the standard EVA Probe tool.

A visibility experiment was conducted on 22 USAF pilots which indicated that the visibility afforded by the IRV configuration was sufficient for successful flight operations.

<u>Research Question 2</u>: "What is the stability and performance of the IRV?

Answer: This question was answered by simulating IRV flying qualities with an already existing NASA MMU flight simulation computer program, Man-In-The-Loop Maneuvering Unit (MILMU). First, the required inputs were gathered concerning MMU, modified ACD, PRE, victim, and portable oxygen system mass properties to arrive at the mass properties of the complete IRV. Also, plume impingement information was obtained. The program was validated by simulating the solo MMU and comparing the predicted performance to published figures. Simulation was then conducted to determine IRV stability and performance. IRV simulation runs included translational and rotational commands in the Primary, Backup, and Satellite Stabilization modes. Results showed that the automatic attitude hold control system was capable of limiting uncommanded IRV rotations to within the control law deadbands during all simulated maneuvers and in all control modes, except during Y translations in the

Backup control mode. The IRV's increased mass and increased center-of-mass/center-of-thrust offset significantly degraded acceleration and specific fuel consumption rate when operating in the Primary control mode, especially for Y- and Z-axis maneuvers. Plume impingement, however, was found to be of minor importance. Translational accelerations in the Backup control mode were found to be one-half those in the Primary mode, but rotational accelerations were unaffected. The Satellite Stabilization mode was found to have significant rotational-to-translational coupling which made it undesireable for IRV use.

<u>Research Question 3</u>: What procedures will the stranded and rescue crews follow to conduct a successful save using the IRV?"

<u>Answer</u>: Current EVA procedures were studied and predicted IRV capabilities considered to propose baseline procedures for IRV use in rescuing the crew of a stranded space shuttle orbiter. Procedures were presented for rescue preparations, rescue operations, and IRV recharging. Alternative procedures were outlined for the simultaneous use of two IRVs, carrying the PREs to a non-equipped stranded orbiter, and rescue operations with a stranded orbiter suffering airlock failure.

Recommendations

This report has been furnished to NASA, and the enclosed data on IRV stability and performance should be evaluated by

NASA EVA experts to determine if this vehicle offers acceptable control response for space rescue operations.

Assuming an affirmative determination is made, additional simulation is required to document IRV propellant consumption during the approach and docking to the tumbling stranded orbiter, and to validate or amend the rescue procedures presented in Chapter VI. MILMU as implemented on the Hewlett-Packard 9825 had an excessive integration cycle time which made it unsuitable for simulating the approach and docking phase. Therefore, it is recommended that such simulations be conducted using the MILMU program on a faster computer or with the Martin Marietta Corporation's MMU simulator.

IRV performance and stability suffer because the modified ACD is larger and weighs more than would a specifically designed connecting device. Therefore, it is recommended that procurement of a next-generation MMU/PRE attachment device be pursued. If properly planned, this device could also serve as a "generic" MMU attachment device suitable for carrying a wide range of payloads. Design of such a device should be preceded by a study which explores the tradeoff between the favorable mass properties obtained by a closely mounted payload versus the stability and performance degradation caused by the accompanying increased plume impingement. In this way, an optimum compromise location could be identified.

The increasing space shuttle flight rate is exposing a growing number of astronauts to the hazards inherent in a

space operations program which does not include a formal rescue plan. This report has proposed an interim space rescue ferry vehicle which appears to provide a rudimentary but immediately available capability for rescuing the crew of a stranded, slowly tumbling spacecraft. If the recommended additional studies are pursued and the results favorable, the proposed design can fulfill, for the short term, a segment of the nation's space rescue requirements.

Appendix A

Thruster Label Diagram and Thruster Select Tables

The following tables present the thruster select logic incorporated in the MMU's Control Electronics Assembly. The first page is a diagram explaining the thruster labeling scheme. All information is reprinted from Volume I of the MMU Operational Data Book (Reference 9).



Figure A.1. Thruster Label Diagram

Note:

~

- Intended direction of motion when thruster is activated: F, Forward; B, Backward; R, Right; L, Left; U, Up; D, Down.
- 2. A and B are separate redundant systems.
- 3. X, Y, and Z axes' origins are at center of mass (cm).
- 4. +X direction, forward (astronaut faces toward +X).
 +Y direction, right (along astronaut's extended right arm).
 +Z direction, down (along astronaut's extended legs).
- 5. L-lever arm for thrusters.
- 6. The arrows at the thruster designators indicate the nitrogen expulsion direction. Force on the MMU is in the opposite direction.

Reference Coordinate System, Thruster Triad Arrangement, and Nomenclature

1	CMDS				PRIME	MODE			
	хөψ	FlB	F2A	F 3A	F4B	BLA	B2B	взв	B4A
1	+	1	1	1	l				
2	-					1	1	1	1
3	+			1		1			
4	-	1						1	
5	+		1			1			
6	-	1					1		
7	++			1	1				
8	+ -	1	1						
9	- +	5 1 1				1	1		
10								1	1
11	+ +		1		l				
12	+ -	1		1				- <u></u>	
13	- +					1		1	
14					·		1		1
15	+ +				l	1			
16	+ -			1			1		
17	- +		1					1	
18		1			····				1
19	+ + +		1	1	1	1			
20	++-	1	·	1	1		1		
21	+ - +	1	1		l			1	
22	+	1	1	1					1
23	- + +			_	l	1	1	1	
24	• + •			l		1	1		1
25	+		1			1		l	1
26		1					1	1	1

X, Theta (Pitch), and Psi (Yaw) Logic Prime Mode

Table XXI

Thruster Select Logic Tables

..

....

· · ·

. .

. . .

	CMDS	PRIME MODE								
 	Ϋ́ØΨ	R2A	R2B	R4A	R4B	LIA	LIB	L3A	L3B	
64	+	1	1	1	1					
65	-					1	1	<u>۱</u>	1	
66	+	1						1		
67	-				1		1	. <u> </u>		
68	+				A11 3	Zero				
69	•					<u> </u>				
70	+ +	l	l							
71	+ -			1	1					
72	- +							1	1	
73						1	1			
74	+ +		1	1						
75	+ -	1			1					
76	- +						1	1		
77						1			1	
78	+ +		1					1		
79	+ -	1							1	
80	- +			1			l			
81					ľ	1				
82	+++	1	1							
83	+ + -	1	1							
84	+ - +			1	1					
85	+			1	1					
86	- + +							1	1	
87	- + -							1	1	
88	+					1	1			
89	·	1				1	1			

-

.

. . . .

Y. Phi (Roll), and Psi (Yaw) Logic Prime Mode

6
	CMDS				PRIME	MODE		·	
	zΦθ	DLA	DLB	D2A	D2B	U 3A	U 3 B	U4A /	U4B
127 128	+	1	1	1	1	1	1	1	L
129 130	+				A11 2	Zero			
131 132	+ -				A11 2	Zero			
133 134	+ + + -	1	1	1	1				
135 136	- + 					1	1	1	1
137 138	+ + + + -	L	1	1	1		•		
139 140	- + 					1	1	1	1
141 142	+++++-				A11 Z	ero			
143 144	- + 				A11 Z	ero			
145 146	+ + + + + =	1	1	1	1				
147 148	+ - + +	1	1	1	1				
149 150	- + + - + -					1	1	1	1
1 51 1 52	+ 					1	1	1	1

Z, Phi (Roll), and Theta (Pitch) Logic Prime Mode

٠,

	CMDS		BACK UI	P MODE A			BACK UP	MODE B	
1	х⊖ч	F2A	F 3A	B LA	B4A	F1B	F4B	B2B	B 3 B
1			-						
2	+	1	1	<u>.</u>		1	1		
3	-			1	1			1	1
4	+		1	1		L	1	1	
5	-	1			1	1			l
6	+	1		1			1		1
7	-		1		1	1		1	
8	+ +		1	1		 	1	1	
9	+ -	1			1	1			1
10	- +		1	1		ļ	1	1	
11		1			1	1			1
12	+ +	1		1		<u> </u>	1		l
13	+ -		1		1	1		1	
14	- +	1		1			1	<u> </u>	1
15			1		1	1		1	
16	++		1	1		ļ		1	
17	+ -		1	1			1	1	_
	- +	1			1		¥		1
19		1	•		1	1			1
20	+ + +		L	L		ļ	L	<u>.</u>	·
21	+ + - 		1				1	1	
- 22	+ - +	1		. <u>.</u>			L		L
23	+	1	1	•	1	1		٩	•
24	- + +	ļ		1		<u> </u>	L	L	L
25	- + -		1	1	1			1	,
20	+			L	<u>I</u>	<u> </u>		1	1
21					L	<u> </u>			L

-

X, Theta (Pitch), and Psi (Yaw) Logic Backup Mode

	CMD	s		BACKUP M				MODE A			BACKUP MODE B							
	ΥZ	ϕ	R2A	R4A	LIA	L3A	DIA	D2A	U 3A	U4A	R2B	R4B	L1B	L3B	DIB	D2B	U3B	U4B
65														_				
66	+		1	1							1	1				<u>-</u>		
67	-				1	1							1	1				
68	+			·			1	1							1	۱ 		
69	-								1	1							1	1
70		+	1			1		<u>v</u>			1			1				
71		-		1	1							1	1					
72	+ +		L	1			L	1				1			1	1		
73	+ -		1	1	,	,	,	,	1	1	1	1	,	,	1	,	1	1
/4																	·	
75	+	+	1	1	I	1	١		1	1	1	١	L	I	١		1	1
70												- <u>-</u>					1	
78	-	+	1	L	1	1	1	1	1	1	L	L	1	1	1	1	I	1
79	 _	•			1	1		1	1				1	1		1	1	
80	+	+	1		-	1	1	1			1		-	1	1	1	-	
81	+			1	1		1	1				1	1		1	1		
82	-	+	1			1			1	1	1			1			1	1
83	-	-		1	1				1	1		1	1				1	1
84	+ +	+	1			1	1	1			1			1	1	1		
85	+ +			1	1		1	1				1	1		1	1		
86	+ -	+	1			1			1	1	1			1			1	1
87	+ -	-	Į	1	1				1	1		1	1				1	1
88	- +	+	1			1	1	1			1			1	1	1		
89	- +	• •		1	1		1	1				1	1		1	1		
90		+	1			1			<u> </u>		1			1		<u> </u>		1
91		-	1	L	L				1	1		L	r				1	ì

Y, I, and Phi (Roll) Logic Backup Mode

		ا د و ۵۰			· · · · · · · · · · · · · · · · · · ·				
<u> </u>				SAII		TABILIZA			
	<u>x + v</u>	FIB	<u> </u>	F3A	F4B	BIA	E 2 B	339	34A
1	•	1	1	1	1				
2	-					1	1	1	1
3	+								_
4	-								
5	+								
6	-								
7	+ +	1	1	1	1				
8	+ -	1	1	1	1				
9	- +					1	1	1	1
10		Ļ				1	1	1	1
11	+ +	1	1	1	1				
12	+ -	1	1	1	1				
13	- +					1	1	1	1
14						1	1	1	1
15	+ +								
16	+ -								
17	- +								
18	• •			· · · · · · · · · · · · · · · · · · ·					
19	+ + +	1	1	1	l				
20	+ + -	1	1	1	1				
21	+ - +	- 1	1	1	1				
22	+	1	1	1	1				
23	- + +	!				1	1	1	1
24	- + -	¦ 				1	1	1	1
25	+	н 1				1	1	1	1
26		(1	1	1	1

				<u>ع مارد و</u>					
	CMDS			SATE	LLITE ST	ABILIZAT	LON		
• •	Y Ø 🌮	R2A	R2B	R4A	R∔B	LIA	LIB	L3A	L3B
64	+	1	1	1	1				
65	-					1	1	1	1
66	+	1	1					1	1
67	-			1	1	1	1		
68	+						1	1	<u> </u>
69	-	1			1				
70	+ +	1	1					····	
71	+ -			1	1				
72	- +							1	1
73						1	1		
74	+ +		1	1			1	1	
75	+ -	1	_		1				
76	- +						1	1	* • • • • • • • • • •
77		1			1	1	_		1
78	+ +		1				i	1	1
79	+ -	1	1		1				1
80	- +			1		L	1	1	
81		1		1	1	1			
82	+ + +		1					1	
83	+ + -	1	1		1				1
84	+ - +			1			1		·
85	+	1		1	1	1			
86	- + +		1				1	1	1
87	- + -	1							1
88	+			1		1	1	1	
89		• - 			1	1			

	CMDS			SAT	ELLITE 3	TABILIZA	TION		
	ZØÐ	DIA	DIB	D2A	D2B	U3A	€3В	U4A	¥₿
127	+	1	1	1	1				
128	; -	•				1	1	1	1
129	+								
130	-								
131	+		1	1					
132	-					1			1
133	+ +	1	1	1	1				
134	+ -	1	1	1	1				
135	- +	•				1	1	1	1
136		<u> </u>				1	1	1	1
137	+ +		1	1					
138	+ -	1			1	1			1
139	- +		1	1			1	1	
140		ļ	<u></u>			1			1
141	++	1	1	1					
1 42	+ -	• •	· • • • • •			1			1
1.43	- +	1 1 1	1	1					
144		, 			_ ~	1			1
145	+ + +		1	1					
146	· + + -	1			1	1			1
1 47	+ - +	: •	1	1					
148	+	1			1	1			1
149	_ + +	•	1	1			1	1	
150	- + -	÷	<u> </u>			1			1
151	+	•	1	1			1	1	
152	'	1				1			I

Z, Fhi (Soll), and Thesa (Pitch) Logic

<u>Appendix</u> B

Standard EVA Equipment

This appendix contains further descriptions of standard NASA extra-vehicular activity (EVA) equipment items referred to in the main text. The following descriptions are reprinted from NASA's Satellite Services Catalog (Reference 20).

EXTRAVEHICULAR MOBILITY UNIT

Overview

The Extravehicular Mobility Unit (EMU) is a self-contained system which provides crew members with environmental protection, life support, communication, visibility, and mobility to perform numerous types of extravehicular activities (EVA's).



EVA CREW MEMBER SIDE REACH ENVELOPE



EVA CREW MEMBER FORE-AFT REACH ENVELOPE





Catalog no. A1-101 September 1983

Performance Description

The EMU can provide the crew member with multiple EVA periods during a single flight. The EMU has an on-orbit recharge capability.

Standard Orbiter provisioning for each mission includes required expendables to provide two crew members the capability each to perform two 6-hour, planned EVA's and one 6-hour Orbiter contingency EVA. A 30-minute secondary oxygen supply is provided as a backup to the primary oxygen system. Instrumentation and a microprocessor subsystem provide for monitoring the status of the EMU performance and expendables, for alerting the crew member to any abnormal system function, and for advising that any subsequent corrective action be taken.

Standard interface attachments include the Manned Maneuvering Unit, the Mini Work Station, the Tool Caddies, the EMU Television System, the EMU Lights, and the Wrist and Waist Tethers. Two EMU's are flown on all Shuttle missions to provide contingency EVA capability.

References

Space Transportation System: EVA Description and Design Criteria, Rev. A. JSC-10615.

Information Contact

Harley L. Stutesman, Jr./EC6 (713) 483-4931

MINI WORK STATION

Overview

ż

ľ

.

ŀ

The Mini Work Station (MWS) is used to tether an extravehicular (EVA) crew member at a worksite and to serve as a tool carrier during the EVA performance.



Performance Description

The MWS consists of an attaching bracket and pins, a position-adjusting mechanism, a T-bar, and a work tether. The MWS attaching bracket has two integral pip pins which insert into a mounting bracket on the hard upper torso of the Extravehicular Mobility Unit (EMU). The position-adjusting mechanism attaches the T-bar to the MWS attaching bracket and allows the T-bar to pivot. The T-bar may be rotated away from the EMU up to 170° and secured in the desired position. It is controlled by a lock-release hand knob on the right-hand side. The MWS T-bar incorporates four pin-and-slot mounting brackets for attaching tool carriers or tools. Caddies are locked in place by slide locks. Two brackets are on the inside of the bar and two are on the outside. The T-bar also incorporates the work tether and tether D-rings. The MWS work tether holds the crew member in the work area. The tether, mounted at the upper T-intersection, is a 4-ft selfretracting cord with a multipurpose end effector; it is either released or locked by means of a lever on top of the reel case. The end effector will hook around circular sections (handrails, door drive linkages, latch actuating rods) up to 1.6 in. in diameter. The end effector can also be clamped onto a flat plate by using a torque knob which is tightened down to prevent slippage. Silicone tips on the end of the jaws also aid in keeping the end effector from slipping when installed on a flat plate. A clutch on the tether lock will slip when a 75-1b force is applied.

The crew member attaches the end effector, positions himself as desired, and locks the tether in place. One MWS is stowed in a crew compartment middeck locker. The second MWS is stowed in the Cargo Bay Stowage Assembly.

References

Beiriger, J.: EVA PLBD Contingency Tools Description Document. Flight Operations Directorate, NASA/JSC, Houston, Texas. Jan. 1981.

Information Contact

Ralph J. Marak/EC6 (713) 483-4336

Overview

Wrist and Waist Tethers are used to attach a crew member to a worksite or to tether tools which are not capable of being stowed during the work period.

Performance Description

The Wrist and Waist Tethers consist of a fabric strip with a hook on each end. Buttons on both sides of the hook must be squeezed simultaneously to open the hook. The Waist Tethers are 24 in. in length (excluding hooks) and are limited to 60 lb of force. The Wrist Tethers are 14 in. in length, and one of them is adjustable. The Wrist Tether is attached to a loop on the Extravehicular Mobility Unit (EMU) glove, and the Waist Tether is attached to a ring on the EMU waist.

Normally flown on each flight are one nonadjustable Wrist Tether per suit (total of two); one adjustable Wrist Tether per suit (total of two); and two Waist Tethers per suit (total of four).

References

Beiriger, J.: EVA PLBD Contingency Tools Description Document. Flight Operations Directorate, NASA/JSC, Houston, Texas. Jan. 1981.

Information Contact

Ralph J. Marak/EC6 (713) 483-4336



Figure B.3. WRIST TETHER ASSY 10151-20041-02

TOOL CADDY

Overview

The Tool Caddy serves three purposes - the stowage of extravehicular activity tools in the Cargo Bay Stowage Assembly, the transfer of tools to the worksite, and the tethering of the tools at the worksite.

Performance Description

The Tool Caddy consists of an 8- by 13-in. stiffened fabric which folds over the tools, closes, and seals with velcro; a tether tab with a 1-in. ring; a pin lock which attaches to a slot fitting on the Mini Work Station; and two split-ring-and-swivel attachments on 3-ft, self-retracting tethers. The split rings and swivels attach a maximum of two tools to each caddy, and four caddies can be attached to one Mini Work Station simultaneously. The tools are held in place by mating velcro on the tools with velcro on the caddy surface. Four caddies containing eight jam removal tools are stowed in middeck locker MF43G with the Mini Work Station. Other caddies are stowed in the Cargo Bay Stowage Assembly.

PROBE

Overview

The Probe is used as a disconnect and jam removal tool.

Performance Description

The Probe is a rod, 0.188-in. in diameter, with a flattened tip similar to that of a screwdriver. It is 8-5/8-in. long excluding the handle.

References

Beiriger, J.: EVA PLBD Contingency Tools Description Document. Flight Operations Directorate, NASA/JSC, Houston, Texas. Jan. 1981.

Information Contact

Fred A. McAllister/EC3 (713) 483-4729

Overview

The Getaway Special (GAS) Beam is a structural frame to which small payloads can be attached.



LTRALE D'4.

Performance Description

The GAS Beam, which connects to the longerons on either side of the Cargo Bay, can be attached at any of 30 sites, and a total of 30 GAS Beams may be carried on a Shuttle mission. The GAS Beam does not contain any interface provisions for electrical power, control, or monitoring.

Specifications

Beam length: 52.3 in. Beam width: 6.0 in. Beam height: 22.4 in.

Maximum weight of payload at a 6.0-in. moment arm: 300 lb

References

Fitting Assembly - Adapter Beam Bridge Getaway Special. Drawing no. V724-340001, Rockwell.

Space Shuttle Interface Control Document. ICD-A-14021, November 1979.

STS and Get Away Special (GAS) Payload Integration Plan, Rev. B. JSC-14021, March 1983.

> Catalog no. B3-107 September 1983



۰.

Appendix C

IRV Visibility Experiment

This appendix contains the results for the MMU visibility experiment referenced in Chapter III. The first page is a tabulation of the results. The second page presents the statistical calculations performed on the results.

Table X	Х	Ι	Ι
---------	---	---	---

Test Subject Eye Level (inches)	Disc Height (inches)	"Over-the-to (inches)	op" Visibility (degrees)
68.75	67.75	1.00	1.081
67.75	66.75	1.00	1.081
67.375	68.00	625	676
71.125	71.75	625	676
63.75	63.75	0.0	0.0
64.3125	64.50	1875	203
62.375	62.5	125	135
68.00	66.50	1.50	1.621
69.875	67.50	2.375	2.566
68.00	68.3125	3125	338
64.25	64.25	0.00	0.00
68.625	67.125	1.50	1.621
68.25	68.4375	1875	203
66.5	67.00	50	541
62.25	62.6875	4375	473
67.00	66.875	.125	.135
70.50	69.50	1.00	1.081
64.125	64.75	625	676
64.50	64.00	.50	.541
67.00	66.875	.125	.135
68.25	67.50	.75	.811
69.0625	66.50	2.5625	2.768

Experimental Results

•

•

•

Statistical Calculations

Mean =
$$X = (X)/N$$
 (Miller:150) (21)

and

Standard Deviation = (X - X) (Miller:151) (22) N - 1

where X is the ith experimental result and N is the sample size. Applying Eqns (21) and (22) to the experimental results on the previous page resulted in:

$$Mean (degrees) = X = .433$$
(23)

Establishing a null hypothesis H : 3.341 = X, and an alternative hypothesis H : 3.341 > X, and assuming that the sample comes from a normal population, the Student-t distribution is the appropriate distribution for testing the hypotheses (Miller:172). The normalized test statistic is defined as:

$$t = 3.341 - X$$
 (25
s/N

Applying Eqn (25) to the experimental results:

$$t = 3.341 - .433 = 13.33$$
 (26)
1.023/22

Entering the Student-t distribution chart (Miller:488) with a value of 13.33, for N-1 = 21 degrees of freedom, reveals that it can be said with greater than 99.5 percent confidence that the null hypothesis (3.341 = X) is false.

<u>Appendix</u> D

MILMU IRV Simulation Phase Plane Plots and End-of-Simulation State Vector Printouts

This appendix contains the phase plane plots and end-ofsimulation state vector printouts for all MILMU simulation runs. The particular run can be identified by the label at the top of the phase plane plot. The accompanying end-ofsimulation printout follows each phase plane plot. All runs began with the same initial conditions, which were:

PEI	r	•	0.000	ннмі	1.55		MET =		0.000 HHMM.	. \$\$			
MU:	R	M50		0	1	0 -6	28537270	XYZ	4732.40	a o.	00	0.00	DXYZ
PL	R	M50	3	88	I	0 -6:	28537270	XYZ	4732.40	ð Ø.	00	0.00	DXYZ
MU	D	ATA	******	н	-90.00	DEC	-72.28	LON	1041 WI	г 111	ESUN	64.6	вета
PL	D	ATA	******	н	-90.00	DEC	-72.28	LON	21 W1	Г 111	ESUN	64.6	BETR
MU	0	M50	*******	SMA	0.00000	ECC	90.00	INC	0.00 RF	AN -90.0	Ø ARG	0.00	TRA
MU	I	MLD	******	HA :	******	HP	90.00	INC	0.00 Rf	AN -90.0	Ø ARG	0.00	TRA
MU:	;	M50	0.00	РСН	0.00	YAW	0.00	ROL	0.000 R>	KB 0.00	0 RYB	0.000	RZB
MU	1	MLV	0.00	PCH	0.00	YAW	0.00	ROL	0.000 R>	KB 0.00	Ø RYB	0.000	RZB
PL	0	M50	*******	SMA	0.00000	ECC	90.00	INC	0.00 RF	AN 90.0	Ø ARG	-180.00	TRA
PL:	1	MLD	******	HA :	*******	HP	90.00	INC	0.00 RF	AN 90.0	Ø ARG	-180.00	TRA
PL	ł	M50	-0.00	PCH	0.00	YAW	0.00	ROL	6.000 R>	KB -0.00	8 RYB	1.207	RCB
PL	1	PLV	0.00	PCH	0.00	YAW	0.00	ROL	6.000 R>	KB -0.00	8 RYB	1.207	PEB
MU	e C	PLV	-0.0	49	0.00	0	0.000	XYZ	0.00	a o.	00	-0.00	DXYZ
PL	R	MLV	3	00	1	0	0	XYZ	-0.00	ð 0.	00	0.00	D⊠YZ
PL	R	MBY	3	00	1	0	0	XYZ	-0.00	ə o.	00	0.00	DXYZ

MU PROPELLANT STATUS COPRIMO JET SELECT OPTION, CROSSFEED COFFED

ISOLATION VALVE Temperature Pressure Propellant WT	(deg F) (LB/IN^2) (LB)	OPEN 0.00 3000.00 15.1154	A A A A	JETS Tank Tank Tank	OPEN 0.00 3000.00 15.1154	BBBB	JETS TANK TANK TANK	30.2308	TOTAL
AMOUNT USED	(LB)	0.0000	A	TANK	0.0000	B	TANK	0.0000	TOTAL



#POST/MILMU VERSION DAGE (1134/18 June4) SESSION REGUL & DS30 / DB NOV 1095 5 SEC +X TRANSLATION, SOLO MMU, PRIMARY CONTROL MODE RUN 0

)

•

•

PE.	Т	=	0.200	HHMM.SS	MET =		0.200 HHMM.SS		
MU	: F	M50	946	66 -0	-62853726	3 XYZ	4733.63	-0.01	0.70 DKYZ
PL	: F	M50	949	48 0	-62853726	3 XYZ	4732.40	0.00	0.71 DXYZ
MU	r	ата	*******	н -89.99	DEC -72.30	S LON	I 794 WT	111 ESUN	64.6 BETA
PL	I	ATA	******	H -89.99	DEC -72.30	5 LON	1 21 WT	111 ESUN	64.6 BETA
MU	: 0	M50	******	SMA 0.00052	ECC 90.00) INC	-0.00 RAN	-90.24 ARG	0.25 TRA
MU	: 1	MLD	\$\$\$\$\$\$\$	HA \$\$\$\$\$\$	HP 90.00	3 INC	: -0.00 RAN	-90.24 ARG	0.25 TRA
MU	:	M50	0.87	PCH -0.80	YAN -0.03	ROL	0.003 RXB	-0.049 RYB	0.069 RZB
MU	:	MLV	0.88	PCH -0.80	YAW -0.0	7 ROL	. 0.003 RXD	-0.049 RYB	0.069 RZB
PL	: ¢	M50	*******	SMA 0.00000	ECC 90.00	D INC	0.00 RAN	90.00 ARG	-180.00 TRA
PL	: 1	MLD	******	HA \$\$\$\$\$\$\$	HP 90.00	9 INC	: 0.00 RAN	90.00 ARG	-180.00 TRA
PL	:	M58	3.20	PCH 46.86	YAW 111.5	2 ROL	4.700 RX3	3.891 RYB	-0.487 RZB
PL	1	PLV	3.21	PCH 46.86	YAW 111.52	2 ROL	. 4.700 RXB	3.891 RYB	-0.487 RZB
MU	: 0	PLV	-0.0	46 -0.000	-0.00	a xyz	1.23	-0.01	-0.01 DXYZ
PL	1 F	MLV	2	82 0		9 XYZ	-1.23	0.01	0.01 DXYZ
PL	1 F	MBY	2:	82 4		4 XYZ	-1.22	-0.35	-0.25 DXYZ

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALVE	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-2.93	A	TANK	-2.93	B	TANK		
PRESSURE	(LB/IN^2)	2933.56	A	TANK	2933.60	B	TANK		
PROPELLANT WT	(LB)	14.8755	A	TANK	14.8757	B	TANK	29.7512	TOTAL
AMOUNT USED	(LB)	0.2399	A	TANK	0.2397	B	TANK	0.4796	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84) SESSION BEGUN 0 0530 / 08 NOV 1985

5 SEC +X TRANSLATION, SOLO MMU, PRIMARY CONTROL MODE

END RUN NO. 0

•

D



Ì



ł

149

.

.

.

<u>.</u>

•

۰. ۰.



MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-3.02	A	TANK	-2.84	B	TANK		
PRESSURE	(LBŽIN^2)	2931.45	A	TANK	2935.50	B	TANK		
PROPELLANT WT	(LB)	14.8679	A	TANK	14.8825	B	TANK	29.7504	TOTAL
AMOUNT USED	(LB)	0.2475	A	TANK	0.2329	B	ТАНК	0.4804	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 0540 / 08 NOV 1985

5 SEC +Y TRANSLATION, SOLO MMU, PRIMARY CONTROL MODE

END RUN NO. 0

• .•



7

. .

E.

151

. . .

1.1

PET = 0.190 HHMM.SS 0.190 HHMM.SS MET * MU: RM50 89916 -0 -628537244 XYZ 4732.41 -0.00 2.03 DXYZ PL:RM50 90216 0 -628537264 XYZ 4732.40 0.00 0.68 DXYZ -89.99 DEC -89.99 DEC -72.36 LON -72.36 LON 111 ESUN 794 WT 64.6 BETA MU DATA \$\$\$\$\$\$\$ H 21 WT 111 ESUN 64.6 BETA PL DATA SSSSSSS H MU:0M50 \$\$\$\$\$\$\$ SMA 0.00029 ECC 90.00 INC -0.00 RAN -0.91 ARG -89.08 TRA -0.91 ARG MU: IMLD \$\$\$\$\$\$ HA 99970.95 HP 90.00 INC -0.00 RAN -89.08 TRA 0.90 ROL MU: M50 1.16 PCH 0.09 YAW -0.060 RXB -0.021 RYB -0.006 RZB MU1 MLV 1.17 PCH 0.09 YAW 0.90 ROL -0.060 RXB -0.021 RYB -0.006 RZB 90.00 ARG -180.00 TRA 90.00 ARG -180.00 TRA PL:0450 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN PL: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP 90.00 INC 0.00 RAN PL: M50 4.35 PCH 43.13 YAW 105.94 ROL 4.817 RXB 3.761 RYB -0.334 RZB 4.36 PCH 105.94 ROL PL: PLV 43.13 YAW 3.761 RYB -0.334 RZB 4.818 RXB 1.35 DXYZ -1.35 DXYZ MU: CPLV -0.049 -0.000 0.003 XYZ 0.01 -0.00 PL:RMLV PL:RMBY -20 XYZ -14 XYZ -0.01 0.00 300 ø 0.01 0.03 -1.46 DXYZ 300 -1

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-3.19	A	TANK	-3.35	B	TANK		
PRESSURE	(LB/IN^2)	2927.61	A	TANK	2923.97	B	TANK		
PROPELLANT WT	(LB)	14.8539	A	TANK	14.8408	B	TANK	29.6947	TOTAL
AMOUNT USED	(LB)	0.2614	A	TANK	0.2746	B	TANK	0.5361	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 0545 / 08 NOV 1985

5 SEC +Z TRANSLATION, SOLO MMU, PRIMARY CONTROL MODE

END RUN NO. 0

.

É.

e





PFT = 0.220 HHMM.SS MET = 0.220 HHMM.SS MU: RM50 104113 0 -628537262 XYZ 4732.40 0.00 0.78 DXY2 PL:RM50 104413 0 -628537262 XYZ 4732.40 0.00 0.79 DXYZ -89.99 DEC -72.37 LON -89.99 DEC -72.37 LON MU DATA \$\$\$\$\$\$\$ H 794 WT 111 ESUN 64.6 BETA PL DATA \$\$\$\$\$\$ -89.99 DEC 21 WT 111 ESUN 64.6 BETA MU: 0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN -89.99 ARG 0.00 TRA MU: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP 90.00 INC -89.99 ARG 0.00 TRA 0.00 RAN -4.58 PCH -8.98 ROL MU: M58 -0.73 YAW 18.159 RX3 0.010 RYB -0.010 RZB -4.49 PCH -0.73 YAW 18.159 RXB -0.010 RZB MU: MLV -8.90 ROL 0.010 RYB PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.00 ARG -179.99 TRA PL: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP 90.00 INC 0.00 RAN 98.88 ARG -179.99 TRA PL: M50 123.57 ROL -0.814 RZB -0.41 PCH 54.41 YAW 4.449 RXB 4.128 RYB PL: PLV 123.57 ROL -0.814 RZB -0.40 PCH 54.41 YAW 4.128 RYB 4.449 RXB MU: CPLV 0.00 0.00 -0.049 0.000 0.000 XYZ -0.00 DXYZ PLIRMLV 300 -0 XYZ 0.00 DXYZ -2.29 DXYZ -0,00 0.00 0 PLIRMBY 299 -23 XYZ -7.11 0.00

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	~1.85	A	TANK	-0.17	B	TANK		
PRESSURE	(LB/IN^2)	2957.97	A	TANK	2996.13	B	TANK		
PROPELLANT WT	(LB)	14.9638	A	TANK	15.1015	B	TANK	30.0653	TOTAL
AMOUNT USED	(LB)	0.1516	A	TANK	0.0139	B	TANK	0.1655	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

والمكرية والمحالية

SESSION BEGUN @ 0555 / 08 NOV 1985

2 SEC +X (ROLL) ROTATION, SOLO MMU, PRIMARY CONTROL MODE

END RUN NO. 0

le de la company de la comp



٠.

155

المركبة والمعروفي فوجه فالتقو والمتعادية

~





MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

-89.96 ARG

17.011 RYB

17.011 RYB

-4.597 RYB

0.00

0.00

-0.11

0.00 TRA

-0.024 RZB

90.02 ARG -179.98 TRA 90.02 ARG -179.98 TRA

-4.597 RYB -2.771 RZB

-0.024 RZB

-2.771 RZB

-0.00 DXYZ

0.00 DXYZ

70.34 BXYZ

0.00 RAN

0.00 RAN

0.00 RAN

2.948 RXB

2.948 RXB

0.00

-0.00

-54.63

-0.064 RXB

-0.064 RXB

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-1.38	A	TANK	-0.02	B	TANK		
PRESSURE	(LB/1N^2)	2968.48	A	TANK	2999.63	B	TANK		
PROPELLANT WT	(LB)	15.0018	A	TANK	15.1141	B	TANK	30.1158	TOTAL
AMOUNT USED	(LB)	0.1136	A	TANK	0.0013	B	TANK	0.1149	TOTAL

90.00 INC

-1.16 ROL

-1.16 ROL

90.00 INC

90.00 INC

59.72 ROL

59.72 ROL

0.000 XYZ

0 XYZ

184 XYZ

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

MUIIMLD SSSSSSS HA SSSSSSS HP

37.80 PCH

37.84 PCH

PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC

PLIIMLD SSSSSSS HA SSSSSSS HP

-0.049

300

237

PL: M50 -109.02 PCH PL: PLV -108.98 PCH

MU: M50

MU: MLV

MU: CPLV

PLIRMLV

PLIRNBY

SESSION BEGUN @ 0600 / 08 NOV 1985

2 SEC +Y (PITCH) ROTATION, SOLO MMU, PRIMARY CONTROL MODE

PET = 1.320 HHMM.SS MET = 1.320 HHMM.SS MUIRM50 435301 0 -620537120 XYZ 4732.40 0.00 3.20 DXYZ PLIRM50 435501 0 -620537119 XYZ 4732.40 0.00 3.20 DXYZ MU DATA \$\$\$\$\$\$\$\$ H -89.96 DEC -72.66 LON 794 HT 111 ESUN 64.6 BETA PL DATA \$\$\$\$\$\$\$ H -89.96 DEC -72.66 LON 21 HT 111 ESUN 64.6 BETA MUIOM50 \$\$\$\$\$\$\$ H -89.96 DEC -72.66 LON 21 HT 111 ESUN 64.6 BETA MUIOM50 \$\$\$\$\$\$\$ H -89.96 DEC -72.66 LON 21 HT 111 ESUN 64.6 BETA MUIOM50 \$\$\$\$\$\$\$ H -89.96 DEC -72.66 LON 21 HT 111 ESUN 64.6 BETA MUIOM50 \$\$\$\$\$\$\$ HA 0.000000 ECC 90.00 INC 0.00 RAN -89.96 ARG 0.00 TRA

-0.34 YAW

-0.34 YAW

64.66 YRW

64.66 YRW

0

-2

0.000

END RUN NO. 0



0.300 HHMM.SS PET = 0.300 HHMM.SS MET = MU: RM50 141972 0 -628537254 XYZ 4732.40 0.00 1.07 DXYZ PL:RM50 142272 0 -628537254 XYZ 4732.40 0.00 1.07 DXYZ -89.99 DEC -72.41 LON -89.99 DEC -72.41 LON MU DATA SSSSSSS H 794 WT 111 ESUN 64.6 BETA PL DATA \$\$\$\$\$\$ 21 WT 111 ESUN 64.6 BETA MU:0M50 \$\$\$\$\$\$ SMA 0.00000 ECC 0.00 RAN -89.99 ARG 0.00 TRA 90.00 INC MU: IMLD \$\$\$\$\$\$ HA \$\$\$\$\$\$ HP 0.00 TRA 0.00 RAN -89.99 ARG 90.00 INC 7.03 PCH -4.98 ROL -0.061 R×B -0.010 RYB 16.539 RZB MU: M50 62.55 YAW MU: MLV 7.04 PCH 62.55 YAW -4.98 ROL -0.061 RXB -0.010 RYB 16.539 RZB PL:0M50 \$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.01 ARG -179.99 TRA PL: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP 90.00 INC 0.00 RAN 90.01 ARG -179.99 TRA 70.95 YAW -127.97 ROL 70.95 YAW -127.97 ROL PL: M50 -83.07 PCH 3.373 RXB 4.602 RYB -2.216 RZB -83.05 PCH 3.373 RXB 4.602 RYB -2.216 RZB PL: PLV -0.00 DXYZ 0.00 DXYZ MUSCPLV -0.049 0.000 0.000 XYZ 0.00 0.00 -0.00 PL:RMLV -0 XYZ 14 XYZ 0.00 300 Ø PLIRMBY -76.90 -39.63 -0.31 DXYZ -266 137

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	Έ	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-1.30	A	TANK	-0.69	B	TANK		
PRESSURE	(LB/IN^2)	2970.43	A	TANK	2984.31	B	TANK		
PROPELLANT WT	(LB)	15.0088	A	TANK	15.0589	B	TANK	30.0677	TOTAL
AMOUNT USED	(LB)	0.1066	A	TANK	0.0565	B	TANK	0.1631	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 0615 / 08 NOV 1985

2 SEC +Z (YAW) ROTATION, SOLO MMU, PRIMARY CONTROL MODE

END RUN NO. 0





-9.4

PET = 0.210 HHMM.SS 0.210 HHMM.SS MET = MU: 8M50 -0 -623537263 XYZ 0 -628537263 XYZ 4733.39 0.74 DOWE 0.75 DOWE 99395 -0.00 PL:RM50 99680 4732.40 0.00 -89.99 DEC -72.37 LON -39.99 DEC -72.37 LON NU DATA SSSSSSS H 1040 WT 111 ESUN 64.6 BETA PL DATA SSSSSSS H 21 WT 111 ESUN 64.6 BETA MU:0M50 \$\$\$\$\$\$\$ SMA 0.00042 ECC 90.00 INC -0.00 RAN -90.23 ARG 0.24 TRA MU: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP 90.00 INC -0.00 RAN -90.23 ARG 0.24 TRA MU: M50 1.54 PCH -0.62 YAW -0.16 ROL -0.013 RXB -0.021 RYB -0.048 RZB -0.62 YAW -0.16 ROL -0.013 RXB 1.55 PCH -0.021 RYB -0.043 RCB MU: MLV 90.00 ARG -179.99 TRA 90.00 ARG -179.99 TRA PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.00 INC 0.00 RAN PL: IMLD SSSSSSS HA SSSSSSS HP 4.009 RYB -0.643 PEB 117.48 ROL 4.580 RXB PL: M50 1.43 PCH 50.73 YAW 4.580 RXB PL: PLV 1.44 PCH 50.73 YAW 117.48 ROL 4.009 RYB -0.643 RZB MUICPLV -0.047 -0.000 -0.000 XYZ 0.99 -0.00 -0.01 DXYZ 0.01 DXYZ -0.12 DXYZ PLIRMLV 286 0 XYZ -0.99 0.00 0 PLIRMBY 286 з 8 XYZ -0.99 0.23

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALVE	I	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg E)	-3.05	A	TANK	-3.12	B	TANK		
PRESSURE	(LBŽINAŽ)	2930.72	A	TANK	2929.12	B	TANK		
PROPELLANT WT	(LB)	14.8652	A	TANK	14.8594	B	TANK	29.7247	TOTAL
AMOUNT USED	(LB)	0.2502	A	TANK	0.2559	B	TANK	0.5061	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 2045 / 07 NOV 1985

5 SEC +X TRANSLATION, IRV, W/IMPINGEMENT, PRIMARY CONTROL MODE

END RUN NO. 0

.



● うちょう たん ひちゅう ひちょう たい



T 4
PET =	0.200	HHMM.SS	MET	*	0.	.200 HHMM.SS		
MU: 8850	946	35 -e	-62853	7263	XYZ	4731.52	-0.00	0.71 Drnz
PL:RM50	9494	48 0	-62853	7263	::YZ	4732.40	0.00	0.71 DL.2
MU DATA	******	н -39.99	DEC -7	2.36	LON	1040 WT	111 ESUN	64.6 BETA
PL DATA	\$\$\$\$\$\$\$	н -89.99	DEC -7	2.36	LON	21 WT	111 ESUN	64.6 BETA
MU: 0M50	*******	SMA 0.00037	ECC 9	0.00	INC	-0.00 RAN	89.97 ARG	-179.96 TPA
MU: IMLD	\$\$\$\$\$\$\$	HA 99922.95	HP 9	0.00	INC	-0.00 RAN	89.97 ARG	-179.96 TRA
MU: M50	-1.58	PCH 0.37	YAW	0.02	ROL	0.001 R×B	0.013 RYB	0.019 RCB
MU: MLV	-1.57	PCH 0.37	YAW	0.02	ROL	0.001 R×B	0.014 RYB	0.019 RZB
PL:0450	*******	SMA 0.00000	ECC 9	0.00	INC	0.00 RAN	90.00 ARG	-180.00 TRA
PL:IMLD	******	HA \$\$\$\$\$\$\$	HP 9	0.00	INC	0.00 RAN	90.00 ARG	-180.00 TRA
PL: M50	3.14	PCH 46.89	YAW 11	1.55	ROL	4.701 RXB	3.890 RYB	-0.486 PZB
PL: PLV	3.15	PCH 46.89	YAW 11	1.55	ROL	4.701 RXB	3.890 RYB	-0.486 PZB
MUSCPLV	-0.0	52 -0.000	- 9	. 000	XYZ	-0.88	-0.00	0.00 DRYZ
PL:RMLV	31	13 6	1	9	XYZ	0.88	0.00	-0.00 DXYZ
PLIRMBY	31	13 -2	:	-8	XYZ	0.88	-0.11	0.05 DXYZ
	FILANT ST	ATHS (PPTM4	IET SEL	FCT (N. CROSSEED	(OFF()	

 ISOLATION VALVE
 OPEN A JETS
 OPEN B JETS

 TEMPERATURE
 (deg F)
 -3.08 A TANK
 -3.01 B TANK

 PRESSURE
 (LB/IN^2)
 2930.08 A TANK
 2931.62 B TANK

 PROPELLANT WT
 (LB)
 14.3629 A TANK
 14.8685 B TANK
 29.7314 TOTAL

 AMOUNT USED
 (LB)
 0.2525 A TANK
 0.2469 B TANK
 0.4994 TOTAL



Ì

. ,

.

· . _]

#POST/MILMU VERSION \$4GF(1134/18_Jum84) SESSION BECUN \$ 2115 / \$7 NOV 1985 5 SEC +Y TRANSLATION, IRV, \$7/IMPINGEMENT, PRIMARY CONTROL MODE RUN 8

..... .

163



#TRAJ/MILMU VERSION 04GF(1134/18jun84)

END RUN NO. 0

•

PET =

5 SEC +Y TRANSLATION, IRV, W/IMPINGEMENT, PRIMARY CONTROL MODE

OPEN B JETS ISOLATION VALVE OPEN A JETS -4.67 A TANK 2894.57 A TANK -1.86 B TANK 2957.61 B TANK 14.9625 B TANK TEMPERATURE . (deg F) PRESSURE (LB/IN^2) PROPELLANT WT (LB) 14.7340 A TANK 29.6966 TOTAL AMOUNT USED (LB) 0.3814 A TANK 0.1529 B TANK 0.5342 TOTAL

SESSION BEGUN @ 2115 / 07 NOV 1985

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

MU: RM50	397524	44 -63	3537144	XYZ	4732.4	3	0.57	3.01 DUVE
PL:RM50	397821	0 -63	8537145	XYZ	4732.4	Ø	0.00	3.00 DC72
						-		
MU DATA	\$\$\$\$\$\$\$ \$	-89.96 DEC	-72.62	LON	1040 W	IT	111 ESUN	64.6 BETH
PL DATA	\$\$\$\$\$\$\$ H	-89.96 DEC	-72.63	LON	21 W	т	111 ESUN	54.6 BETA
MIL:0450		0.00001 FCC	90.00	INC	0.01 B	AN -	78.09 ARG	-11.37 TPA
MULATINE	******* 40	000000 200	00.00	THC	0.01 0	<u>ан</u> _	70 00 000	-11 07 100
NOTINED	*******	22222.27 nr	90.00	INC	0.01 4	- 11	70.07 HKG	-11.or IRH
MU: M50	-0.60 PCH	-0.76 YAW	-1.25 4	ROL	-0.055 R	×B	0.016 P7B	0.011 FZB
MU: MLV	-0.56 PCH	I -0.77 YAW	-1,25 (ROL	-0.055 R	×B	0.016 RYB	0.011 RZB
PL + 0M50		1 0 00000 ECC		TNC	0 00 P	an	90 02 BPC	-179 99 788
PC: UNDO	Server She	0.00000 200	70.00	1110	0.00 K	AU	20.02 MRG	170.00 700
PL:IMLD	35555555 HH	35555355 HP	90.00	INC	0.00 R	HN	90.02 HKG	-1/9.98 TRH
PL: M50	-115.90 PCH	-30.04 YAW	170.99	ROL	-9.435 R	×B -	9.446 RYB	-18.903 RZB
PL: PLV	-115.76 PCH	-30.04 YAW	170.99	ROL	-9.435 R	×B -	9.446 RYB	-18.903 RZB
						•		
MUSCPLV	-0.049	0.007	0.000	XYZ	0.0	3	0.07	0.01 DXYZ
PL:RMLV	298	-44	-1	XYZ	-0.0	3	-0.57	-0.01 DXYZ
PL:RMBY	298	-40	-5 :	XYZ	-0.0	3	-0.62	0.02 DXYZ

1.240 HHMM.5S MET = 1.240 HHMM.SS











0.210 HHMM.SS PET = MET = 0.210 HHMM.SS 4732.42 MU: RM50 99381 -0 -628537253 XYZ -0.01 1.43 DOVE PL:RM50 99680 0 -628537262 XYZ 4732.40 0.00 0.75 0272 NU DATA \$\$\$\$\$\$ -39.99 DEC -72.37 LON 1040 WT 111 ESUN 64.6 BETA -89.99 DEC -72.37 LON PL DATA \$\$\$\$\$\$ 21 WT 111 ESUN 64.6 BETA -86.23 TRA -86.23 TRA MU: 0M50 \$\$\$\$\$\$\$ SMA 0.00014 ECC 90.00 INC -0.00 RAN -3.76 ARG MU: IMLD \$\$\$\$\$\$\$ HA 99986.06 HP 90.00 INC -0.00 RAN -3.76 ARG -0.027 RYB -0.027 RYB 1.53 PCH 0.82 ROL MU: M50 -1.81 YAW 0.094 RXB 0.011 R2B 1.54 PCH -1.81 YAW 0.82 ROL 0.094 RXB 0.011 RZB MU: MLV 90.00 ARG -179.99 TRA 90.00 ARG -179.99 TRA PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.00 INC PL: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP 0.00 RAN -0.646 RZB -0.647 RZB PL: M50 1.61 PCH 50.66 YAW 117.38 ROL 4.578 RXB 4.012 RYB PL: PLV 1.62 PCH 50.66 YRW 117.38 ROL 4.578 RXB 4.012 RYB MU:CPLV -0.049 -0.000 0.002 XYZ 0.02 -0.01 0.68 DXYZ PL:RMLV 300 -9 XYZ -0.02 0.01 -0.68 DXYZ 0 PL:RMBY 300 -1 XYZ -0.06 -0.84 DXYZ 10 -0.00

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-2.28	R	TANK	-4.42	B	TANK		
PRESSURE	(LB/IN^2)	2948.07	A	TRNK	2900.06	B	TANK		
PROPELLANT WT	(LB)	14.9280	A	TANK	14.7540	B	TANK	29.6820	TOTAL
AMOUNT USED	(LB)	0.1374	A	TANK	0.3614	B	TANK	0.5488	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84) SESSION BEGUN 0 2130 / 7 NOV 1985

5 SEC +Z TRANSLATION, IRV, W/ IMPINGEMENT, PRIMARY CONTROL MODE

END RUN NO. 0

۲



1.180 HHMM.SS MET = PET = 1.180 HHMM.SS MU: RM50 369130 -0 -628537163 XYZ -0.00 4732.48 2.79 D.WZ PL:RM50 369427 0 -628537162 XYZ 4732.40 0.00 2.78 DXYZ -89.97 DEC -72.61 LON -89.97 DEC -72.61 LON MU DATA \$\$\$\$\$\$\$ 1040 WT 111 ESUN 64.6 BETA -72.61 LON PL DATA SSSSSSS H 64.6 BETR 21 WT 111 ESUN -87.17 ARG -87.17 ARG MU:0M50 \$\$\$\$\$\$\$ SMA 0.00003 ECC 90.00 INC -0.00 RAN -2.80 TRA MU: IMLD SSSSSSS HA SSSSSSS HP 90.00 INC -0.00 RAN -2.30 TRA MU: M50 -3.65 PCH -0.55 YAW 66.57 ROL 15.601 RXB 0.010 RYB 0.010 PZB MU: MLV -3.62 PCH -0.55 YAW 66.57 ROL 15.601 RXB 0.010 RYB 0.009 RZB PL:0M50 ####### SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.01 ARG -179.98 TRA PL: IMLD SSSSSSS HA SSSSSSS HP 90.00 INC 0.00 RAN 90.01 ARG -179.98 TRA 34.68 YAW -144.11 ROL 34.68 YAW -144.11 ROL 1.209 RXB PL: M50 67.46 PCH -3.280 RYB -5.036 RZB PL: PLV 67.49 PCH 1.209 RXB -3.280 RYB -5.036 RZB MU:CPLV -0.049 -0.000 -0.000 XYZ 0.08 -0.00 0.01 DXYZ PL:RMLV PL:RMBY -0.01 DXYZ 4.12 DXYZ 1 XYZ -0.08 0.00 297 р -15 -10 XYZ -0.08 296 -2.72

l

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-9.69	A	TANK	-1.25	9	TANK		
PRESSURE	(LBŽIN^2)	2784.06	A	TANK	2971.51	B	TANK		
PROPELLANT WT	<lb></lb>	14.3300	A	TANK	15.0127	B	TANK	29.3427	TOTAL
AMOUNT USED	(LB)	0.7854	A	TANK	0.1027	B	TANK	0.3381	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84) SESSION BEGUN 0 2110 / 07 NOV 1985

2 SEC +X ROTATION, IRV, W/IMPINGEMENT, PRIMARY CONTROL MODE

END RUN NO. 0

, ,



. .

9

APDST/MILMU VERSION BAGF(1134/18 Jun 84) SESSION BEGUN B 8447 / 719 NDV 1985 5 SEC +Y (PIICH) ROTATION, IRV, W/IMPINGEMEINT, PRIMARY CONTROL, MOLE RIN B

6

169

1.

PET = 1.270 HHMM.SS MET = 1.270 HHMM.SS -1 -628537135 XYZ 0 -628537135 XYZ 4732.43 3.11 0272 MU: RM50 411721 -0.01 3.10 D:272 PL:RM50 412019 4732.40 0.00 -89.96 DEC -72.64 LON -89.96 DEC -72.64 LON MU DATA \$\$\$\$\$\$\$ H 1041 WT 111 ESUN 64.6 BETA PL DATA \$\$\$\$\$\$ 21 WT 111 ESUN 64.6 BETA MU:0M50 \$\$\$\$\$\$\$ SMA 0.00001 ECC 90.00 INC -0.00 RAN -76.88 ARG -13.09 TRA MU: IMLD \$\$\$\$\$\$\$ HA 99999.96 HP 90.00 INC -0.00 RAN -76.88 ARG -13.09 TRA -0.002 RXB -0.002 RXB -2.82 YAW -2.82 YAW MILE MSØ 86.73 PCH 0.80 ROL 10.122 RYB 0.011 RZB 10.122 RYB 86.77 PCH 0.011 RZB 0.80 ROL MU: MLV 90.02 ARG -179.98 TRA 90.02 ARG -179.98 TRA PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.00 INC PL:IMLD \$\$\$\$\$\$ HA \$\$\$\$\$\$ HP 0.00 RAN 87.51 YAW -117.59 ROL 87.51 YAW -117.59 ROL 2.265 RXB -4.358 RYB -3.661 R2B PL: M50 55.35 PCH -4.358 RYB -3.661 RZB PL: PLV 55.39 PCH 2.265 RXB MU: CPLV -0.049 -0.000 0.000 XYZ 0.03 -0.01 0.01 DXYZ PLIRMLY 298 0 XYZ -0.03 0.01 -0.01 DXYZ 1 PLIRMBY 6 297 XYZ -52.47 -0.00 2.92 DXYZ 17

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-3.65	A	TANK	-0.03	B	TANK		
PRESSURE	(L8/IN^2)	2917.37	A	TANK	2999.27	B	TANK		
PROPELLANT WT	(LB)	14.8168	A	TANK	15.1128	B	TANK	29.9296	TOTAL
AMOUNT USED	(LB)	0.2986	A	TANK	0.0026	B	TANK	0.3012	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN 0 0440 / 08 NOV 1985

5 SEC +Y (PITCH) ROTATION, IRV, W/IMPINGEMENT, PRIMARY CONTROL MODE

END RUN NO. 8

•

•

.

0



È

PET = 0.500 HHMM.SS MET = 0.500 HHMM.SS -0.01 1.80 DCVZ -0 -628537226 XYZ 4732.42 MU: 8M50 236621 0 -628537226 XYZ 4732.40 0.00 1.78 DEVZ PL:RM50 236920 -89.98 DEC -72.49 LON -89.98 DEC -72.49 LON 64.6 BETA MU DATA \$\$\$\$\$\$\$ 1041 WT 111 ESUN 111 ESUN 64.6 BETA 21 WT PL DATA \$\$\$\$\$\$\$ H -0.00 RAN -73.07 ARG -16.91 TRA 90.00 INC MU:0M50 ####### SMA 0.00001 ECC -73.07 ARG -16.91 TRA MU: IMLD \$\$\$\$\$\$\$ HA 99999.95 HP 90.00 INC -0.00 RAN 7.066 RZB MU: M50 -4.76 PCH -77.55 YAW -0.60 ROL -0.037 RXB -0.010 RYB 7.066 RZB MU: MLV -4.74 PCH -77.55 YAW -0.60 ROL -0.038 RXB -0.010 RYB 90.01 ARG -179.99 TRA PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.01 ARG -179.99 TPA PL: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$ HP 90.00 INC 0.08 RAN PL: M50 -148.44 PCH -33.45 YAW -47.99 ROL 0.923 RXB 2.713 RYB -5.410 RZB PL: PLV -148.42 PCH -33.45 YAW -47.99 ROL 0.922 RXB 2.713 RYB -5.410 RZB 0.000 XYZ 0.02 -0.01 0.01 DXYZ MU:CPLV -0.049 -0.000 -0 XYZ -22 XYZ -0.01 DXYZ 0.17 DXYZ 0.01 -0.02 PLIRMLY 299 0 PL:RMBY 35.90 -7.88 291 64

MU PROPELLANT STATUS ('PRIM' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E (dec F)	0PEN -3.32	A	JETS Tank	OPEN -0.87	B B	JETS Tank		
PRESSURE PROPELLANT WT	(LB/IN^2) (LB)	2924.82 14.8438	A	TANK TANK	2980.08 15.0436	B B	TANK TANK	29.8875	TOTAL
AMOUNT USED	(LB)	0.2716	A	TANK	0.0717	B	TANK	0.3433	TOTAL

*TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 2230 / 07 NOV 1985

5 SEC +Z ROTATION, IRV, W/IMPINGEMENT, PRIMARY CONTROL MODE

END RUN NO. 0



.

PET = 0.250 HHMM.SS MET = 0.250 HHMM.SS 0.89 DOVE MU: RM50 118317 -0 -628537260 XYZ 4732.90 -0.00 0 -628537259 XYZ 4732.40 0.00 0.89 DXV2 FL: RM50 118610 -89.99 DEC -72.38 LON 1041 WT 111 ESUN NU DATA \$\$\$\$\$\$\$ H 64.6 BETA -89.99 DEC -72.38 LON 64.6 BETA PL DATA \$\$\$\$\$\$\$ 21 WT 111 ESUN MU:0M50 \$\$\$\$\$\$\$ SMA 0.00021 ECC 90.00 INC -0.00 RAN -90.27 ARG 0.28 TRA MU: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP 90.00 INC -0.00 RAN -90.27 ARG 0.28 TRA -0.060 RZB -0.060 RZB MU: M50 1.60 PCH -0.70 YAW -0.17 ROL -0.016 RXB -0.015 RYB -0.016 RXB 1.61 PCH -0.70 YAW -0.17 ROL -0.015 RYB MU: MLV PL:0450 ####### SMA 0.00000 ECC 0.00 RAN 90.00 ARG -179.99 TRA 90.00 INC PL: IMLD SSSSSSS HA SSSSSSS HP 90.00 INC 0.00 RAN 90.00 ARG -179.99 TRA -15.22 PCH -15.21 PCH PL: M50 65.74 YAW 149.18 ROL 4.065 RXB 4.383 RYB -1.314 RZB 65.74 YAW -1.314 RZB PL: PLV 149.18 ROL 4.065 RXB 4.383 RYB MU: CPLV -0.048 -9.000 -0.000 XYZ 0.50 -0.00 -0.00 DXYZ 0.00 DXYZ -0.08 DXYZ 0 XYZ -0.50 PLIRMLV 293 ø 0.00 PL:RMBY 293 4 9 XYZ -0.50 0.30

MU PROPELLANT STATUS (BUPB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	0.00	A	TANK	-3.32	B	TANK		
PRESSURE	(LBŽINA2)	3000.00	A	TANK	2924.63	B	TANK		
PROPELLANT WT	(LB)	15.1154	A	TANK	14.8432	B	TANK	29.9585	TOTAL
AMOUNT USED	(LB)	0.0000	A	TANK	0.2722	B	танк	0.2722	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 0300 / 08 NOV 1985

5 SEC +X TRANSLATION, IRV, W/IMPINGEMENT, BACKUP B CONTROL MODE

END RUN NO. 0



, d P

9

#POST/MILMU VERSION BAGE (1134/18 Junea) SESSION BEGUN & RAIR / RA HOV 1995 5 SEC -X TRANSLATION, IRV, W/IMPINGEMENT, BACKUP B CONTROL MOLE RUN B

MET = PET a A 250 HHMM.SS 0.250 HHMM.SS 0 -628537260 XYZ 0.89 DC72 118301 4731.95 0.00 MU: RM50 0 -628537259 XYZ 4732.40 0.89 0002 PL:RM50 118610 0.00 MU DATA \$\$\$\$\$\$\$ H -89.99 DEC -72.38 LON 1041 WT 111 ESUN 64.6 BETA PL DATA \$\$\$\$\$\$ -89.99 DEC -72.38 LON 21 WT 111 ESUN 64.6 BETA 90.00 INC 0.00 RAN 90.00 ARG -179.99 TPA MU:0M50 \$\$\$\$\$\$\$ SMA 0.00019 ECC MU: IMLD \$\$\$\$\$\$\$ HA 99961.07 HP 90.00 INC 0.00 RAN 90.00 ARG -179.99 TPA 0.15 ROL -0.018 R×B MILL MSØ -1.57 PCH 1.54 YAW 0.010 RYB -0.014 PZB 1.54 YAW 0.15 ROL 0.010 PYB -0.014 PZB -1.55 PCH -0.018 RXB MU: MLV 90.00 INC 0.00 RAN 90.00 ARG -179.99 TPA 90.00 ARG -179.99 TPA PL:0M50 ####### SMA 0.00000 ECC 0.00 RAN 90.00 INC PL: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP -15.09 PCH 4.384 RYB -1.316 RZB PL: M50 65.73 YAW 149.08 ROL 4.064 RXB -1.316 RZB 4.384 RYB PL: PLV -15.08 PCH 65.73 YAW 149.08 ROL 4.064 RXB MU:CPLV -0.051 0.000 -0.000 XYZ -0.45 0.00 0.00 DXYZ PL:RMLV 309 0 XYZ 0.45 -0.00 -0.00 DXYZ -0 PLIRMBY 308 -8 -8 XYZ 0.45 0.06 0.04 DXYZ

MU PROPELLANT STATUS ('BUPB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	9 9	JETS		
PRESSURE	(LB/IN^2)	3000.00	8	TANK	2922.80	B	TANK	50 AF14	TOTO
PRUPELLANT WI		15,1154		TANK	14.8365	8	TOUR	27.7017	TOTAL
AMOUNT USED	(LB)	0.0000	н	THNK	0.2789	в	INNK	0.2.37	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 0310 / 08 NOV 1985

5 SEC -X TRANSLATION, IRV, W/IMPINGEMENT, BACKUP B CONTROL MODE

END RUN NO. 0



.

.

.

. . .

#POSI/MILMU VERSION #4GF (1134/18Jum84) SESSION PERTULON PAIS / BR HDV 398 5 SEC +Y TRANSLATION, IRV, W/IMPINGEMENT, BACKUP B CONTROL, MODEL RUN B

177

۰.





÷

MICROCOPY RESOLUTION TEST CHART

PET = 0.320 HHMM.55 MET = 0.320 HHMM.SS 14 -628537253 XY2 0 -628537252 XYZ MU: PM50 151438 4732.43 0.51 1.12 0.72 1.14 DOVZ 151737 4732.40 PL: PM50 0.00 -89.99 DEC -72.41 LON -89.99 DEC -72.41 LON NU DATA SSSSSSS H 1040 WT 111 ESUN 64.6 BETA PL DATA \$\$\$\$\$\$ 21 WT 111 ESUN 64.6 BETA MU:0M50 \$\$\$\$\$\$\$ SMA 0.00001 ECC 90.00 INC 0.01 RAN -110.73 ARG 20.74 TPA MU: IMLD ######## HA 99999.90 HP 90.00 INC 0.01 RAN -110.73 ARG 20.74 TRA -0.025 RXB -0.025 RXB -0.010 RYB -0.010 RYB 1.42 PCH 1.27 ROL MU: M50 -5.96 YAW 0.010 RZB 1.27 ROL 1.44 PCH -5.96 YAW 0.010 RZB MU: MLV 90.01 ARG -179.99 TRA 90.01 ARG -179.99 TRA PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN PL:IMLD \$\$\$\$\$\$ HA \$\$\$\$\$\$ HP 98.00 INC 0.00 RAN 65.12 YAW -101.60 ROL 65.12 YAW -101.60 ROL 4.620 RYB -2.520 RZB 4.620 RYB -2.520 RZB PL: M50 -104.04 PCH 3.063 RX1 PL: PLV -104.03 PCH 3.063 RXB MU:CPLV -0.049 0.002 -0.000 XYZ 0.03 0.51 -0.02 DXYZ PLIRMLV 299 1 XYZ -0.03 -0.51 0.02 DXYZ -14 299 PLIRMBY 17 8 XYZ 0.03 -0.57 -0.01 DXYZ

MU PROPELLANT STATUS ('BUPB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALVE	1	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	0.00	A	TANK	-7.32	B	TANK		
PRESSURE	(LB/IN^2)	3000.00	A	TANK	2835.92	B	TANK		
PROPELLANT WT	(LB)	15.1154	A	TANK	14.5202	8	TANK	29.6356	TOTAL
AMOUNT USED	(LB)	0.0000	A	TANK	0.5952	B	TANK	0.5952	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84) SESSION BEGUN 0 0315 / 08 NOV 198

5 SEC +Y TRANSLATION, IRV, W/IMPINGEMENT, BACKUP B CONTROL MODE

END RUN NO. 0

.



ſ

PET = 0.270 HHMM.55 MET # 0.270 HHMM.SS 1.47 BC/2 MU: RM50 127775 -0 -629537247 XYZ 4732.42 -0.01 0 -618537257 XYZ 0.96 DOG Z PL:RM50 128075 4732.40 0.00 -89.99 DEC -72.39 LON -89.99 DEC -72.39 LON 111 ESUN 1040 WT 64.6 BETA MU DATA \$\$\$\$\$\$\$ 21 WT 64.6 BETA PL DATA SSSSSSS H 111 ESUN MU: 0M50 \$\$\$\$\$\$\$ SMA 0.00011 ECC 90.00 INC -0.00 RAN -4.45 APG -85.53 TPA -85.53 TRA MU: IMLD \$\$\$\$\$\$\$ HA 99989.63 HP 90.00 INC -0.00 RAN -4.45 ARG MU: M50 1.52 PCH -2.45 YAW 0.84 ROL 0.073 RXB -0.010 RYB 0.011 RZB MU: MLV 1.53 PCH -2.45 YAW 0.84 ROL 0.073 RXB -0.010 RYB 0.011 RZB PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.01 ARG -179.99 TRA PL: IMLD \$\$\$\$\$\$\$ HA \$\$\$\$\$\$\$ HP 90.00 INC 0.00 RAN 90.01 ARG -179.99 TRA -35.72 PCH -35.71 PCH 71.30 YAW 176.22 ROL 71.30 YAW 176.22 ROL 3.790 RXB 4.507 RYB -1.673 PZB PL: M50 71.30 YAW 3.790 RXB 4.507 RYB -1.673 RZB PL: PLV 0.002 XYZ -10 XYZ -3 XYZ 0.51 DXYZ -0.51 DXYZ -0.049 -0.000 0.02 -0.01 MU: CPLV PL:RMLV PL:RMBY -0.02 0.01 300 8 -0.58 DXYZ 299 13 -0.00 -0.06

MU PROPELLANT STATUS (BUPB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	0.00	A	TANK	-5.58	B	TANK		
PRESSURE	(LBZINA2)	3000.00	A	TANK	2874.37	B	TANK		
PROPELLANT WT	(LB)	15.1154	A	TANK	14.6605	B	TANK	29.7759	TOTAL
AMOUNT USED	· LB)	0.000	A	TANK	0.4549	B	TANK	0.4549	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 0330 - 08 NOV 1985

5 SEC +2 TRANSLATION, IRV, W/IMPINGEMENT, BACKUP B MODE

END RUN NO. 0



181

٠.

. .

'' (PET = A. 260 HHMM. SS MET = 0.260 HHMM.SS MU:RM50 123043 -0 -628537259 XYZ 4732.43 -0.01 0.92 BXYZ PL:RM50 123342 0 -628537258 XYZ 4732.40 0.00 0.93 DXYZ -89.99 DEC -72.39 LON -89.99 DEC -72.39 LON MU DATA \$\$\$\$\$\$ 1041 WT 111 ESUN 64.6 BETA PL DATA \$\$\$\$\$\$ 21 WT 111 ESUN 64.6 BETA MU: 0M50 \$\$\$\$\$\$\$ SMA 0.00001 ECC 98.88 INC -0.00 RAN -92.68 ARG 2.61 TRA 90.00 INC -0.00 RAN -92.60 ARG 2.61 TRA MU: IMLD SSSSSSS HA SSSSSSS HP -1.13 YAW -12.60 ROL 0.010 RYB -0.010 RZB -1.71 PCH 15.433 RXB MU: M50 -1.13 YAW -12.60 ROL 0.011 RYB -0.010 RZB -1.70 PCH 15.433 RXB MU: MLV 90.00 INC 90.00 INC 90.00 ARG -179.99 TRA 90.00 ARG -179.99 TRA 0.00 RAN PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 0.08 RAN PLIIMLD SSSSSSS HA SSSSSSS HP PLI M50 -22.77 PCH 68.86 YAW 160.34 ROL 3.919 RX3 4.459 RYB -1.504 RZB 4.459 RYB -1.505 RZB PL: PLV -22.75 PCH 68.86 YAW 168.34 ROL 3.919 RXB MUICPLV -0.849 -0.000 -0.000 XYZ 0.03 -0.01 -0.00 DXYZ PLIRHLV 8 XYZ 0.01 0.00 DXYZ 300 -0.03 Ø PLIRMBY -7 XYZ -1.80 -2.03 DXYZ 299 8 -0.03

MU PROPELLANT STATUS ('BUPB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALVE		OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	0.00	A	TANK	-4.80	B	TANK		
PRESSURE	(LB/IN^2)	3000.00	A	TANK	2891.55	Ð	TANK		
PROPELLANT WT	(LB)	15.1154	A	TANK	14.7230	B	TANK	29.8384	TOTAL
AMOUNT USED	(LB)	0.0000	A	TANK	0.3924	Ð	TANK	0.3924	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 0430 / 08 NOV 1985

2 SEC +X (ROLL) ROTATION, IRV, W/IMPINGEMENT, BACKUP B CONTROL MODE

END RUN NO. 8

たけにアナビビーしたいたちのと見た

ł

(.

.



















	11420 10000			1.400 44111.00		
1U: RM50	487440	1 -628	3537 9 81 X	rz 4732.43	0.01	3.68 DUVZ
LIRM50	487737	0 -628	537081 X	(Z 4732.40	0.00	3.67 DK7Z
1U DATA	\$\$\$\$\$\$\$ H	-89.96 DEC	-72.71 L	DN 1041 WT	111 ESUN	64.6 BETA
PL DATA	\$\$\$\$\$\$\$ H	-39.96 DEC	-72.71 L	DN 21 WT	111 ESUN	64.6 BETA
10:0150	******* SMA (0.00001 ECC	90.00 II	IC 0.00 RAN	-76.24 ARG	-13.71 TRA
1U:IMLD	\$\$\$\$\$\$\$ HA 99	9999.96 HP	90.00 II	NC 0.00 RAN	-76.24 ARG	-13.71 TRA
1U: M50	-87.32 PCH	-3.85 YAW	1.28 R	L 0.077 RXB	10.151 RYB	0.010 R28
10: MLV	-87.27 PCH	-3.85 YAW	1.28 R)L 0.077 RXB	10.151 RYB	0.010 RZB
L:0850	******* SMA 0	3.00000 ECC	90.00 II	IC 0.00 RAN	90.02 ARG	-179.98 TRA
PL:IMLD	\$\$\$\$\$\$\$ HA \$1	\$\$\$\$\$\$ HP	90.00 II	IC 0.00 RAN	90.02 ARG	-179.98 TRA
PL: M50	-100.51 PCH	12.16 YAW	96.42 R	DL 4.454 RXB	-4.124 RYB	-0.809 RZB
PL: PLV	-100.46 PCH	12.16 YAW	96.42 R	DL 4.454 RXB	-4.124 RYB	-0.808 RZB
U:CPLV	-0.049	0.000	0.000 X	Z 0.03	0.01	0.01 DXYZ
PLIRMLY	297	-1	-0 X'	1Z -0.03	-0.01	-0.01 DXYZ
LIKUBT	1.4	-7	-297 X	74 52.36	-0.41	₹148 ЛХ ХХ

MU PROPELLANT STATUS ('BUPB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALVE		OPEN	A	JETS	OPEN	B	JETS	
TEMPERATURE	(deg F)	0.00	A	TANK	-3.74	B	TANK	
PRESSURE	(LB/IN^2)	3000 .00	A	TANK	2915.28	B	TANK	
PROPELLANT WT	(LB)	15.1154	A	TANK	14.8092	B	TANK	29.9246 TOTAL
AMOUNT USED	(LB)	0.0000	A	TANK	0.3061	B	TANK	0.3061 TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84) SESSION BEGUN 0 0415 / 08 NOV 1985

5 SEC +Y (PITCH) ROTATION, IRV, W/IMPINGEMENT, BACKUPB CONTROL MODE

END RUN NO. 0





















. . .



PET = 0.340 HHMM.SS MET = 0.340 HHMM.55 MU: RM50 160902 -0 -629537251 XYZ 4732.42 -0.00 1.19 DEG 2 PL:RM50 161202 0 -628537250 XYZ 4732.40 0.00 1.21 D.WZ -89.99 DEC -72.42 LON -89.99 DEC -72.42 LON MU DATA SSSSSSS H 1041 WT 111 ESUN 64.6 BETA PL DATA SSSSSSS H 21 WT 111 ESUN 64.6 BETA MU: 0M50 \$\$\$\$\$\$\$ SMA 0.00001 ECC 90.00 INC -0.00 RAN -114.14 ARG 24.15 TRA MU: IMLD \$\$\$\$\$\$\$ HA 99999.89 HP -0.00 RAN -114.14 ARG 90.00 INC 24.15 TPA MU: M50 -173.42 PCH -4.18 YAW 176.22 ROL MU: MLV -173.41 PCH -4.18 YAW 176.22 ROL -0.035 RXB -0.010 RYB 6.988 PZB -0.035 RXB -0.010 RYB 6.988 RZB 90.01 ARG -179.99 TRA PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 0.00 RAN 90.01 ARG -179.99 TRA PL: IMLD SSSSSSS HA SSSSSSS HP 90.00 INC PL: M50 -116.83 PCH 2.808 RXB 4.569 RYB -2.952 RZB 55.63 YAW -84.89 ROL PL: PLV -116.81 PCH 55.63 YAW -84.89 ROL 2.308 RXB 4.569 RYB -2.952 RZB MU: CPLV -0.049 -0.000 -0.000 XYZ 0.03 -0.00 -0.02 DXYZ 1 XYZ 37 XYZ 299 PLIRMLV -0.03 0.00 0.02 DXYZ ø 0.08 DXYZ PLIRMBY -296 19 2.36 36.12

2020-0

MU PROPELLANT STATUS ('BUPB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALVE		OPEN	A	JET\$	OPEN	B	JETS		
TEMPERATURE	(deg F)	0.00	A	TANK	-4.30	B	TANK		
PRESSURE	(LBŽIN^2)	3000.00	A	TANK	2902.83	B	TANK		
PROPELLANT WT	(LB)	15.1154	A	TANK	14.7641	B	TANK	29.8794	TOTAL
AMOUNT USED	(LB)	0.0000	A	TANK	0.3513	B	танк	0.3513	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

SESSION BEGUN @ 0400 / 08 NOV 1985

A MARCHA

A TALAY AND A REAL

5 SEC +2 (YAW) ROTATION, IRV, W/IMPINGEMENT, BACKUP B CONTROL MODE

END RUN NO. 0





Ē

· · · · · ·

.

187

<u>____</u>

.



MU PROPELLANT STATUS ('STAB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALV	Έ	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-2.63	A	TANK	-2.63	B	TANK		
PRESSURE	(LB/IN-2)	2940.17	A	TANK	2940.17	B	TANK		
PROPELLANT WT	(LB)	14.8994	A	TANK	14.8994	B	TANK	29.7989	TOTAL
AMOUNT USED	(L B)	0.2168	A	TANK	0.2160	B	TANK	0.4319	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84) SESSION BEGUN 0 234 / 07 NOV 1985 1 SEC +X (ROLL) ROTATION, IRV, W/IMPINGEMENT, SATELLITE STABILIZATION CONTROL MODE

END RUN NO. 0





0.380 HHMM.SS 0.380 HHMM.SS PFT = MET = 179834 4732.47 1.97 0272 MU: RM50 -0 -628537228 XYZ -0.01 PL:RM50 180131 0 -628537244 XYZ 4732.40 0.00 1.36 D.5 Z -89.98 DEC -72.44 LON -89.98 DEC -72.44 LON MU DATA \$\$\$\$\$\$\$ H 1041 WT 111 ESUN 64.6 BETA PL DATA \$\$\$\$\$\$\$ H 21 WT 111 ESUN 64.6 BETA MU:0M50 \$\$\$\$\$\$ SMA 0.00011 ECC 90.00 INC -0.00 RAN -15.82 ARG -74.17 TRA MU: IMLD \$\$\$\$\$\$ HA 99991.45 HP 90.00 INC -0.00 RAN -15.82 ARG -74.17 TRA -59.89 PCH -59.87 PCH -0.91 ROL -0.011 RXB MU: M50 0.11 YAW 9.041 RYB 0.022 REB -0.91 ROL -0.011 RXB 9.041 RYB 0.022 PZB MU: MLV 0.11 YAW 90.01 ARG -179.99 TRA 90.01 ARG -179.99 TRA PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN PLIIMLD \$\$\$\$\$\$ HA \$\$\$\$\$\$ HP 90.00 INC 0.00 RAN -66.27 ROL PL: M50 -128.57 PCH 4.351 RYB -3.662 RZB 34.88 YAW 2.264 RXB -128.56 PCH -66.27 ROL 2.264 RXB 4.351 RYB -3.662 RZB PL: PLV 34.80 YAW 0.003 XYZ -17 XYZ MU:CPLV -0.049 -0.000 0.07 -0.01 0.52 DXYZ PL:RMLV 298 -0.07 0.01 -0.52 DXYZ ø PL:RMBY 135 -266 XYZ 41.48 0.01 21.06 DXYZ 4

MU PROPELLANT STATUS ('STAB' JET SELECT OPTION, CROSSFEED 'OFF')

ISOLATION VALVE	E	OPEN	A	JETS	OPEN	B	JETS		
TEMPERATURE	(deg F)	-1.65	A	TANK	-1.65	B	TANK		
PRESSURE	(LB/IN^2)	2962.36	A	TANK	2962.36	B	TRNK		
PROPELLANT WT	(LB)	14.9797	A	TANK	14.9797	B	TANK	29.9593	TOTAL
AMOUNT USED	(LB)	0.1357	A	TANK	0.1357	B	TANK	0.2714	TOTAL

#TRAJ/MILMU VERSION 04GF(1134/18jun84) SESSION BEGUN 0 2300 / 07 NOV 1385
5 SEC +Y (PITCH) ROTATION, IRV, W/IMPINGEMENT, SATELLITE STABILIZATION CONTPOL MODE

END RUN NO. 0





END RUN NO. 0

ISOLATION VALVE

TEMPERATURE

AMOUNT USED

PROPELLANT WT

PRESSURE

0.300 HHMM.SS

(deg F)

(LB)

(LB)

(LBZINA2)

#TRAJ/MILMU VERSION 04GF(1134/18jun84)

141974

142272

PET #

MU: 8450

PL:RM50

MU DATA ######## H

PL DATA \$\$\$\$\$\$\$

*

59.86 TRA MU:0M50 \$\$\$\$\$\$\$ SMA 0.00006 ECC 90.00 INC -0.01 RAN -149.85 ARG 90.00 INC -0.01 RAN -149.85 ARG 59.86 TPA MU: IMLD ######## HA 99997.14 HP 174.95 ROL 9.909 RCB 179.69 PCH -64.28 YAW -0.010 RXB -0.010 RYB MU: M50 MU: MLV 179.70 PCH -64.28 YAW 174.95 ROL -0.011 RXB -0.010 RYB 9.909 RZB PL:0M50 \$\$\$\$\$\$\$ SMA 0.00000 ECC 90.00 INC 0.00 RAN 90.01 ARG -179.99 TPA PLIIMLD \$\$\$\$\$\$ HA \$\$\$\$\$\$ HP 90.00 INC 0.00 RAN 90.01 ARG -179.99 TRA PL: M50 -82.66 PCH 71.12 YRW -128.23 ROL 3.367 RXB 4.605 RYB -2.224 FZB PL: PLV -82.65 PCH 71.12 YAW -128.23 ROL 3.367 RXB 4.605 RYB -2.224 RZB -0.001 XYZ 0.07 MUICPLV -0.049 -0.002 -0.51 -0.23 DXYZ 0.51 0.23 DXYZ PLIRMLV 298 4 XYZ -0.07 13 PL: RMBY -141 262 25 XYZ 44.91 24.84 0.28 DXYZ MU PROPELLANT STATUS ('STAB' JET SELECT OPTION, CROSSFEED 'OFF')

OPEN A JETS

-2.72 A TANK

2938.22 A TANK

14.8924 A TANK

0.2238 A TANK

5 SEC +2 (YAW) ROTATION, IRV, W/IMPINGEMENT, SATELLITE STABILIZATION CONTROL MODE

MET =

-13 -628537258 XYZ

-39.99 DEC -72.41 LON -89.99 DEC -72.41 LON

0 -628537254 XYZ

0.300 HHMM.SS

4732.46

4732.40

1041 WT

21 WT

OPEN B JETS

-2.25 B TANK 2948.87 B TANK

14.9389 B TANK

0.1845 B TANK

SESSION BEGUN @ 2250 / 07 NOV 1985

-0.51

0.00

111 ESUN

111 ESUN

0.84 0.72

1.07 5272

64.6 BETA

64.6 BETA

29.8233 TOTAL

0.4075 TOTAL

Bibliography

- Brown, Nelson E. "Space Shuttle Crew Safety Provisions," <u>Space Rescue and Safety 1975, Volume 41, Proceedings of the 8th International Space Rescue and Safety Symposium, Lisbon, 21-27 September 1975, edited by Philip H. Bolger. San Diego: American Astronautical Society Publications, 1976.
 </u>
- Chiu, P. B., P. M. Muhn, and D. J. Pearson. "Plume Impingement Model, Primary RCS Version (PIM900): Level C Formulation Specification." McDonnell Douglas Technical Services Co, Houston Astronautics Division, TX, 20 October 1978.
- D'Souza, Frank A. and Vijay K. Garg. <u>Advanced Dyna-</u> mics. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1984.
- 4. Greenwood, Donald T. <u>Principles</u> of <u>Dynamics</u>. Englewood Cliffs, NJ: Prentice-Hall, 1965.
- 5. Harwell, W. D., Design Engineer. Personal interview. Johnson Space Center, National Aeronautics and Space Administration, Houston TX, 27 June 1985.
- Huntsman, David, Mechanical Engineering Officer. Telephone interview. Johnson Space Center, Houston, TX, 23 April 1985.
- 7. Joels, Kerry Mark and Gregory P. Kennedy. <u>The Space</u> <u>Shuttle Operator's Manual</u>. New York: Ballantine Books, 1982.
- "Joint Mission Update," <u>Spaceworld</u>, <u>V-11-263</u>: 15 (No-vember 1985).
- 9. Martin Marietta Aerospace Corp. <u>Manned Maneuvering</u> <u>Unit (MMU) Operational Data Book, Volume I. NASA Con-</u> tract No. NAS9-17018. Denver Aerospace Division, CO, January 1984.
- 10. Martin Marietta Aerospace Corp. <u>Manned Maneuvering</u> <u>Unit (MMU) Operational Data Book, Volume II. NASA Con-</u> tract No. NAS9-17018. Denver Aerospace Division, CO, October 1984.
- Martin Marietta Aerospace Corp. <u>Manned Maneuvering</u> <u>Unit Post Mission Summary Report, STS 51-A.</u> NASA Contract No. NAS9-17018. Denver Aerospace Division, CO, February 1985.

- Martin Marietta Aerospace Corp. <u>Manned Maneuvering</u> <u>Unit User's Guide</u>. NASA Contract No. NAS9-17018. Denver Aerospace Division, CO, July 1985.
- McCandless, Bruce II, Capt, USN, Astronaut, National Aeronautics and Space Administration. Personnel interview. Denver CO, 5 September 1985.
- 14. McConville, John T. and others. <u>Anthropometric Rela-</u> <u>tionships of Body and Body Segment Moments of Inertia</u>. <u>Report No. AFAMRL-TR-80-119</u>. Air Force Aerospace Medical Research Laboratory, Wright Patterson AFB OH, December 1980.
- 15. Meriam, J. L. <u>Dynamics</u>. New York: John Wiley & Sons, 1975.
- 16. Miller, Irwin and John E. Freund. <u>Probability and</u> <u>Statistics for Engineers</u> (Second Edition). Englewood Cliffs NJ: Prentice Hall, Inc., 1977.
- Mussack, Christopher, Computer Analyst. Telephone interview. Martin Marietta Aerospace Corp., Denver CO, 2 Oct 1985.
- 18. National Aeronautics and Space Administration. "EVA Systems," <u>Shuttle Flight Operations Manual, Volume 15</u>. Houston: Lyndon B. Hohnson Space Center, 6 January 1984.
- 19. National Aeronautics and Space Administration, Crew Systems Division. "Manned Evaluation of Two Personnel Rescue Spheres (PRS) Inside a Proposed Airlock Configuration." Johnson Space Center, Houston TX, 13 August 1974.
- 20. National Aeronautics and Space Administration. <u>Satel-lite Services Catalog</u>. Publication No. JSC-19211. Johnson Space Center, Houston TX: Research and Engineering Directorate, September 1983.
- 21. National Aeronautics and Space Administration. <u>User's</u> <u>Guide for the HP-9825A Desk Top Flight Simulator</u>. Publication No. JSC-19239. Houston: Johnson Space Center, September 1983.
- 22. "NASA Striving for 24-Launch Goal After Fast Shuttle Pad Turnaround," <u>Aviation Week and Space Technology,</u> <u>122</u>: 78 (13 May 1985).

- 23. Obergefell, Louise A., Analyst, Modeling and Analysis Branch. Personal interview. Air Force Aerospace Medical Research Laboratory, Wright-Patterson AFB OH, 15 August 1985.
- 24. "President, Senators Proposing Space Rescue Operation Plans, <u>Aviation Week and Space Technology</u>: 16-17 (9 July 1984).

- 25. Rhodes, D. B., Manager, McDonnell Douglas Technical Services Co. "MMU Plume Dynamic Pressure." Transmittal Memo No. 1.2-TM-FMC63A18-14 to R. W. Becker/FM2, Johnson Space Center, Houston TX. NASA Contract No. NAS9-16715, Task Order No. FMC63A18, 18 March 1983.
- 26. Rogers, L.J.A. "Use of the Manned Maneuvering Unit for On-Orbit Rescue Operations," <u>Proceedings of the 36th</u> <u>Congress of the International Astronautical Federation</u>. IAA-85-332. Pergamon Press, Oxford, 1985.
- 27. Schine, R., Engineer. Telephone interviews--28 October and 7 November 1985. Personal interview. 6 September 1985. Space Operations Simulation Laboratory, Martin Marietta Aerospace, Denver CO.
- Schlosser, James O. "Personnel Rescue System." Crew Systems Division, Johnson Space Center, Houston TX, Undated.
- 29. Schlosser, James O., Technician. Personal interviews. Johnson Space Center, National Aeronautics and Space Administration, Houston TX, 28 June and 27 September 1985.
- 30. Schmelz, M. D. "Westar/Palapa Satellite Retrieval Mission--AKM Capture Device and Antenna Bridge Structure Mass Properties Analysis." NASA Contract No. NAS9-15800. Lockheed Engineering and Management Services Co., Houston TX, October 1984.
- 31. Schmelz, M. D., Engineer. Telephone interview. Lockheed Engineering and Management Services Co, Houston TX, 12 August 1985.
- 32. Stearns, E.V. "Ad Hoc Working Panel on Rescue and Escape," <u>Proceedings of the Symposium on Space</u> <u>Rendezvous, Rescue, and Recovery.</u> 220-222. Western Periodicals, North Hollywood, CA, 1963.
- 33. The White House. "Statement by the President." Press release announcing the signing of Senate Joint Resolution 236. Washington, D.C., 30 October 1984.
34. Whitsett, Charles E., Chief, EVA and MMU Worksite Equipment Branch. Telephone interviews--18 April and 7 October 1985. Personal interviews--26 June and 27 September 1985. Johnson Space Center, Houston TX.

- 35. Wiesel, William. Lecture materials distributed in MC 5.33, Problems in Spaceflight. School of Engineering, Air Force Institute of Technology (AU), Wright-Patterson AFB, OH, April 1985.
- 36. Wilson, S. W., Engineer. Telephone interview. TRW Corporation, Houston TX, 13 July 1983.
- 37. Wilson, S. W. and D. K. Phillips. "Delivery of Software for the HP-9825T Man-In-The-Loop MMU (MILMU) Simulator Version 02H." Letter to NASA/Johnson Space Center/FM2. Contract No. NAS9-16275. TRW Corporation, Houston TX, 13 July 1983.
- 38. Wilson, S. W. and D. K. Philips. "Software Verification Test Results for DTFS Versions 04B and 04C." Letter to NASA/Johnson Space Center/FM2. NASA Contract No. NAS9-16275, Correspondence Control No. SN37788. TRW Corporation, Houston TX, 14 July 1982.

VITA

Captain James D. Halsell, Jr. was born on 29 September 1956 in Monroe, LA. He graduated from West Monroe High School in 1974 and attended the U. S. Air Force Academy, from which he received the degree of Bachelor of Science in General Engineering and a Regular Commission in the USAF in May 1978. Following Undergraduate Pilot Training at Columbus AFB, MS, and Fighter Lead-In Training at Holloman AFB, NM, he flew the F-4D with the 429th Tactical Fighter Squadron, Nellis AFB, NV, from May 1980 to May 1981. He was then reassigned to the 70th Tactical Fighter Squadron, Moody AFB, GA, where he served as an F-4E pilot and flight instructor until entering the School of Engineering, Air Force Institute of Technology, in May 1984.

> Permanent address: 205 Elmwood Drive West Monroe, LA 71291

> > 197

FILMED

END

3-86

DTIC