JSC-12635

CR151437

# SPACE TRANSPORTATION SYSTEM/CARGO MASS PROPERTIES CALCULATION USING AN INTERACTIVE SYSTEM

Job Order 44-139


(NASA-CR-151437) SPACE TRANSPORTATION SYSTEM/CARGO MASS PROPERTIES CALCULATION USING AN INTERACTIVE SYSTEM (Lockheed Electronics Co.) 35 p HC A03/MF A01 N77-27171

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Prepared By

Lockheed Electronics Company, Inc.

Systems and Services Division

Houston, Texas



Contract NAS 9-15200


For

EXPERIMENT SYSTEMS DIVISION



*National Aeronautics and Space Administration*

**LYNDON B. JOHNSON SPACE CENTER**

***Houston, Texas***

June 1977

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SEPO-139-32

JSC-12635

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

June 1977

LEC-10765
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# TECHNICAL REPORT INDEX/ABSTRACT

*(See instructions on reverse side.)*

| | |
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13. ABSTRACT

Description of the methodology used by the NASA/JSC Experiments and Payloads Project Office, Experiment Systems Division, and the STS Utilization Planning Office, Shuttle Payload Integration and Development Program Office, to perform STS cargo mass properties calculations using an interactive computer system.

14. SUBJECT TERMS

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## FIGURES

# SPACE TRANSPORTATION SYSTEM/CARGO MASS PROPERTIES CALCULATION USING AN INTERACTIVE SYSTEM

## 1. INTRODUCTION

This paper was developed in response to Job Order 44-139, Experiments and Payloads Project Office, Experiment Systems Division, dated October 29, 1976. It is a description of the mass properties methodology implemented to accomplish Space Transportation System (STS) engineering analysis and planning, and to perform compatibility assessment studies of various integrated STS payloads and carrier configurations.

### 1.1 PURPOSE

To describe the methodology used by the NASA/JSC Experiments and Payloads Project Office, and the STS Utilization Planning Office, Shuttle Payload Integration and Development Program Office, to perform STS cargo mass properties calculations using an interactive computer system.

### 1.2 OBJECTIVES

a. Describe the method for the STS cargo mass properties calculation in support of the STS Utilization Planning effort.

b. Illustrate with examples the mass properties calculation for specific payloads.

### 1.3 SCOPE

This paper will discuss the planning and analysis process requirements and techniques, the interactive computer system and database, and the effort required to perform the mass properties calculation.

## 2. PLANNING AND ANALYSIS PROCESS

The Shuttle will provide space transportation services for the scientific user community, commencing with the June 1980 time frame. Specific flight phases that are adaptable to payload needs on each flight are various orbital maneuvers, rendezvous, deployment, retrieval, and on-orbit servicing. As part of the STS Utilization Planning function, each proposed flight is assessed to ensure cargo/Shuttle feasibility, compatibility, and operation within the STS performance and constraints limitations. This paper describes the techniques, capability, and methodology used by the STS Utilization Planning Office in assessing a proposed flight cargo by determining the individual payload and composite cargo location, and calculating the composite mass properties of the cargo and Orbiter vehicle. An overview of this process is illustrated in figure 1.

The STS Utilization Planning and Analysis process for mass properties is illustrated in the block diagram/flowchart, figure 2. A functional description of each block follows.

### 2.1 STS 100 FORM

Assignment on an STS flight is obtained through initiating a request for flight assignment (STS 100 Form) and subsequent planning and negotiations with the STS Operations Office at NASA Headquarters. Specific payload characteristics, mass properties, and unique requirements and constraints are identified by the user on this form. The STS User Handbook is a guide to initiating a request for flight assignment (ref. 1). The user's handbook provides information on NASA STS management and procedures, STS flight systems, STS launch and landing operations, and STS flight operations.

### 2.2 FLIGHT REQUIREMENTS

The flight purpose, requirements, launch direction, orbit, operational environment, etc., are evaluated to determine orbiter dry weights, consumables, personnel, flight kits and special equipment or requirements, which in turn drive the vehicle configuration.

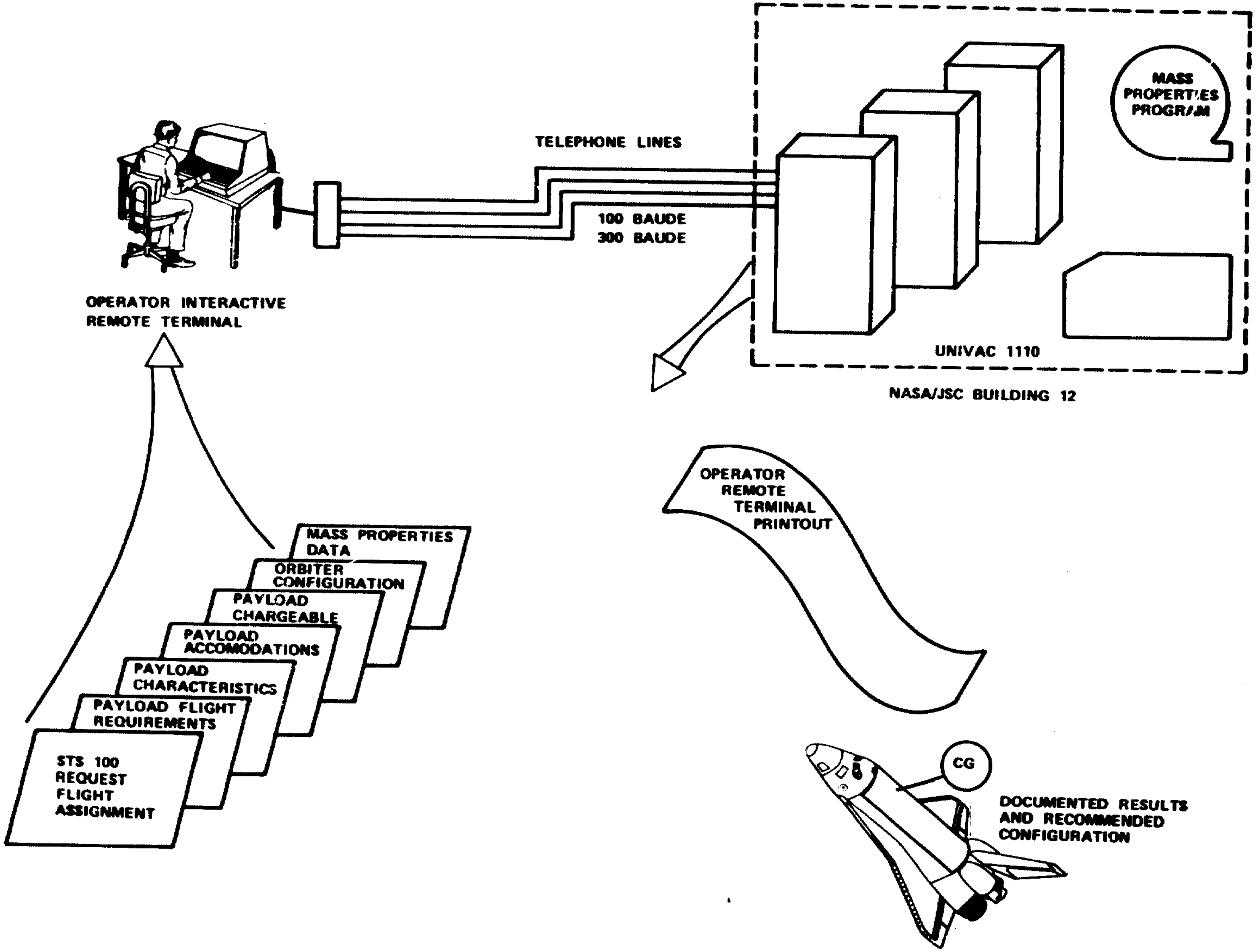



Figure 1.— Operator interactive overview.

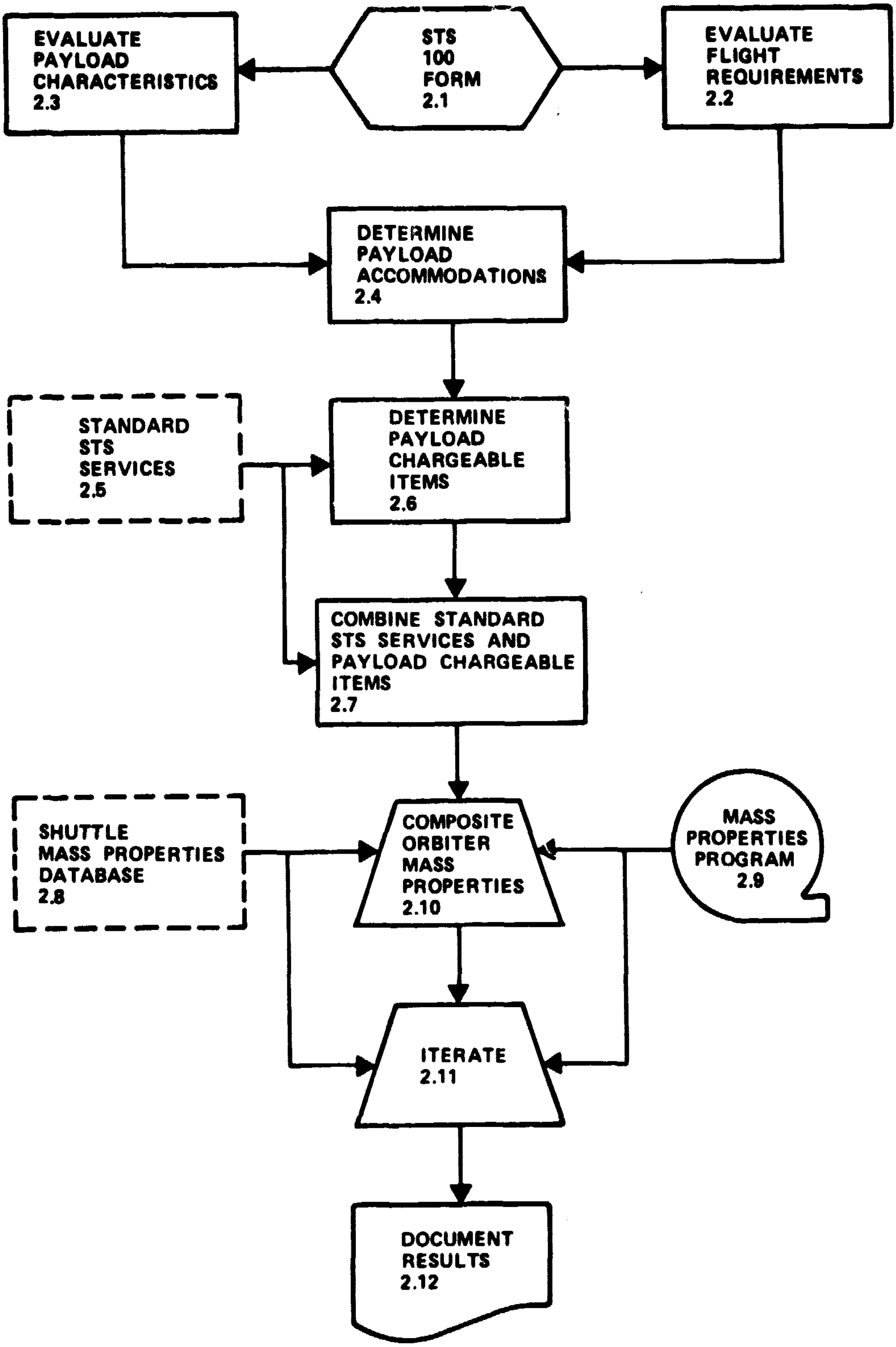



Figure 2.– Mass properties calculation.

## 2.3 PAYLOAD CHARACTERISTICS

Payload characteristics are identified by the user on the STS 100 Form and through additional documentation as necessary. This information is used to determine payload mass properties, physical dimensions, placement within the Orbiter, interfaces with Orbiter services, additional flight kits, and consumables.

## 2.4 PAYLOAD ACCOMMODATIONS

Subsequent to flight requirements and payload characteristics evaluation, the payload is tentatively assigned to an STS flight. Additional payloads following the same evaluation procedure may be assigned to the same proposed STS flight. At this point, the individual payloads are located within the orbiter payload bay forming a proposed cargo configuration for this particular STS flight.

Once the payload location is selected (to obtain a composite vehicle CG) payload attach points and hardware fittings (keel, bridges, longerons) are determined. The fittings required are dependent upon payload location points. The physical dimensions of the payloads and the available attach points influence payload location. A composite mass properties calculation is made of the payload and payload hardware, which in turn is used in the composite vehicle/cargo mass properties calculation.

## 2.5 STANDARD STS SERVICES

The standard STS flight configuration and services capability is based on 1-day flight operations, a three-man flight crew, the standard vehicle dry weights, and required consumables to achieve the aforementioned performance. A mass properties breakdown of this detail for standard STS services is illustrated in table I. Table I tabulates the Orbiter 102 weights, CG, and performance data applicable to a $28.5^{o}$ inclination and a 160-nmi circular orbit. For purposes of illustration and lack of availability of more specific data, table I data is used for the SPACELAB 1 example, which requires a $57^{o}$ inclination and a 160-nmi circular orbit.

## Table I.

## ORBITER MASS PROPERTIES

| | WT | X | Y | Z | |
|---|---|---|---|---|---|
| OV-102 OFT-1 INERT | 140,000 | 1056.5 | 0.9 | 368.8 | |
| PAYLOAD BAY LINER INSTALLATION | 101 | 942.0 | 0 | 340. | |
| PAYLOAD BAY LINER | 254 | 942 | 0 | 340 | |
| RMS INSTALLATION | 260 | 866 | -83.5 | 444.1 | |
| RMS | 920 | 866 | -83.5 | 444.1 | |
| SEAT RECONFIGURATION | 110 | 506 | 0 | 452.4 | |
| PAYLOAD INTERROGATOR | 60 | | | | |
| PAYLOAD DATA INTERLEVER | 36 | | | | |
| SIGNAL PROCESSOR | 42 | | | | |
| KU BAND INSTALLATION | 337 | 550 | 90 | 480 | |
| OFT OV-102 INERT | 142,120 | 105[illegible].5 | .4 | 369.7 | |
| SSME X3 INERT | 19,479 | 1491.9 | -.1 | 383.6 | |
| EPS TANK SET 3 | 735 | 1010. | -4 | 297 | |
| PERSONNEL (3 CREWMEN; 1-3 DAY FLIGHT) | 2,013 | 504.3 | .9 | 380.2 | |
| SUBTOTAL (3 CREWMEN, 3 EPS TANKS, 1-3 DAYS) | 22,227 | 1380.1 | -.1 | 380.4 | |
| ORBITER WITHOUT CARGO & CONSUMABLES | 164,347 | 1097.1 | .3 | 371.2 | |
| NONPROPULSIVE CONSUMABLES | 5,220 | 1003.3 | -4.6 | 337.4 | - 2,668 |
| MPS PROPELLANT | 5,206 | 1408.5 | 12.9 | 355.2 | - 4,500 |
| OMS PROPELLANT | 25,104 | 1417 | 0 | 475.8 | -23,444 |
| RCS PROPELLANT | 7,374 | 1004.2 | 2. | 434.3 | - 5,757 |
| SUBTOTAL | 42,904 | 1294.7 | 1.3 | 437.2 | -36,369 |
| ∇ ORBITER PRELAUNCH (3 CREW, 3 EPS TKS, 1-3 DAYS) | 207,251 | 1138.5 | .5 | 384.8 | |
| CONSUMED TO EI | -36,369 | 1320.3 | 1.6 | 444.2 | |
| ② ORBITER AT EI (3 CREW, 3 EPS TANKS. 1-3 DAYS) | 170,882 | 1099.8 | .3 | 372.2 | |

## 2.6 PAYLOAD CHARGEABLE ITEMS

In addition to the standard STS services, some payloads will require additional payload chargeable items. Some of the requirements which determine these items are special vehicle hardware, equipment, or services not included as part of the standard services, i.e., special orbit requirements, special flight operations, or additional flight crew support. Appendix A, form NASA-S-77-2533C, summarizes the more common of these additional payload chargeable items.

## 2.7 COMBINE STANDARD STS SERVICES AND PAYLOAD CHARGEABLE ITEMS

A composite Orbiter vehicle consists of the cargo (everything contained in the payload bay plus any equipment located elsewhere in the Orbiter which is user unique and not carried in the standard baseline Orbiter weight budget) plus the standard Orbiter vehicle. The Mass Properties Calculation step 2.10 (reference figure 2) is based upon this composite Orbiter vehicle.

## 2.8 SHUTTLE MASS PROPERTIES DATABASE

The Shuttle program's mass properties database is utilized for mass properties calculations for all established vehicle weights and constraints and is supplemented as necessary with proposed payloads data, carriers, and any items not controlled by the Shuttle office.

The mass properties calculations are dependent upon the availability of accurate, complete weights data. A Shuttle weights database has been established and is controlled and maintained by the Shuttle program office (references 2 and 3).

The data is available under major groupings, e.g., Orbiter, External Tank, Solid Rocket Booster, Space Shuttle Main Engine, flight kits, and payload weight chargeable options. Subgrouping mass properties data is also available, i.e., Orbiter 102 Inert Summary Weight Statement, personnel, and cabin stowed equipment.

## 2.9 MASS PROPERTIES PROGRAM

The interactive program utilized in the mass properties calculation is a routine of the ELDON program, which in turn is used to determine Orbital Maneuvering System (OMS) and Reaction Control System (RCS) fuel requirements for an individual mission. The routine is called as necessary by the ELDON program. This routine MSPROP takes an input from the user at the terminal (weight, CG, in X, Y, Z STS coordinates, and moments of inertia (optional)) and sums it with the previous inputs and returns to the user a new composite vehicle/cargo weight, CG, and moments of inertia.

## 2.10 COMPOSITE ORBITER MASS PROPERTIES

Mass properties are calculated for each payload, the total cargo, and the composite Orbiter vehicle.

The general approach taken in the mass properties calculation is as follows. Two basic computations are made, to determine:

a. The entry interface (EI) weight (down weight) which occurs at 400,000 ft as the Orbiter returns to land. The vehicle has a maximum composite entry weight and CG limit.

b. Return-to-launch-site (RTLS) and abort-once-around (AOA). The RTLS calculation is made using the prelaunch vehicle weight (wet) less an allowance for fuel consumption and OMS/RCS fuel dumped. The AOA calculation deletes additional fuel and has the same constraints as for RTLS.

## 2.11 ITERATE

In the event the operational constraints are not met, changes are made directed toward correcting the problem area, through shifting payloads to different CG positions, reducing payload weights, or ballasting as necessary. The mass properties calculation is then made again to verify acceptable performance, and repeated as necessary.

## 2.12 DOCUMENT RESULTS

The results of the analysis, assumptions, and recommended vehicle configuration are documented on forms designed to show flight assignment of a payload and the resulting composite vehicle mass properties (Appendixes A and B).

# 3. EXAMPLES

## 3.1 SPACELAB 1 (LONG MODULE AND PALLET)

An example of the mass properties calculation for a single payload is developed in Appendix A. The payload location, CG, and weight are shown on pages A-3 and A-4. Composite weights with attachment hardware are shown for the SPACELAB and tunnel plus pallet. Both up and down weights are given. The backup sheets, (pages A-5 through A-7) give the payloads, attachment points and hardware with weights and CG. Page A-8 illustrates the additional payload chargeable items (flight kits, personnel, etc.). An annotated computer printout of the mass properties calculation is shown on page A-9.

## 3.2 TDRS/2-STAGE IUS AND SBS/SSUS D

The mass properties calculation for a multiple cargo composed of a Tracking and Data Relay Satellite (TDRS) boosted by an Interum Upper Stage (IUS) and a Systems Business Satellite (SBS) boosted by a Spinning Solid Upper Stage Delta class spacecraft (SSUS D) is developed in Appendix B. The placement of these two payloads is illustrated on page B-4 and the mass properties of each payload are shown respectively on pages B-6 and B-7. The computer printout of the mass properties calculation combining the two payloads and the standard Orbiter vehicle is annotated on page B-8. The calculation is performed to determine the mass properties first at entry interface using the "Orbiter at EI" value from table I marked ② and then second at RTLS and AOA using the Orbiter Prelaunch value marked ▽1.

## 4. ILLUSTRATIONS OF PROGRAM USAGE

### 4.1 INITIAL ANALYSIS REQUIRING FURTHER CHANGES

The initial placement of payloads may require further shifting around to assess the CG or weight constraints, i.e., in the Appendix A example the SPACELAB was initially located 2 feet further toward the front. The AOA CG would have shifted forward (from station $X_0$ 1080.4 shown) to station $X_0$ 1076.0 which violates the station $X_0$ 1076.7 constraint, resulting in moving the SPACELAB location aft (as shown).

### 4.2 EFFORT REQUIRED TO PERFORM ANALYSIS

The effort required to perform analyses depends on the detail required in assessing the proposed payload and flight requirements, and determining payload location and weight/CG. A typical analysis might require 1 to 2 days and two or three people.

Initial time to set up and run a mass properties calculation similar to the Appendix A example would be 1 day to determine initial vehicle and payload configuration, and 1 day to run the interactive program and document the results.

Computer time required would be approximately 1.5 seconds each time the calculation was repeated.

## 5. REFERENCES


1. Space Transportation System User Handbook, NASA/JSC.

2. Shuttle Operational Data Book, Rev A Volume I - Shuttle Systems Performance and Constraint Data, Volume II - Shuttle Mission Mass Properties Data, JSC-08934, September 1975.

3. Shuttle Systems Monthly Weight and Performance Status Report, JSC 09095-28, published monthly.

# APPENDIX A

# EXAMPLE OF

# MASS PROPERTIES CALCULATION

# FOR

# SPACELAB 1 (LONG MODULE AND PALLET)

**STS 100 FORM** | **REQUEST FOR FLIGHT ASSIGNMENT** | **DATE:** 5/18/77

**To:** SPACE TRANSPORTATION SYSTEMS OPERATIONS
MAIL CODE MO
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON D.C. 20546

**FROM:** ____________

/S/

**FLIGHT OBJECTIVES:**

SPACELAB 1

___ Earnest money  X NASA approved
___ Commercial  X ESA approved
___ Other Government ___ DOD approved

Flight period Late CY 1980 or specific date ____
Inclination range 57° or specific inclination ____
Altitude range 250 KM or specific altitude within 5 KM
Payload configuration Long Module + Single Pallet
Flight duration, hours attached 165 Hr Discipline ____

MISSION TYPE:
___ Deployment
X Attached
___ Servicing
___ Retrieval

Crew complement: Commander, pilot, mission specialist plus option for additional mission specialist(s) 0 or payload specialist(s) 2

Payload Operations Control Center support:
___ GSFC ___ JPL X JSC ___ Other ___ Not required ___

STDN and Tracking and Data Relay Satellite system support (comment):

Payload mass properties including flight kits:

| | | | | | |
|---|---|---|---|---|---|
| Weight: | Launch | 32,000 | lb. | | kg |
| | Landing | 32,000 | lb. | | kg |
| Diameter: | Launch | | inches | | mm |
| | Landing | | inches | | mm |
| Length: | Launch | | inches | | mm |
| | Landing | | inches | | mm |

Specify flight kits used in weight: (see JSC07700 vol. XIV):

Payload kWh estimate ____ kWh

Payload constraints and/or unique requirements:
No Additional OMS
No Planned EVA
No Power or Cooling During Ascent & Descent

Orientation, pointing, sunlight constraints, etc. (comment):

Special prelaunch and postlanding off-line support at launch and landing site (comment):

Special prelaunch and postlanding on-line support while in the Orbiter (comment):

(OVER)

**Other comments:**

## Those organizations that will be non-U.S. Government users should also provide the following information:

- Do you request a dedicated flight? If so, do you intend to sublet services to other users?
- Do you request consideration in STS exceptional program selection process?
- Are you willing for your payload to fly on a space-available (standby) basis?
- Do you request to be flown under the definition of a "small self-contained package"?
- State desired date to begin contract negotiations.
- Does payload (or payloads) require revisit and/or retrieval services?
- List known optional services currently under consideration in order that flight requirements can be established

NASA-S-77-2531 D

# FLIGHT ASSIGNMENT

FLIGHT NO. ________ LAUNCH DATE ________

OV- 102 NASA [X] DOD [ ] COMM [ ] INTER [ ]

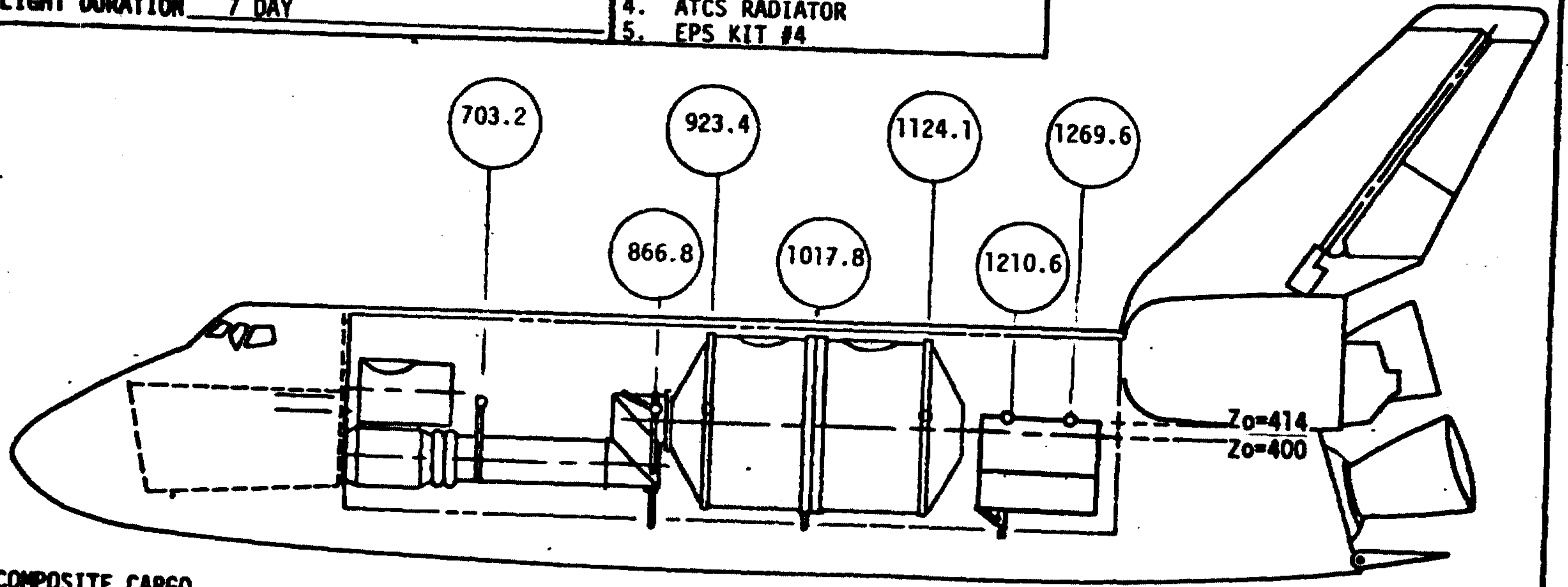
CREW SIZE 5 MAN

FLIGHT DURATION 7 DAY

MAJOR FLIGHT KITS
1. A/L TUNNEL ADAPTER
2. PL BAY MOUNTED A/L
3. ARS DUCT
4. ATCS RADIATOR
5. EPS KIT #4

DATE: 5/18/77

REV:




COMPOSITE CARGO
WT (LB): UP 31,985
WT (LB): DN 31,112

PL IDENT : SPACELAB 1, TUNNEL
PL COMPOSITE:
WT (LB): UP 24,653
DN 23,780
CG (IN): Xo 953.7
Yo -2.2 Zo 385.6
DIM (IN): L
PL ORBIT: ALT (NM) INC(°)
STS ORBIT: ALT (NM) INC(°)

PL IDENT : PALLET
PL COMPOSITE:
WT (LB): UP 7,332
DN 7,332
CG (IN): Xo 1238.6
Yo -2.8 Zo 387.5
DIM (IN): L
PL ORBIT: ALT (NM) INC(°)
STS ORBIT: ALT (NM) INC(°)

PL IDENT :
PL COMPOSITE:
WT (LB): UP
DN
CG (IN): Xo
Yo Zo
DIM (IN): L
PL ORBIT: ALT (NM) INC(°)
STS ORBIT: ALT (NM) INC(°)

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NASA-S-77-2530E

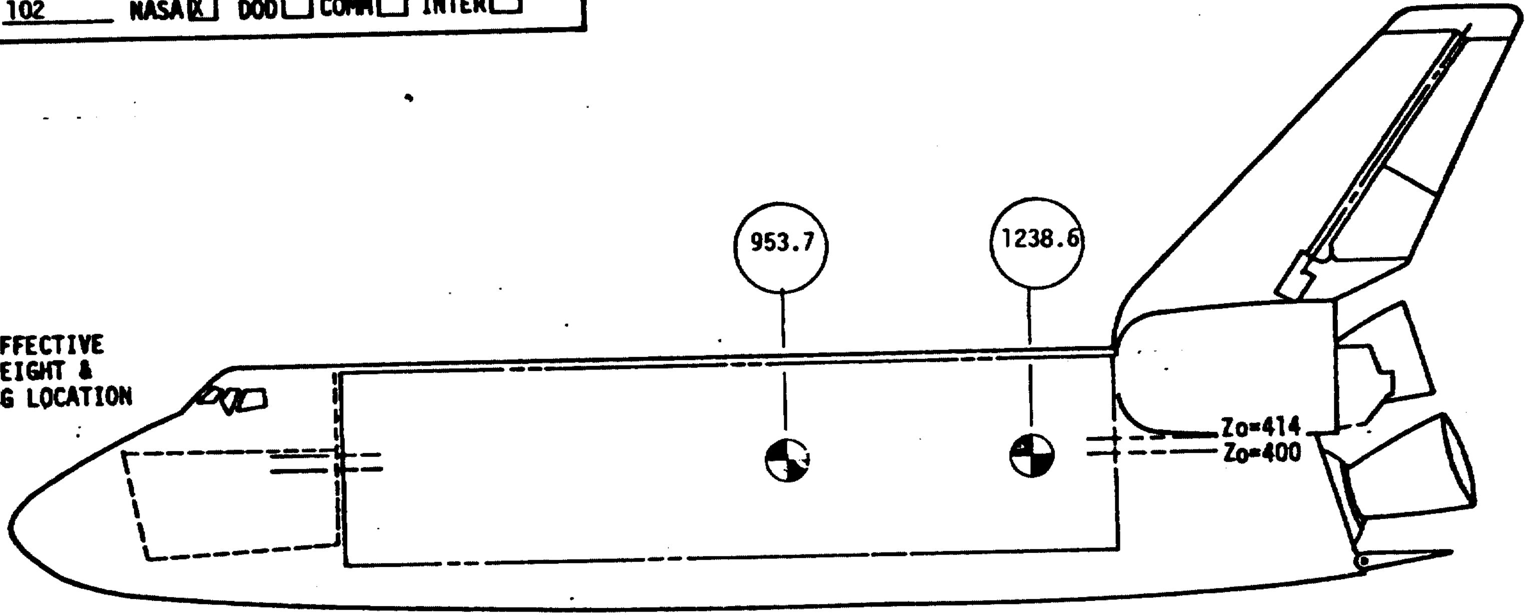
# FLIGHT ASSIGNMENT WORKSHEET

DATE: 5/18/77 REV:

FLIGHT NO. ______ LAUNCH DATE ______

OV- 102 NASA [X] DOD [ ] COMM [ ] INTER [ ]

EFFECTIVE WEIGHT & CG LOCATION




A-4

**COMPOSITE VEHICLE**

| CARGO WT | | | | | | BALLAST | | NOMINAL ENTRY | RTLS | AOA |
|---|---|---|---|---|---|---|---|---|---|---|
| | CG (IN) | | | | | WT (LB) | | WT (LB): 202,417 | WT (LB): 210,614 | WT (LB): 207,113 |
| | | WT(LB) | Xo | Yo | Zo | CG (IN) | | CG (IN): | CG (IN): | CG (IN): |
| ① | UP | 24653 | 953.7 | -2.2 | 385.6 | Xo | | Xo= 1087.0 | Xo= 1084.5 | Xo= 1079.0 |
| | DN | 23780 | 950.2 | 0 | 388.7 | | | %= 65.8 | %= 65.6 | %= 65.2 |
| ② | UP | 7332 | 1238.6 | -2.8 | 387.5 | Yo | | Yo= -0.1 | Yo= 0.1 | Yo= -0.2 |
| | DN | 7332 | 1238.6 | -2.8 | 387.5 | | | | | |
| ③ | UP | | | | | Zo | | | | |
| | DN | | | | | | | | | |

SEPO-139-35

# PAYLOAD CHARGEABLE WEIGHT SUMMARY

FLIGHT NO: ______ PL IDENTIFICATION: SPACELAB Tunnel DATE: 5/18/77

LAUNCH DATE ______ REV: ______

MISSION TYPE: DEPLOYMENT [ ] ATTACHED [X] RETRIEVAL [ ] SERVICING [ ]

| CARRIER ATTACHMENT STABILIZING LOCATION | | PRIMARY LOCATION | | KEEL LOCATION | |
|---|---|---|---|---|---|
| Xo (IN) | 703.2 | Xo (IN) | 866.8 | Xo (IN) | 866.8 |
| BL NO. | (1) | BL NO. | (1) | KB NO. | (1) |
| BR NO. | | BR NO. | | ACTIVE | |
| DF | | DF | | PASSIVE | |
| NDF | | NDF | | | |

PAYLOAD CHARGEABLE ATTACHMENT

(1) bridges & fittings are specially made ref telcon Crumley, MSFC.

| | WT (LB) | CG (IN) (STS COORD) Xo | Yo | Zo |
|---|---|---|---|---|
| STABILIZING 16 (1) + 16 = | 32 | 703.2 | 0 | 414 |
| PRIMARY 16 (1) + 16 = | 32 | 866.8 | 0 | 414 |
| KEEL = | 16 | 866.8 | 0 | 305 |
| LONG FITTING 2 x 10.5 (1) = | 21 | 703.2 | 0 | 414 |
| 2 x 10.5 = | 21 | 866.8 | 0 | 414 |
| COMPOSITE UP & DN = | 122 | 795.7 | 0 | 399.7 |

| ITEM | WT (LB) | CG (IN) (STS COORD) Xo | Yo | Zo |
|---|---|---|---|---|
| CARRIER | (2) | | | |
| ASE | (2) | | | |
| PAYLOAD | (2) | | | |

COMPOSITE (2) see Spacelab, weights added to Spacelab Payload

| | WT (LB) | Xo | Yo | Zo |
|---|---|---|---|---|
| UP | | | | |
| DOWN | | | | |
| TOTAL UP | 122 | 795.7 | 0 | 399.7 |
| TOTAL DOWN | 122 | 795.7 | 0 | 399.7 |

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# PAYLOAD CHARGEABLE WEIGHT SUMMARY

FLIGHT NO: ______ PL IDENTIFICATION: SPACELAB (Long) DATE: 5/18/77

LAUNCH DATE ______ REV: ______

MISSION TYPE: DEPLOYMENT ☐ ATTACHED ☒ RETRIEVAL ☐ SERVICING ☐

| CARRIER ATTACHMENT STABILIZING LOCATION | | PRIMARY LOCATION | | KEEL LOCATION | |
|---|---|---|---|---|---|
| Xo (IN) | 923.5 | Xo (IN) | 1124.1 | Xo (IN) | 1017.8 |
| BL NO. | None | BL NO. | 10 | KB NO. | 8 |
| BR NO. | 7 | BR NO. | 10 | ACTIVE | |
| DF | | DF | | PASSIVE | |
| NDF | | NDF | | | |

PAYLOAD CHARGEABLE

ATTACHMENT

| | | | WT (LB) | CG (IN) (STS COORD) | | |
|---|---|---|---|---|---|---|
| **STABILIZING** | | | | | | |
| 0 | + 163 | = | 163 | Xo 949.3 | Yo 94 | Zo 414 |
| **PRIMARY** | | | | | | |
| 145 | + 145 | = | 290 | Xo 1115.5 | Yo 0 | Zo 414 |
| | KEEL | = | 182 | Xo 1017.8 | Yo 0 | Zo 305 |
| **LONG FITTING** | | | | | | |
| 1 | x 51 | = | 51 | Xo 923.5 | Yo 94 | Zo 414 |
| 2 | x 51 | = | 102 | Xo 1124.1 | Yo 0 | Zo 414 |
| COMPOSITE UP & DN | | = | 788 | Xo 1047.5 | Yo 19.4 | Zo 388.8 |

| ITEM | WT (LB) | CG (IN) (STS COORD) Xo | Yo | Zo |
|---|---|---|---|---|
| CARRIER | | | | |
| ASE | | | | |
| PAYLOAD | 19,743 | 988.8 | -1.9 | 394.2 |
| **COMPOSITE** | | | | |
| UP | 19,743 | 988.8 | -1.9 | 394.2 |
| DOWN | 19,743 | 988.8 | -1.9 | 394.2 |
| **TOTAL** UP | 20,531 | 991. | -1.1 | 394. |
| DOWN | 20,531 | 991. | -1.1 | 394. |

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# PAYLOAD CHARGEABLE WEIGHT SUMMARY

FLIGHT NO: ______ PL IDENTIFICATION: Pallet DATE: 5/18/77

LAUNCH DATE ______ REV: ______

MISSION TYPE: DEPLOYMENT [ ] ATTACHED [X] RETRIEVAL [ ] SERVICING [ ]

| CARRIER ATTACHMENT STABILIZING LOCATION | | PRIMARY LOCATION | | KEEL LOCATION | |
|---|---|---|---|---|---|
| Xo (IN) | 1210.6 | Xo (IN) | 1269.6 | Xo (IN) | 1210.6 |
| BL NO. | 12 | BL NO. | 13 | KB NO. | 12 |
| BR NO. | 12 | BR NO. | 13 | ACTIVE | |
| DF | | DF | | PASSIVE | |
| NDF | | NDF | | | |

PAYLOAD CHARGEABLE

ATTACHMENT

| | | | WT (LB) | CG (IN) (STS COORD) Xo | Yo | Zo |
|---|---|---|---|---|---|---|
| STABILIZING | | | | | | |
| 195 | + | 195 | = 390 | 1278. | 0 | 414 |
| PRIMARY | | | | | | |
| 169 | + | 169 | = 338 | 1220. | 0 | 414 |
| | | KEEL | = 270 | 1210.6 | 0 | 305 |
| LONG FITTING | | | | | | |
| 2 | x | 51 | = 102 | 1210.6 | 0 | 414 |
| 2 | x | 51 | = 102 | 1269.6 | 0 | 414 |
| COMPOSITE UP & DN | | | = 1202 | 1240.1 | 0 | 389.5 |

| ITEM | WT (LB) | CG (IN) (STS COORD) Xo | Yo | Zo |
|---|---|---|---|---|
| CARRIER | | | | |
| ASE | 1457.7 | 1237.54 | 1.71 | 363.93 |
| PAYLOAD | 4671.95 | 1238.52 | -4.97 | 394.41 |
| COMPOSITE | | | | |
| UP | 6130 | 1238.3 | -3.4 | 387.2 |
| DOWN | 6130 | 1238.3 | -3.4 | 387.2 |
| TOTAL UP | 7332 | 1238.6 | -2.8 | 387.5 |
| TOTAL DOWN | 7332 | 1238.6 | -2.8 | 387.5 |

NASA-S-77-2532 B SEPO-139-35

# PAYLOAD CHARGEABLE WEIGHT SUMMARY

FLIGHT NO. ______ PL IDENTIFICATION: SPACELAB DATE: 5/18/77

LAUNCH DATE ______ REV: ______

| FLIGHT KITS | | WT (LB) | CG (IN) (STS COORD) Xo | Yo | Zo |
|---|---|---|---|---|---|
| DOCKING MODULE (UP & DN) | | | | | |
| A/L TUNNEL ADAPTER (UP & DN) | | 900 (1) | 621 | 0 | 357.9 |
| P/L BAY MOUNTED A/L (UP & DN) | | 912 | 609 | 0 | 371.5 |
| ARS DUCT (UP & DN) | | 21 | 621 | 0 | 357.9 |
| ATCS RADIATOR | WET | 173 | 1216 | 61 | 473. |
| | DRY | 141 | 1216 | 150 | 366. |
| RMS # 2 | | | | | |
| FC & WW TANKS | UP | | | | |
| | DOWN | | | | |
| KU-BAND COMM | | | | | |
| MSS PCM RECORDER | | | | | |
| EPS KIT #1 | WET | | | | |
| | DRY | | | | |
| KIT #2 | WET | | | | |
| | DRY | | | | |
| KIT #3 | WET | | | | |
| | DRY | | | | |
| KIT #4 | WET | 1643 | 1000. | -39 | 299. |
| | DRY | 770 | 942 | -10. | 299. |
| KIT #5 | WET | | | | |
| | DRY | | | | |
| KIT #6 | WET | | | | |
| | DRY | | | | |
| KIT #7 | WET | | | | |
| | DRY | | | | |
| EPS TANK | WET | | | | |
| SETS IN BAY | DRY | | | | |
| OMS KIT 500' ΔV | WET | | | | |
| | DRY | | | | |
| 1000' ΔV | WET | | | | |
| | DRY | | | | |
| 1500' ΔV | WET | | | | |
| | DRY | | | | |
| CONTROL & DISPLAY | | | | | |
| CABLING | | 112 | 609 | 0 | 371.5 |
| EXTENDED MISSION | | | | | |
| **CREW EQUIPMENT (ABOVE 3 MAN DAYS)** | | | | | |
| FIXED WT (LB) (PER MAN) | 5th Seat | 54. | 494 | 48 | 340. |
| 370.7 X 2 = | | 741.4 | 497.2 | 24.4 | 364.6 |
| TIME DEPENDANT (PER MAN, PER DAY) | | | | | |
| 13.7 X 2 X 7 = | | 191.8 | 504.3 | 0.9 | 380.2 |
| 3 X 4 | | 164.4 | | | |
| TOTAL (2) | UP | 4,000.6 | 767. | -8.1 | 342.1 |
| | DOWN | 3,127.6 | 687.7 | 7.6 | 354.1 |

(1) Not charged to Payload wt (already in inert veh. wt)
(2) Assumes EPS Kit #4 dry wt

SEPD-139-35

```
INSERT PRELAUNCH VEH. WT         0.0.0.0
C.G. (WITH MOMENTS OF            207351.1139.5..5.384.9
INERTIA = 0)                     /0.0.0.0.0.0

                                 MASS(LB)        CG(INCHES)                     INERTIA (SLUG-FT2*10**6)
                                           X        Y       Z       IXX      IYY      IZZ      PXY      PXZ
                                  PYZ
                                 BASE VEHICLE:
                                 207351.   1139.5   .5    384.9   .0000    .0000    .0000   .00000   .000
                                 .00000

LESS Δ FOR FITTINGS & SHIFTING   >-450.1120.5.0.389.5
AIRLOCK                          >0.0.0.0.0.0
                                 ADD PAYLOAD:
                                  -450.    1120.5   .0    389.5   .0000    .0000    .0000   .00000   .000
                                 .00000

                                 COMPOSITE VEHICLE:
                                 206901.   1139.5   .5    384.9  -.0000   -.0000   -.0000  -.00000   .000
                                 .00000

ADD PAYLOAD                      >31985.1019.-2.3.336
                                 >0.0.0.0.0.0
                                 ADD PAYLOAD:
                                  31985.   1019.0  -2.3   336.0   .0000    .0000    .0000   .00000   .000
                                 .00000

                                 COMPOSITE VEHICLE:
                                 238786.   1122.5   .1    385.0   .0001    .0354    .0355   .00200  -.000
                                 -.00002

LESS RTLS Δ                      >-28172.1407..7.475.8
                                 >0.0.0.0.0.0
                                 ADD PAYLOAD:
                                 -28172.   1407.0   .7    475.8   .0000    .0000    .0000   .00000   .000
                                 .00000

RTLS                             COMPOSITE VEHICLE:
                                 210614.   1084.5   .0    372.8  -.0568   -.5294   -.4734   .00033  -.179
                                 -.00033

LESS AOA Δ                       >-3501.1409.4.13.7.434.3
                                 >0.0.0.0.0.0
                                 ADD PAYLOAD:
                                  -3501.   1409.4  13.7   434.3   .0000    .0000    .0000   .00000   .00
                                 .00000

AOA                              COMPOSITE VEHICLE:
                                 207113.   1079.0  -.2    371.9  -.0599   -.6134   -.5537  -.00253  -.194
                                 -.00102

                                 >
INITIALIZE PROGRAM @ 0           31985.
                                 0.0.0.0
INSERT PAYLOAD WT & CG           >31985.1019.-2.3.336
                                 >0.0.0.0.0.00

                                 MASS(LB)        CG(INCHES)                     INERTIA (SLUG-FT2*10**6)
                                           X        Y       Z       IXX      IYY      IZZ      PXY      PXZ
                                  PYZ
                                 BASE VEHICLE:
                                  31985.   1019.0  -2.3   336.0   .0000    .0000    .0000   .00000   .00
                                 .00000

ADD CV @ EI                      >170882.1099.8..3.372.2
                                 >0.0.0.0.0.0
                                 ADD PAYLOAD:
                                 170882.   1099.8   .3    372.2   .0000    .0000    .0000   .00000   .0000
                                 .00000

                                 COMPOSITE VEHICLE:
                                 202867.   1087.1  -.1    374.4   .0011    .0391    .0390   .00122  -.0065
                                 -.00021

LESS Δ FOR FITTINGS &            >-450.1120.5.0.389.5
SHIFTING AIRLOCK                 >0.0.0.0.0.0
                                 ADD PAYLOAD:
                                  -450.    1120.5   .0    389.5   .0000    .0000    .0000   .00000   .0000
                                 .00000

EI                               COMPOSITE VEHICLE:
                                 202417.   1087.0  -.1    374.3   .0011    .0389    .0379   .00122  -.0065
                                 -.00021

                                 >@XX TIO
                                 *EXECUTION TERMINATED*
                                 >@FIN

                                 RUNID: ADV.I     ACCT: 32048-J196-C    PROJECT: FMC-L79495
                                 TIME:    TOTAL: 00:00:01.017     CHARGE: 00:00:12.035
                                          CAU:   00:00:00.368     I/O:    00:00:00.543
                                          CC/ER: 00:00:00.206     WAIT:   00:31:31.104
                                 IRC:     PC -- 224433             SC -- 393581
                                 START:   15:14:18 JUN 01.1977   FIN:  15:47:24 JUN 01.1977
                                 *TERMINAL INACTIVE*
```

APPENDIX B

EXAMPLE OF

MASS PROPERTIES CALCULATION

FOR

MULTIPLE CARGO

(TDRS/2-STAGE IUS

AND SBS/SSUS D)

**STS 100 FORM** — **REQUEST FOR FLIGHT ASSIGNMENT** — **DATE:** 5/23/77

**To:** SPACE TRANSPORTATION SYSTEMS OPERATIONS
MAIL CODE MO
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON D.C. 20546

**FROM:** ____________

/S/

**FLIGHT OBJECTIVES:**

Place Communications Satellite in Geostationary Orbit

___ Earnest money ___ NASA approved
___ Commercial ___ ESA approved
___ Other Government ___ DOD approved

Flight period a. May 1980, b. June 1980 or specific date c. July 1980

MISSION TYPE

Inclination range ____ or specific inclination $26.6^{0} \pm 0.24^{0}$ — X Deployment

Altitude range 150 ± 3nm perigee or specific altitude 193.2 ± 48.0 nm apogee — ___ Attached

Payload configuration TDRSS/IUS/ASE — ___ Servicing

Flight duration, hours attached Minimum Discipline see constraints below — ___ Retrieval

Crew complement: Commander, pilot, mission specialist plus option for additional mission specialist(s) 0 or payload specialist(s) 0

Payload Operations Control Center support:

X GSFC ___ JPL X JSC ___ Other ___ Not required ___

STDN and Tracking and Data Relay Satellite system support (comment):

Payload mass properties including flight kits:

| | | | | | |
|---|---|---|---|---|---|
| Weight: | Launch | 39920 | lb. | | kg |
| | Landing | 3777 | lb. | | kg |
| Diameter: | Launch | 115 | inches | | mm |
| | Landing | 115 | inches | | mm |
| Length: | Launch | 437.9 | inches | | mm |
| | Landing | 148.8 | inches | | mm |

Specify flight kits used in weight (see JSC07700 vol. XIV):

Payload kWh estimate ____ kWh

Payload constraints and/or unique requirements: Geostationary final orbit.
Liquid apogee engine

Orientation, pointing, sunlight constraints, etc. (comment):

Parking Orbit, Doors Open
<1.2 hrs. max. direct sunlight
<4.0 hrs. max. no sun

Parking Orbit, Doors Closed
2 hrs. max.

Special prelaunch and postlanding off-line support at launch and landing site (comment):

100,000 class clean room environment

Special prelaunch and postlanding on-line support while in the Orbiter (comment):

$65^{0}$ FAIR on pad; $GN_2$ prelaunch (T-2 hrs.) purge acceptable

(OVER)

Other comments:

**Those organizations that will be non-U.S. Government users should also provide the following information:**

- Do you request a dedicated flight? If so, do you intend to sublet services to other users?
- Do you request consideration in STS exceptional program selection process?
- Are you willing for your payload to fly on a space-available (standby) basis?
- Do you request to be flown under the definition of a "small self-contained package"?
- State desired date to begin contract negotiations.
- Does payload (or payloads) require revisit and/or retrieval services?
- List known optional services currently under consideration in order that flight requirements can be established.

| STS 100 FORM | REQUEST FOR FLIGHT ASSIGNMENT | DATE: 5/23/77 |
|---|---|---|

| | |
|---|---|
| To: SPACE TRANSPORTATION SYSTEMS OPERATIONS<br>MAIL CODE MO<br>NATIONAL AERONAUTICS AND SPACE ADMINISTRATION<br>WASHINGTON D.C. 20546 | FROM: ______<br>______<br>______<br>______<br>/S/ |
| FLIGHT OBJECTIVES:<br>Deploy SBS Communications Satellite to Geostationary Orbit | X Earnest money ___ NASA approved<br>X Commercial ___ ESA approved<br>___ Other Government ___ DOD approved |

Flight period a. June/July 1980 b. Oct/Nov 1980 or specific date c. Backup 2nd Quarter FY 1981

MISSION TYPE:

Inclination range 28.5 or specific inclination ______ X Deployment

Altitude range 160 NMI or specific altitude ______ ___ Attached

Payload configuration Delta 3910 PAM Class ___ Servicing

Flight duration, hours attached ______ Discipline ______ ___ Retrieval

Crew complement: Commander, pilot, mission specialist plus option for additional mission specialist(s) ______ or payload specialist(s) ______

Payload Operations Control Center support:

___ GSFC ___ JPL ___ JSC ___ Other ___ Not required ___

STDN and Tracking and Data Relay Satellite system support (comment):

Payload mass properties including flight kits:

| | | | | | |
|---|---|---|---|---|---|
| Weight: | Launch | 8340 | lb. | ______ | kg |
| | Landing | 2250 | lb. | ______ | kg |
| Diameter: | Launch | 86 | inches | ______ | mm |
| | Landing | ______ | inches | ______ | mm |
| Length: | Launch | 92 | inches | ______ | mm |
| | Landing | ______ | inches | ______ | mm |

Specify flight kits used in weight: (see JSC07700 vol. XIV):

Payload kWh estimate .75 kWh

Payload constraints and/or unique requirements:

Orientation, pointing, sunlight constraints, etc. (comment):

Minimum Sunlight
Near Room Temperature

Special prelaunch and postlanding off-line support at launch and landing site (comment):

Special prelaunch and postlanding on-line support while in the Orbiter (comment):

(OVER)

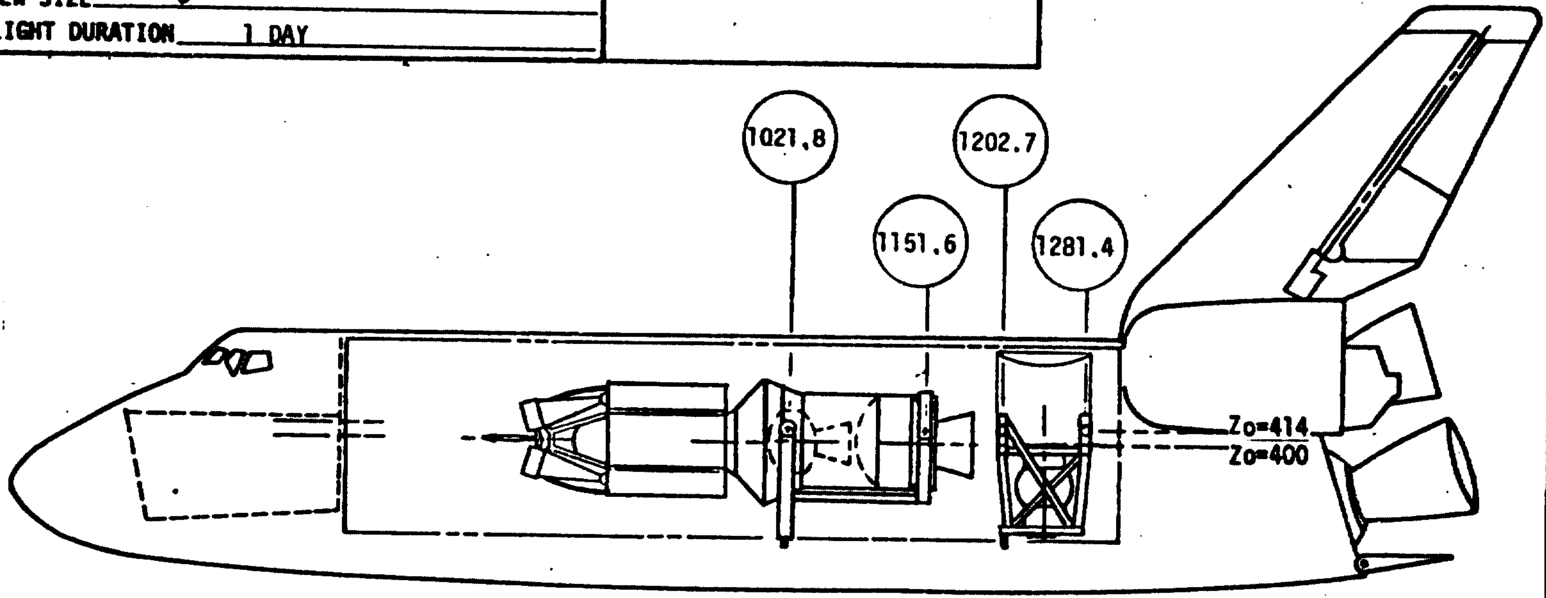
Other comments:

**Those organizations that will be non-U.S. Government users should also provide the following information:**

- Do you request a dedicated flight? If so, do you intend to sublet services to other users?
- Do you request consideration in STS exceptional program selection process?
- Are you willing for your payload to fly on a space-available (standby) basis?
- Do you request to be flown under the definition of a "small self-contained package"?
- State desired date to begin contract negotiations.
- Does payload (or payloads) require revisit and/or retrieval services?
- List known optional services currently under consideration in order that flight requirements can be established.

# FLIGHT ASSIGNMENT

| | | | |
|---|---|---|---|
| FLIGHT NO. ______ LAUNCH DATE ______<br>OV- 102 NASA [X] DOD [ ] COMM [ ] INTER [ ]<br>CREW SIZE 3<br>FLIGHT DURATION 1 DAY | MAJOR FLIGHT KITS | DATE: 5-23-77 | REV: |




COMPOSITE CARGO
WT (LB): UP 50,530
WT (LB): DN 8,199

| | | |
|---|---|---|
| PL IDENT : TDRS (IUS 2-STAGE) | PL IDENT : SBS (SSUS D) | PL IDENT : |
| PL COMPOSITE: | PL COMPOSITE: | PL COMPOSITE: |
| WT (LB): UP 40890 | WT (LB): UP 9640 | WT (LB): UP |
| DN 4747 | DN 3452 | DN |
| CG (IN): Xo 1073.5 (1044.9) | CG (IN): Xo 12421 (1242.2) | CG (IN): Xo |
| Yo 0 Zo 399.8 (398.7) | Yo 0 Zo 431.4 (396.3) | Yo Zo |
| DIM (IN): L | DIM (IN): L | DIM (IN): L |
| PL ORBIT: ALT (NM) INC(°) | PL ORBIT: ALT (NM) INC(°) | PL ORBIT: ALT (NM) INC(°) |
| STS ORBIT: ALT (NM) INC(°) | STS ORBIT: ALT (NM) INC(°) | STS ORBIT: ALT (NM) INC(°) |

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NASA-S-77-2530IE

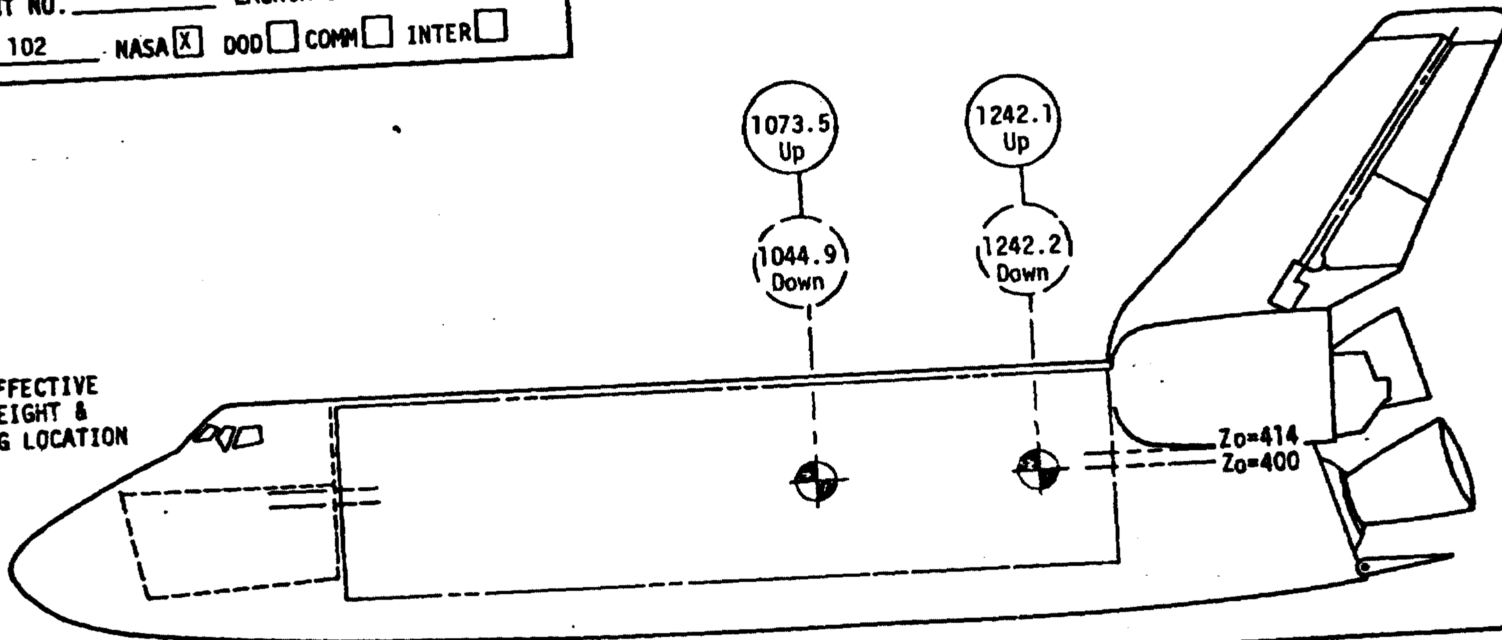
# FLIGHT ASSIGNMENT WORKSHEET

DATE: 5-23-77 REV:

FLIGHT NO. ______ LAUNCH DATE ______

OV- 102 NASA [X] DOD [ ] COMM [ ] INTER [ ]

EFFECTIVE WEIGHT & CG LOCATION




B-5

COMPOSITE VEHICLE

| CARGO WT | | | | | BALLAST | | NOMINAL ENTRY | RTLS | AOA |
|---|---|---|---|---|---|---|---|---|---|
| | | CG (IN) | | | WT (LB) | | WT (LB): 179,081 | WT (LB): 229,609 | WT (LB): 226,108 |
| | WT(LB) | Xo | Yo | Zo | CG (IN) | | CG (IN): | CG (IN): | CG (IN): |
| ① UP | 40890 | 1073.5 | 0 | 399.8 | Xo | | Xo= 1101.1 | Xo= 1098.3 | Xo= 1093.5 |
| ① DN | 4747 | 1044.9 | 0 | 398.7 | Yo | | %= 66.9 | %= 66.7 | %= 66.3 |
| ② UP | 9640 | 1242.1 | 0 | 431.4 | Zo | | Yo= 0.3 | Yo= 0.1 | Yo= 0.2 |
| ② DN | 3452 | 1242.2 | 0 | 396.3 | | | | | |
| ③ UP | | | | | | | | | |
| ③ DN | | | | | | | | | |

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# PAYLOAD CHARGEABLE WEIGHT SUMMARY

FLIGHT NO: ______ PL IDENTIFICATION: TDRS A/IUS 2-STAGE DATE: 5/23/77

LAUNCH DATE ______ REV: ______

MISSION TYPE: DEPLOYMENT [X] ATTACHED [ ] RETRIEVAL [ ] SERVICING [ ]

| CARRIER ATTACHMENT STABILIZING LOCATION | | PRIMARY LOCATION | | KEEL LOCATION | |
|---|---|---|---|---|---|
| Xo (IN) | 1021.8 | Xo (IN) | 1151.6 | Xo (IN) | 1021.8 |
| BL NO. | 8 | BL NO. | 11 | KB NO. | 8 |
| BR NO. | 8 | BR NO. | 11 | ACTIVE | |
| DF | | DF | | PASSIVE | |
| NDF | | NDF | | | |

PAYLOAD CHARGEABLE

ATTACHMENT

| | | | WT (LB) | CG (IN) (STS COORD) | | |
|---|---|---|---|---|---|---|
| STABILIZING | | | | | | |
| 147 | + 147 | = | 294 | Xo 1009.8 | Yo 0 | Zo 414 |
| PRIMARY | | | | | | |
| 145 | + 145 | = | 290 | Xo 1165.9 | Yo 0 | Zo 414 |
| | KEEL | = | 182 | Xo 1109.8 | Yo 0 | Zo 305 |
| LONG FITTING | | | | | | |
| 2 | x 51 | = | 102 | Xo 1021.8 | Yo 0 | Zo 414 |
| 2 | x 51 | = | 102 | Xo 1151.6 | Yo 0 | Zo 414 |
| COMPOSITE UP & DN | | = | 970 | Xo 1072.6 | Yo 0 | Zo 393.5 |

| ITEM | WT (LB) | CG (IN) (STS COORD) | | |
|---|---|---|---|---|
| CARRIER | 32,643 | Xo 1093.7 | Yo 0 | Zo 400 |
| ASE | 3,777 | Xo 1037.8 | Yo 0 | Zo 400 |
| PAYLOAD | 3,500 | Xo 924.1 | Yo 0 | Zo 400 |
| COMPOSITE | | | | |
| UP | 39,920 | Xo 1073.5 | Yo 0 | Zo 400 |
| DOWN | 3,777 | Xo 1037.8 | Yo 0 | Zo 400 |
| TOTAL UP | 40,890 | Xo 1073.5 | Yo 0 | Zo 399.8 |
| TOTAL DOWN | 4747 | Xo 1044.9 | Yo 0 | Zo 398.7 |

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# PAYLOAD CHARGEABLE WEIGHT SUMMARY

FLIGHT NO: ______ PL IDENTIFICATION: SBS A/SSUS-D DATE: 5/23/77

LAUNCH DATE ______ REV: ______

MISSION TYPE: DEPLOYMENT [X] ATTACHED [ ] RETRIEVAL [ ] SERVICING [ ]

| CARRIER ATTACHMENT STABILIZING LOCATION | | PRIMARY LOCATION | | KEEL LOCATION | |
|---|---|---|---|---|---|
| Xo (IN) | 1202.7 | Xo (IN) | 1281.4 | Xo (IN) | 1202.7 |
| BL NO. | 12 | BL NO. | 13 | KB NO. | 12 |
| BR NO. | 12 | BR NO. | 13 | ACTIVE | |
| DF | | DF | | PASSIVE | |
| NDF | | NDF | | | |

PAYLOAD CHARGEABLE

ATTACHMENT

| | | | | WT (LB) | CG (IN) (STS COORD) Xo | Yo | Zo |
|---|---|---|---|---|---|---|---|
| STABILIZING | 169 | + | 169 | = 338 | 1220 | 0 | 414 |
| PRIMARY | 195 | + | 195 | = 390 | 1278 | 0 | 414 |
| | | | KEEL | = 270 | 1220 | 0 | 305 |
| LONG FITTING | 2 | x | 51 | = 102 | 1202.7 | 0 | 414 |
| | 2 | x | 51 | = 102 | 1281.4 | 0 | 414 |
| COMPOSITE UP & DN | | | | = 1202 | 1242.6 | 0 | 389.5 |

| ITEM | WT (LB) | CG (IN) (STS COORD) Xo | Yo | Zo |
|---|---|---|---|---|
| CARRIER | 3868 | 1242.05 | 0 | 451 |
| ASE | 2250 | 1242.05 | 0 | 400 |
| PAYLOAD | 2320 | 1242.05 | 0 | 451 |
| COMPOSITE | | | | |
| UP | 8438 | 1242.05 | 0 | 437.4 |
| DOWN | 2250 | 1242.05 | 0 | 400 |
| TOTAL UP | 9640 | 1242.1 | 0 | 431.4 |
| TOTAL DOWN | 3452 | 1242.2 | 0 | 396.3 |

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```
•UNIVAC 1100 OPERATING SYSTEM  VER. 31.244.212C (RSI)•
>@RUN GDLXI.3304P-J196-C.FMT-L70495
DATE: 052577        TIME: 092002
>@USE D..DOWNS.
READY
```

EXECUTE MP PROGRAM TDRS/IUS

```
>@XQT D.MP
```

DOWN WEIGHT & CG

TDRS/IUS DOWN WEIGHT & CG

```
>4747,1044.9,0,398.7
>0,0,0,0,0,0,

  MASS(LB)        CG(INCHES)                         INERTIA (SLUG-FT2*10**6)
              X        Y        Z        IXX       IYY       IZZ      PXY      PXZ
  PYZ
  BASE VEHICLE:
   4747.    1044.9     .0    398.7    .0000     .0000     .0000   .00000   .0000
 .00000
```

SBS/SSUS-D DOWN WEIGHT & CG

```
>3452,1242.1,0,396.3
>0,0,0,0,0,0
  ADD PAYLOAD:
   3452.    1242.1     .0    396.3    .0000     .0000     .0000   .00000   .0000
 .00000
```

COMBINED CARGO DOWN

```
  COMPOSITE VEHICLE:
   8199.    1127.9     .0    397.7    .0000     .0168     .0166   .00000  -.0002
 .00000
```

ORBITER AT EI

```
>170882,1099.8,.3,372.2
>0,0,0,0,0,0
  ADD PAYLOAD:
  170882.   1099.8     .3    372.2    .0000     .0000     .0000   .00000   .0000
 .00000
```

EI

```
  COMPOSITE VEHICLE:
  179081.   1101.1     .3    373.4    .0011     .0192     .0181  -.00001   .0010
-.00001
```

REINITIALIZE PROGRAM AT 0

```
>.0.
0,0,0,0
```

TDRS/IUS UP WEIGHT & CG

```
>40890,1073.5,0,399.8
>0,0,0,0,0,0

  MASS(LB)        CG(INCHES)                         INERTIA (SLUG-FT2*10**6)
              X        Y        Z        IXX       IYY       IZZ      PXY      PXZ
  PYZ
  BASE VEHICLE:
  40890.    1073.5     .0    399.8    .0000     .0000     .0000   .00000   .0000
 .00000
```

SBS/SSUS-D UP WEIGHT & CG

```
>9640,1242.1,0,431.4
>0,0,0,0,0,0
  ADD PAYLOAD:
   9640.    1242.1     .0    431.4    .0000     .0000     .0000   .00000   .0000
 .00000
```

COMBINED CARGO UP

```
  COMPOSITE VEHICLE:
  50530.    1105.7     .0    405.8    .0017     .0495     .0479   .00000   .0050
 .00000
```

ORBITER PRELAUNCH

```
>207251,1138.5,.5,384.8
>0,0,0,0,0,0
  ADD PAYLOAD:
  207251.   1138.5     .5    384.8    .0000     .0000     .0000   .00000   .0000
 .00000

  COMPOSITE VEHICLE:
  257781.   1132.1     .4    388.9    .0056     .0629     .0573   .00014   .0029
-.00009
```

LESS RTLS Δ

```
>-28172,1407,.7,475.9
>0,0,0,0,0,0
  ADD PAYLOAD:
  -28172.   1407.0     .7    475.9    .0000     .0000     .0000   .00000   .0000
 .00000
```

RTLS

```
  COMPOSITE VEHICLE:
  229609.   1098.3     .4    378.3   -.0461    -.5048    -.4507  -.00042  -.1603
-.00027
```

LESS AOA Δ

```
>-3501,1409.4,13.7,434.3
>0,0,0,0,0,0
  ADD PAYLOAD:
   -3501.   1409.4   13.7    434.3    .0000     .0000     .0000   .00000   .0000
 .00000
```

AOA

```
  COMPOSITE VEHICLE:
  226108.   1093.5     .2    377.4   -.0406    -.5015    -.5331  -.00360  -.1707
-.00004
```