Data Requirements for the Payload Data Package Annex

Payload Integration Plan Annex No. 1

June 1993

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

DESCRIPTION OF CHANGES TO

BLANK BOOK ANNEX NO. 1

DATA REQUIREMENTS FOR THE PAYLOAD DATA PACKAGE ANNEX

CHANGE NO.	DESCRIPTION/AUTHORITY	DATE	PAGES AFFECTED
--	Baseline Issue/B14090-1	09/--/78	All
REV A	Clarify Mass Properties Data;	03/--/79	All
Chg. 1	Revise Mass Properties accuracy reqmts.; Update data reqmts. definition/B14090-2; -3; -4		
2	Identification of access/ removal envelopes/B14090-5	03/20/79	3
3	Correct errors/B14090-6	04/25/79	1,2,3,4,5
4	Update RF link reqmts./B14090-7	09/12/79	5,6,7,8
REV B	Consolidate Rev. A changes	11/05/79	All
1	Add new direction to Preface	12/19/79	vi
REV C	Update annex/B14090-10	05/30/80	All
1	PDRS Auto Trajectories definition/B14090-9	11/19/80	iii,iv,6, 6A,6B,6C 14,15,16,17
2	RF Amplifier Change/ B14090-12	07/24/93	4
REV D	General Revision— Word One Format/B14090-13	03/08/82	All
1	Add Hazardous Materials, Paragraph 4.9/B14090-14	05/05/83	v,20
2	Update Section 4.1/B14090-15	01/25/84	13

DESCRIPTION OF CHANGES (CONTINUED)

BLANK BOOK ANNEX NO. 1

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CHANGE NO.	DESCRIPTION/AUTHORITY	DATE	PAGES AFFECTED
3	Update Preface, Table of Contents, Sections 3.0, 3.1, 3.2, 3.3, 3.4, and add Section 3.5/B14090-16;-17	04/11/85	iii,iv,7, 8,9,10,10A
	Document number changed from JSC 14090 to JSC 21000-A01 per CR B14090-19, dated 3/7/86		
4	Weight Data Certification, Preface, Table of Contents, Sections 1.5, 1.6, and Figures 1-3, 1-4, 5-1, and 5-2/B21000-A01-19	07/07/86	iii,iv,v,4, 6,6A,6B,21, 22
5	Change to Signature Sheet, Figure 5-1/B21000-A01-18	07/24/86	21
6	Drawing Data, Sections 2.0, 2.1, 2.2, and add Sections 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 2.3, 2.3.1, 2.3.2, 2.4, 2.4.1, 2.4.2, 2.4.3, 2.5, 2.5.1, 2.5.2, and 2.5.3; Editorial Changes, Preface/B21000-A01-21;-23	07/02/87	iii,iv, v,vi,6, 6B,6C, 6D,6E, 6F,7,22
7	Weight Data, Section 1.1, 1.5 1.6; Figure 1-5; Editorial Changes/B21000-A0-22	08/26/87	iv,v,vi,1 1A,6,6A, 6B,6C,6D, 6E,6F,6G, 6H,6I

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DATA REQUIREMENTS FOR THE PAYLOAD DATA PACKAGE ANNEX

CHANGE NO.	DESCRIPTION/AUTHORITY	DATE	PAGES AFFECTED
REV E	Clarification, Section 1.2; Revise Data Requirements, Section 1.4, Figures 1-1 and 1-3, add Figure 1-5; Chargeable Weight, Section 1.1; Revise Data Requirements, Section 2.1; Weight and Mass Properties, Section 2.0; EMC Bonding, Section 3.5; Payload Deployment and Retrieval System Translation Requirements, Section 4.1, Figures 4-1 through 4-4, add Figure 4-5 through 4-10, Tables 4-1, 4-2, and 4-3/B-21000-A01-20	09/16/87	All
	Document number changed from JSC 21000-A01 to NSTS 21000-A01 per CRG00051 dated 02/20/87		
1	Change Preface, section 4.5; add section 2.1.2a; incorporate editorial corrections to Rev E/B21000-A01-25	09/09/88	iii,iiiA, 5,6,6A, 16,23
	Editorial errata to include errata changes to Rev E	10/24/88	cover, 28,32
2	Revise section 4.9/B21000-A01-26	03/28/89	v,24,24A

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CHANGE NO.	DESCRIPTION/AUTHORITY	DATE	PAGES AFFECTED
3	Update Table of Contents and section 3.5 to include subsections 3.5.1, 3.5.2, 3.5.3, and 3.5.4/B21000-A01-27	04/07/89	iv,v,vi, vii,15,16, 16A,16B
4	Update section 2.1.3/B21000-A01-28	08/11/89	iv,7,8,8A
5	Update preface and figure 5-2/ B21000-A01-029	11/07/89	iii,iiiA, 45
6	Update table of contents and sections 2.2.1, 2.2.2, 2.3, 2.3.1, and 2.3.2; add sections 2.3.3 and 2.3.4/B21000-A01-030	03/12/90	iv,v,vi, vii,8A,9, 10,10A, 10B,10C
7	Update section 2.1.2/B21000-A01-032	04/20/90	6A,7
	Errata to correct pagination and section 2.1.2	06/05/90	5,6,6A, 6B,7,8
8	Update sections 2.1.1 and 2.2.1, and errata to correct section 2.1.2/B21000-A01-033	10/10/90	6,6A,8A
9	Update section 2.1.2/ B21000-A01-034	02/20/91	6A,6B

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CHANGE NO.	DESCRIPTION/AUTHORITY	DATE	PAGES AFFECTED
10	Update table of contents and sections 2.3.1, 2.3.2, and 3.5.1, renumber 2.3.4 to 2.3.5 and add 2.3.4 and renumber 3.5.4 to 3.5.5 and add 3.5.4, and add figure 2-1/B21000-A01-031A;-035	06/05/91	iv,v,vii, 10,10A,10B, 10C,10D, 15,16A,33A, 33B,33C
REV F	General revision/B21000-A01-037	07/02/91	All
1	Update table of contents and replace entire section 2.0 and figures 2-1 through 2-6/B21000-A01-038	08/04/92	vii,viii, ix,16,17, 18,19,20, 21,22,23, 24,25,26, 27,27A,27B, 27C,27D
REV G	Pagination revision which includes updating table of contents, preface and sections 1.1.2, 2.2.3, 2.3.6, 2.4.2, 2.4.3, and section 2.5; delete section 1.1.3 and figure 2-8/B21000-A01-039; -041;-042;-043	03/04/93	All
1	Update section 1.1.2/B21000-A01-040	03/18/93	2,3
REV H	General revision/B21000-A01-045	05/11/93	All

DESCRIPTION OF CHANGES (CONTINUED)

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DATA REQUIREMENTS FOR THE PAYLOAD DATA PACKAGE ANNEX

CHANGE NO.	DESCRIPTION/AUTHORITY	DATE	PAGES AFFECTED
REV I	General revision/B21000-A01-046	06/08/93	All
1	Update table of contents and sections 2.1.2, 2.1.3, 2.1.5, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.5, and 2.4.2; replace figure 2-1 and delete figure 2-2 and renumber remaining figures/B21000-A01-048	10/19/93	x,15,16, 17,18,19, 22,23,24, 25,26,27, 28
2	Update preface, sections 1.1.1, 1.1.2, 1.4.1, 2.1.1, 2.1.4, and 2.2.1 and figures 2-3 and 4-2/B21000-A01-049	12/13/94	iii,iv,v, 1,2,9,15, 16,25,25A, 46
	Errata to correct figure 2-3.	03/24/95	25A
3	Update table of contents and sections 1.1.2 and 1.2.2/ B21000-A01-0050	11/01/95	vi,3,4,4A
4	Update foreword, preface, and figures 4-1 and 4-2/B21000-A01-0051	08/22/97	iii,iv,v, 45,46
5	Update sections 1.2.1 and 1.2.2/B21000-A01-0052	12/14/98	4,5
6	Update section 3.1.2/B21000-A01-0053	09/22/99	30,30A

DESCRIPTION OF CHANGES (CONCLUDED)

BLANK BOOK ANNEX NO. 1

DATA REQUIREMENTS FOR THE PAYLOAD DATA PACKAGE ANNEX

CHANGE NO.	DESCRIPTION/AUTHORITY	DATE	PAGES AFFECTED
7	Update foreword, preface, table of contents, sections 1.1.1, 1.4.2, 1.4.3, 1.5.2, 2.1.4, 2.3.2, 2.3.3, 2.4.2, 2.4.3, 2.4.5, and figure; delete section 2.3.6/B21000-A01-0055	01/18/00	Foreword, iii,iv,v, vii,1,9, 10,15,16, 18,19,20, 21,46
8	Update section 3.1.2/B21000-A01-0056	04/09/02	30
9	Update foreword, preface and section 1.3.5/B21000-A01-0057A	07/25/03	Foreword, v,8,8A,9

Note: Dates reflect latest approval date of CR's received by PILS.

FOREWORD

This document defines the format and content of the payload data required for the Space Shuttle Program (SSP) elements to integrate a payload into the flight and ground operations. The annexes required and scheduled for submittal of data by a specific payload are identified in the basic Integration Plan (IP) for the payload/mission. The customer is requested to provide the data defined and return the completed data to the United Space Alliance (USA) Annex 1 Book Manager identified.

The USA Annex 1 Book Manager will review the data for SSP implementation and contact the customer if there are any questions or if further negotiation of the data is required and will subsequently initiate the process to publish the annex.

John P. Shannon, Manager
Flight Operations and Integration

PREFACE

This annex describes the payloads configuration, weight and mass properties, avionics, and physical function data for installation, deployment, and/or retrieval of the payload as related to the Orbiter. The payload-to-Orbiter design to interface has been defined in the payload-unique Interface Control Document (ICD). This annex describes the payload configuration and substantiates the agreed-to design interface.

Customers receiving Space Shuttle Program (SSP) support equipment (Payload Integration Plan (PIP) optional service equipment and integration hardware) which is incorporated into the payload, shall consider it as payload elements or items and provide related payload data within this annex. However, the equipment stowed in the Orbiter crew compartment lockers at launch shall be excluded from this annex.

This document defines the requirements for preparation of data and documentation that are levied on a payload for their preparation of the Payload Data Package Annex. The requirements specified in this document are written generically; however, requirements not applicable to a specific payload will only be deleted by mutual agreement.

All data submissions made in response to this document are to be reproducible masters. The Annex 1 Book Manager will prepare an SSP draft in response to the customer's initial submittal (followed by a preliminary draft if necessary) and a review draft for the formal review. The customer's approval of the annex is via a signed signature page as shown in figure 4-1, and a signed Baseline CR. The annex preface shall have (as a minimum) the content of the preface shown in figure 4-2.

The customer's schedule for initial submit of these required data is defined in the individual schedule of the Integration Plan (IP), Carrier Integration Plan (CIP), Mission Integration Plan (MIP), Payload Integration Plan (PIP) or the Flight Production Schedule (FPS). As a general rule, four submissions will be required from the customer as follows:

a. The initial submittal of the annex should occur no later than 45 days after the payload IP is baselined but not later than 5 1/2 months prior to the SSP Cargo Integration Review (CIR). As a minimum, the following specific data are required (in the initial submittal) to support Space Shuttle Engineering Integration Products.

1. Section 1.0 - A complete set of mechanical and electrical drawings that are referenced in the text. These drawings must be under customer configuration control and represent the current payload configuration.

2. Section 2.0 - Estimated or calculated weight and mass property data.

If the required data is not available, it should be annotated as To Be Determined (TBD) within the text and summarized in appendix A with an anticipated schedule of its availability. The balance of the required data must be incorporated in the second submittal noted below.

b. The second submittal shall represent the customer's approval of a formal review draft developed by the Annex 1 Book Manager. This draft and Baseline CR shall be released to the customer no later than 3 months prior to the CIR. The customer approval should occur no later than 2 months prior to the CIR. The review draft and any customer changes will be subsequently reviewed and baselined by the SSP no later than 30 days prior to CIR to establish and assure the compatibility of the specific payload and cargo for flight. All outstanding TBD data shall be recognized or dispositioned at the CIR.

c. The third submittal shall update the annex at the time of the payload delivery to the launch site. This update shall describe the final payload configuration and report the results of an actual payload weight and balance test. This update will support and verify the final Space Shuttle performance analysis required for the Launch Site Flow Review.

d. The fourth submittal shall certify the weight and mass properties prior to each flight of the payload. This certification will support payload assessment at each Flight Readiness Review (FRR).

Subsequent to the annex baseline, revisions or updates should be via an Integration Control Board Change Request/Directive (Change Request) as described in the Configuration Management Requirements, NSTS 07700 Vol. IV. These submittals should be completed and approved by the customer (with appropriate copies of reproducible drawings and figures) and forwarded to the Payload Data Package Annex 1 Book Manager, with a copy to the Payload Integration Manager (PIM).

Questions and/or comments on the Payload Data Package requirements should be directed to the United Space Alliance (USA) Payload Data Package Annex Manager, USH-700E/Ronald W. Finn at the USA-Houston, 281-280-6847.

CONTENTS

TABLES

FIGURES

1.0 PAYLOAD CONFIGURATION

1.1 Mechanical Configuration

1.1.1 General.- Mechanical drawings shall be submitted to describe the payload at the assembly/installation level. The drawings shall show the general configuration and complete interface installation information necessary to locate, position, mount, and attach the payload/Space Shuttle items relative to supporting structure or to other related Space Shuttle items. The drawings are to include information in terms of area and space, access clearances, training clearances, and similar data required for the installation and operation of the items delineated.

Note: The above drawing data are not presented in this annex for crew compartment (mounted or stowed) payload experiment elements. These data are described in the NSTS 21000-ICA Orbiter Crew Compartment Interface Control Annex.

1.1.2 Mechanical Drawing Data.- The drawings shall describe the payload and specific items as follows:

a. Static payload envelope - Sufficient dimensional information of the payload static envelope shall be provided to identify the payload moldline (see figure 1-1). The payload moldline is the outer static boundary or surface envelope of the payload structure. Specific dimensions of this envelope including all protrudence beyond the general surface of the payload contour (e.g., antennas, fixtures, brackets, tubing, wire bundles, etc.), shall be provided. Dimensional drawings shall also be provided for each payload appendage if it is extended or deployed while the payload is within the Orbiter cargo bay or held by the Remote Manipulator System (RMS). This data shall be adequate to support a Space Shuttle Program (SSP) Orbiter protrudence and/or clearance analysis and to construct a payload model for mission design analysis and crew training.

   The actual length of the payload in the cargo bay is based upon the following:

Static length	----- in.
Dynamic excursions (+/- ----- in.)	----- in.
Operational clearances:	
Forward	----- in.
Aft	----- in.

b. Mechanical/electrical interfaces - Identify all payload and associated Airborne Support Equipment (ASE) mechanical and electrical interfaces to the Orbiter. The type of interface, specific location, attach hardware, clearances, and orientation shall be provided for the following.

   1. Mechanical attach/release points; e.g., trunnions, adaptor plates, restraint arms, spin tables, Grapple Fixtures (GF's), release/jettison devices, etc.

   2. Entry/departure of all fluid lines and cargo bay thermal supply/exhaust ducts. Provide the specific length of line/duct from the payload’s last attach point to the Orbiter interface.

   3. Electrical/avionics interface cables. Provide the specific length of the cable from the payloads last attach point to the Orbiter interface. If a cable is provided by the SSP from the Orbiter interface to the payload, as an optional service, provide the location of the payload connector and cable attach point (cable clamp).

   4. Payload cables, fluid lines, and thermal ducts to be routed on the Orbiter between payload elements. Identify each cable, its specific length, and entry/departure connector and attach point on the payload.

c. Deployment and/or retrieval access envelopes - Identification and dimensions of all clearances required for access.

d. Payload assembly identification - Drawings shall provide appropriate annotation to identify significant payload modules and/or elements. Describe the anticipated general configuration and location of the payload and ASE within the cargo bay.

e. Payload antenna - Drawings shall provide the identity of all antennas, specific locations, required clearances, and Field of View (FOV).

f. Payload origin and coordinates - The position and orientation of the Payload Axis System (PAS) in the Orbiter cargo bay is defined with respect to the Orbiter Structural Reference System (OSRS) and is dimensionally depicted in figure 1-2. The location of the PAS is described as follows:

$$\begin{matrix} X = 0 \\ Y = 0 \\ Z = 0 \end{matrix}_{PAS} \quad \text{at} \quad \begin{matrix} X = \text{--- in.} \\ Y = \text{--- in.} \\ Z = \text{--- in.} \end{matrix}_{OSRS}$$

The transformation matrix defining the orientation of the PAS is as follows:

$$\begin{matrix} X \\ Y \\ Z \end{matrix}_{PAS} = \begin{vmatrix} \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \end{vmatrix} \begin{matrix} X \\ Y \\ Z \end{matrix}_{OSRS}$$

g. Identify location of all payload pyrotechnic devices.

h. Schematic diagrams - Mechanical and thermal flow drawings clearly detailing mechanism functions and thermal flow to and from payload end items, respectively, are required for the following:

1. All hazardous mechanical or thermal payload systems.

2. All mechanical and thermal payload systems for which the Orbiter crew or the Mission Control Center (MCC) has operational responsibility in any nominal or contingency case.

1.2 Electrical Configuration

1.2.1 General.- Electrical drawings shall provide schematics of the payload avionics to describe the functional interfaces to the Space Shuttle. The drawings shall show the general avionics functional flow, cable/connector drawings of the interface wiring to the Space Shuttle, and specific schematics of both safety-critical circuits and the use of Space Shuttle electrical power and the exchange of data; e.g., command, monitor, telemetry data and/or recording by the Space Shuttle. These data shall support the development of flight operations functional drawings, the verification of Space Shuttle power, command, and data resource allocations to the payload and assure that safety-critical circuits are properly integrated with the Space Shuttle.

Note: The above drawing data are not presented in this annex for crew compartment (mounted or stowed) payload experiment elements not functionally related to the cargo bay payload. These data are described in the NSTS 21000-ICA, Crew Compartment Interface Control Annex (ICA).

1.2.2 Electrical Drawing Data.- The drawings shall include the payload-specific items as follows:

a. Functional flow diagrams - The functional flow data shall provide an overview (block diagram) describing all power distribution, control signal, and status monitoring circuits between the Space Shuttle interface and the payload end item for which any of the following criteria apply:

    1. Flightcrew onboard the Space Shuttle Orbiter

    2. Mission Control Center (MCC)/Payload Operations Control Center (POCC) using the Space Shuttle Orbiter command system

    3. Normal or contingency monitor status

    4. Payload-related flight critical item or hazard monitored by Space Shuttle Safety

    5. Data passing only as a copper path through a pallet, carrier, booster, etc., to the Orbiter

    6. T-0 umbilical measurement and command data usage

b. Schematic diagrams - Electrical drawings of circuit functions shall clearly indicate the circuit path from/to the Space Shuttle interface, but are not limited to

    1. Circuit protection devices with fuses, circuit breakers, switches, relays, power supplies and the respective current ratings.

    2. Command processing functions including verification stages, Multiplexers/Demultiplexers (MDM's), command timing logic circuits, command inhibit/enable functions, command output enable methods, etc.

    3. Measurement and telemetry points and verification techniques used to verify that end items have received power and are properly responding to commands.

4. Payload-related command and monitoring circuits via the T-0 umbilical system.

5. Detailed schematics, with the circuit path traceable from the Orbiter command/data/power device to the payload end item, are required for all payload systems for which the Orbiter crew or the MCC has operational responsibility in any nominal or contingency case.

c. Interface wiring - Detailed Space Shuttle/payload interface wiring data shall be provided for each interface connector/plug as follows:

   1. Identification number of the connector/plug and wire harness

2. Function identification of each wire and wire size including spares

3. Function identification of each payload wire passing through pallet, carrier, booster, etc.

d. Safety-critical circuits - A schematic shall be provided that identifies all payload safety-critical circuit paths and shall include the following:

1. Circuit path shall be traceable from the Space Shuttle command and/or monitor device to the hazard end item.

2. Identify each (connector/pin) Safety Critical Circuit (wire) passing through an ICD controlled interface.

3. Identify each sequential inhibit device utilized by the circuit.

4. Identify all redundant circuits or paths associated with the safety-critical end item.

5. Identify each payload device which process or alters the circuit signal from the Space Shuttle interface to the hazard end item.

Note: The safety-critical schematics should exclude the interim (pass through) connections within the Orbiter and within the payload.

1.3 Drawing and Figure Requirements

1.3.1 General.- This annex is the primary source of drawing data distribution to SSP organizations. To assure a cost-effective distribution and provide rapid exchange of data, an electronic data transfer method is required. The customer shall provide a copy of the referenced drawings and figures per the specifications noted. A reproducible hard copy shall accompany the electronic data transfer as well. Exceptions shall be negotiated with the Annex 1 Manager where electronic data transfer is not available.

1.3.2 Drawing Specifications.- The MIL-STD-100 (current copy) or equivalent engineering standards shall be used as a guide for the preparation of drawings and figures. If the customer does not use the MIL-STD-100, a copy of the customer's drawing standards as a guide shall be provided to clarify symbols and techniques used for drawings preparation.

The drawings shall be submitted per the minimum requirements as follows:

a. All line work and lettering shall be sufficiently opaque to be legible in full size or reduced size copies prepared to support the annex submittal of drawings referenced in the released annex (D size 11-in. high by 22-in. wide by run).

b. Drawings sheets shall be numbered, indicate the initial release date, and annotated with appropriate revision indicator.

c. The initial sheet shall contain a signature block with an appropriate certification signature present.

d. The drawings shall present the payload geometry in three views of projection, or more if appropriate, to assure items required are adequately described.

e. Specific data shall be provided so that size, shape, angular displacement, and location of an item can be determined without calculation.

f. Where approved drawing changes are made prior to the release of a drawing revision or level change, the appropriate authorized change order shall accompany the supplied drawing.

1.3.3 Figure Specifications.- Figures shall be provided where customer drawings are not available to detail the required engineering data or when a drawing is inappropriate to provide the required data.

The figures shall be submitted per the minimum requirements as follows:

a. All line work and lettering shall be sufficiently opaque to be legible in full size of 11-in. high by 8 1/2-in. or as much as 22-in. wide by run (as a fold-out for publication).

b. The figure shall present the payload geometry in three views of projection, or more if appropriate, to assure items required are adequately described.

c. Specific data shall be provided so that size, shape, angular displacement, and location of an item can be determined without calculation.

d. Symbols used in the figure shall be per the customer drawings specifications noted above.

e. A prepliminary copy of the figure may be submitted at the time of annex submittal. However, a reproducible master of the figure shall be provided, without revision, at the time of customer approval of the annex to support the annex review, approval, and publication.

1.3.4 Three Dimensional Payload Model Specifications.- The customer shall provide a three dimensional Computer Aided Design (CAD) model of all cargo bay payloads. Each should contain geometry only. Dimensions, labels, drawing format, notes, etc., are not desired.

An accurate model is required to support clearance analysis simulations (ground operations and on-orbit), crewmember or camera viewing of the payload from the Aft Flight Deck (AFD), and deployment/retrieval flight dynamics. Minimum requirements are defined below.

a. The model may be provided as a wireframe and/or a solid (both are preferred).

b. Models shall be full scale (1:1 ratio).

c. Physical proportions of the model should equate with dimensioned detail drawings for trunnions, scuff plates, latches, GF's, umbilicals and all other interfacing areas.

d. If necessary, enveloping of static physical geometry is acceptable in noninterfacing areas provided these criteria are followed.

    1. Enveloping of gaps between protrusion edges with a depth of .5 in. or less is acceptable. Refer to figure 1-1 (sheet 1 of 3).

2. Enveloping of gaps greater than .5 in. in depth is acceptable if the enveloped area is defined by two or more protrusions, with protrusion edges within 12 in. of each other. Refer to figure 1-1 (sheet 2 of 3).

3. Enveloping of cavities on a surface plane with a depth of .5 in. or less is acceptable. Refer to figure 1-1 (sheet 1 of 3).

4. Enveloping of cavities greater than .5 in. in depth is acceptable if the cavities are less than 12 in. across. Refer to figure 1-1 (sheet 3 of 3).

1.3.5 Electronic Data Transfer.- To facilitate the submittal of annex data (e.g., 3-D models, drawings, figures, data listings) an electronic data transfer shall be used.

The data transfer shall occur per the minimum requirements as follows:

a. The data transfer method for 3-D models shall be compatible with one of the following CAD formats:

   1. Computer Aided Three-Dimensional Interactive Application (CATIA) (version 4 UNIX based)

   2. I-deas (3-D) geometry model

   3. Auto-CAD Release 2000i (or previous)

   4. Drawing Exchange File (DXF)

   5. Initial Graphics Exchange Specification (IGES) version 3.0 and subsequent. IGES translator should comply with MIL-D-28000 CLASS 2.

b. The following three files are required for submitting the Payload/Cargo Element (CE) CAD data, (e.g., 2-D drawings, 3-D models, figures, data listings).

   1. Read-Me file – To provide general information about the contents of files, sending system, person to contact (phone number and email address), sender’s company name and address.

   2. STEP file – In ASCII format to provide 3-D geometry model. Required for non-CATIA or non-Ideas payload contractor users only.

3. Sterolithopgraphy Format (SLA), Graphics Interchange Format (GIF) or Hewlett-Packard Graphics File (HPGL) file – Shall consist of payload drawing (with dimensions) and ISO view picture of the total payload assembly model (solid) with hidden lines removal from its native system for visualization purpose and model validation. SLA shall be formatted in binary and less than 20 MB. If the SLA/GIF/HPGL file is not available, a fax/hard copy is acceptable.

Recommend a maximum of 20 MB file size for each STEP and/or IGES file. The desired model size of the total payload assembly should be no greater than 8 MB.

For contractors sending I-deas (3-D) geometry model: Model data file can be transferred by Internet. The model data requirement: I-deas' Universal file format (.unv) or archive file (.arc). Boeing currently uses I-deas Master's Series version 7.2 for production.

c. The data transfer method for all drawings other than the 3-D model shall be plotted to a disk file in a "plot" format only.

d. Data transfer by wire (telephone modem, Local Area Network (LAN) connection, etc.) or magnetic media.

   1. Internet connection: FTP firewall.slb.cal.boeing.com (for external environment). In the event the above link changes in the future and does not work, contact the book manager for the current address.

   2. E-mail connection: See book manager for current subcontractor point of contact e-mail address. There is a 5 MB max file size limited by Internet Gateway.

e. Data transfer by tape, CD, etc:

   1. UNIX Work-station (SGI, SUN, IBM, HP):

      (a) Tape requirement: 4mm, 8mm, or ¼ in. - cartridge

      (b) Tape and CD format: UNIX TAR

      (c) Floppy Disk requirement: 3.5 in. Disk Backup, or TAR on IBM RS/6000

   2. IBM/PC

      (a) Floppy disk requirement: 1.44 MB 3.5 in.

      (b) Floppy disk format: IBM DOS/MS-DOS

f. Configuration control is maintained on plot files by having read-only access. Verification of 3-D models shall be accomplished by forwarding to the customer a representative data set (hard copy) of perspective views of the 3-D models as a product of the electronic transfer. The customer shall in turn review and acknowledge that the data are correct as transferred.

1.4 Submittal Schedule

1.4.1 General.- Drawings shall be submitted to a SSP central payload data facility for the maintenance and distribution of payload configuration data. The drawings submitted should be selected from the customers existing payload drawing files.

1.4.2 Initial Submittal.- The customer provided configuration data may be initially submitted per the schedule established by the customer for the payload Preliminary Design Review (PDR), Critical Design Review (CDR), or Safety review (if they occur prior to the required initial Annex 1 draft submittal as established in the PIP, MIP, CIP, or IP schedule or the FPS). The Annex 1 Book Manager and the Mission Operations Directorate (MOD)/Cargo Operations Project Engineer will support the customer in reviewing the payload documentation/drawing tree and respective Data Packages, or equivalent, etc., and select that data which are relevant to the Space Shuttle payload integration, flight safety, and flight operations requirements (based upon the criteria provided in sections 1.1 and 1.2 above). The annex book manager(s) should be informed (via the PIM) 10 working days prior to the scheduled reviews.

If the submittal of this data is keyed to the payload design/development schedule, the required configuration data shall be listed and annotated to include a schedule of availability as it is understood at the time of the annex submittal.

1.4.3 Configuration Data Update.- The Annex 1 Book Manager will catalog the submitted data and provide a full accounting of available data in Annex 1. All configuration data provided by the customer shall be cataloged in the annex in terms of subject, number, revision level, and date of release. The customer shall forward to the payload data facility all subsequent configuration data updates in accordance with the PIP annex schedule (also reference Preface) and/or in a timely manner. The customer is required to status all discontinued drawings/schematics previously supplied.

Note: Customer-provided documents (excluding drawings/ schematics) uniquely required by the Space Shuttle Mission Operations Directorate (MOD) for flight documentation and training tool development shall be listed in the Flight Operations Support Documentation.

1.5 Publication and Distribution

1.5.1 General.- The SSP shall provide a central payload data facility for the maintenance and distribution of payload configuration data listed in Annex 1. The central facility shall update the data as changes are issued by the customer, and distribute copies of the changes as appropriate. The customer shall provide a point-of-contact for coordinating documentation/drawing distribution requirements.

1.5.2 Supplementary Data Distribution.-

1.5.3 Proprietary Data.- The SSP (including the National Aeronautics and Space Administration (NASA) and the supporting SSP operations contractor) shall recognize and protect customer proprietary information to the extent practical. The customer shall list all data considered as proprietary and provide a point-of-contact for access approval of this data. Any SSP organization requiring access to designated proprietary data shall coordinate the data request with the PIM and obtain appropriate written approval of the customer prior to its release.

Note: The SSP flight documentation produced from proprietary material in support of payload operations shall also be protected, as negotiated in the Flight Operations Support Documentation.

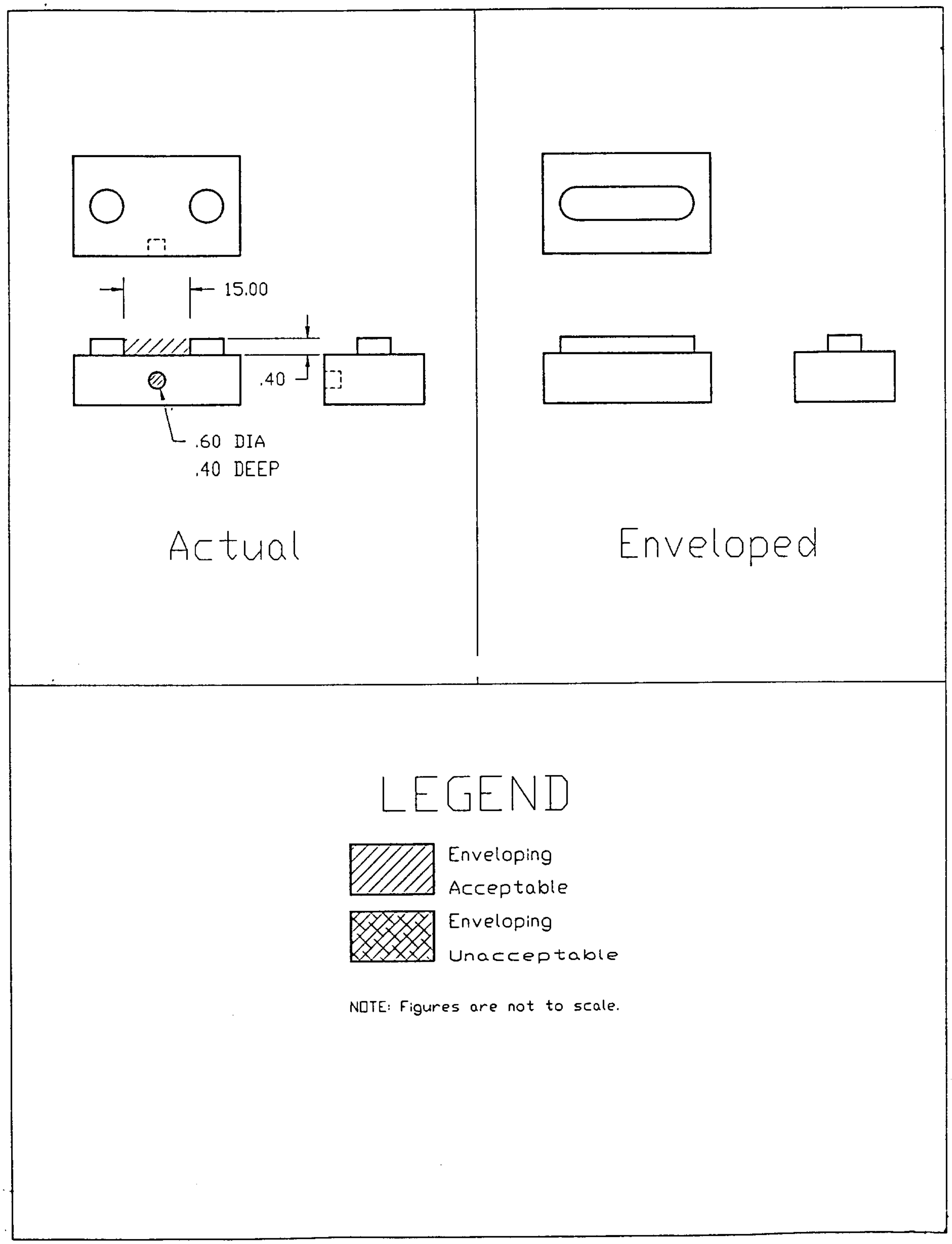


Figure 1-1.- Static envelope examples (sheet 1 of 3).

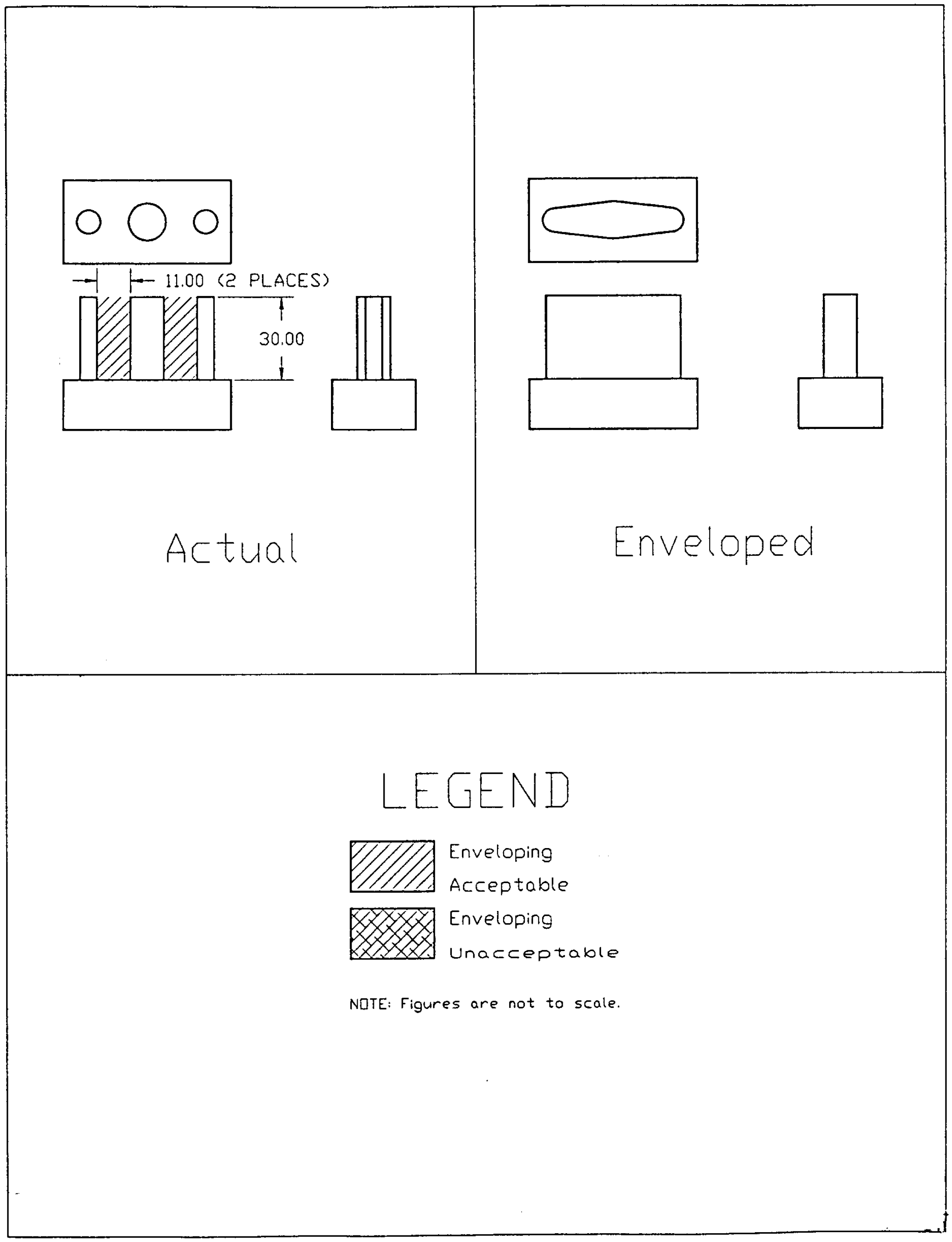


Figure 1-1.- Static envelope examples (sheet 2 of 3).

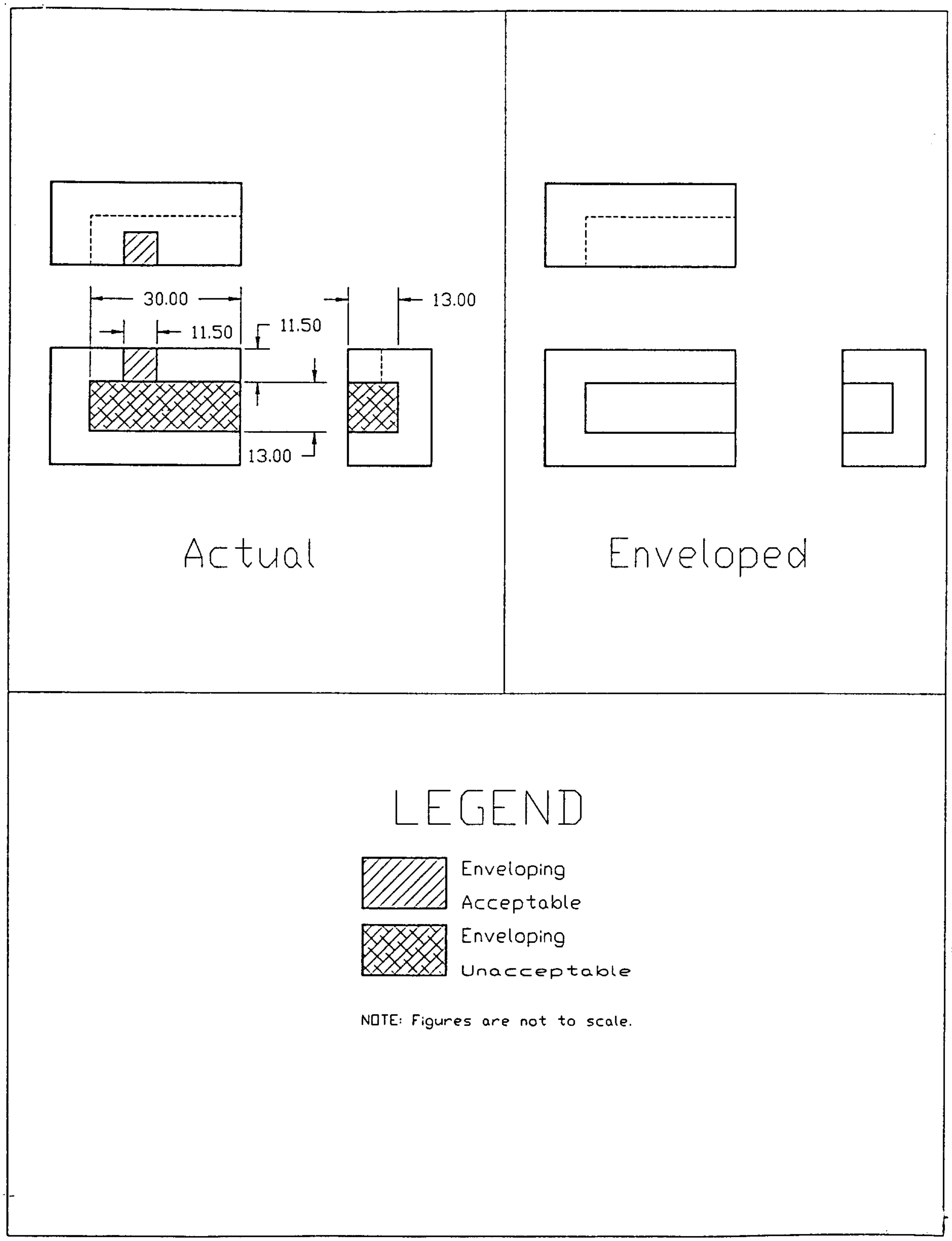
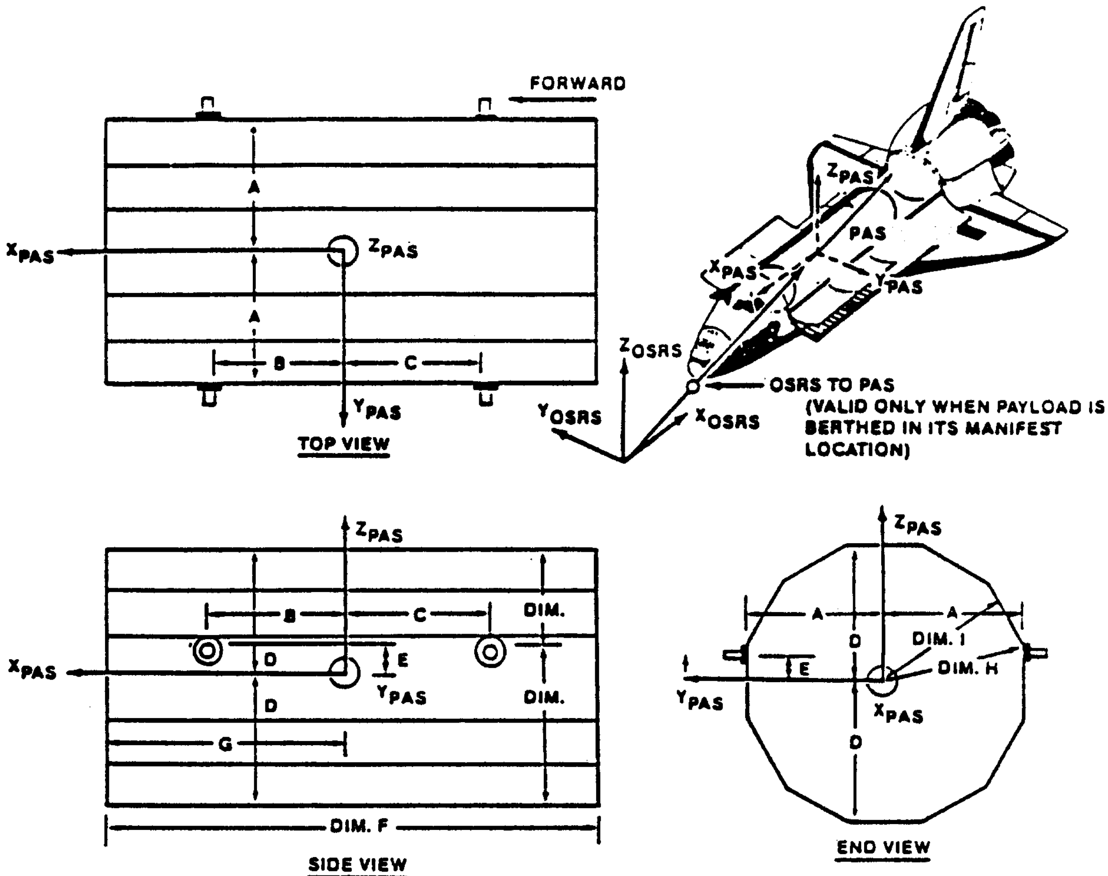


Figure 1-1.- Static envelope examples (sheet 3 of 3).



INCLUDE SUFFICIENT DIMENSIONING TO RELATE THE PAS TO PAYLOAD STRUCTURE: (In IN.)

DIM. A =	DIM. G =
DIM. B =	DIM. H =
DIM. C =	DIM. I =
DIM. D =	
DIM. E =	
DIM. F =	

INCLUDE SUFFICIENT DIMENSIONING TO CLEARLY OUTLINE ALL SIGNIFICANT PAYLOAD STRUCTURE AND FEATURES

Figure 1-2.- (PAS) definition example.

2.0 WEIGHT AND MASS PROPERTIES

The customer shall provide current mass property data to support Space Shuttle mission manifesting and performance planning and to assure that the payload weight does not exceed the control weight limitations described in the IP (PIP, MIP, etc) section 4.1.

2.1 Weight Data

2.1.1 General.- The current approved control limits of the cargo bay payload weight shall be listed as described in the IP as well as the corresponding current cargo bay payload weights.

2.1.2 Format.- A corresponding breakdown of the payload weights shall be provided in accordance with the format as shown in figure 2-1 (Payload control weight reporting format example). The corresponding current payload weight shall be provided showing the percentage of each weight item that is estimated, calculated, or actual.

2.1.3 Location and Weight Chargeability.- The weight of respective payload elements/assemblies and support equipment placed in the Orbiter shall be provided. This weight data shall also indicate the respective supplier (customer or SSP) and to which the weight is chargeable. The format of the data listing is shown in figure 2-1.

2.1.4 Schedule.- Weight data shall be submitted according to the schedule given in the individual IP or as follows:

a. Initial data submittal to the annex draft

b. Approval of the annex for baseline (submitted as redlines to the approved draft)

c. Update subsequent to SSP approval of annex 1

    1. CIR

    2. One month prior to the Launch Site Flow Review or upon delivery of the payload to the SSP Payload Integration Facility at NASA John F. Kennedy Space Center (KSC)

3. Correction as a result of a weight and center of gravity (c.g.) measurement

4. Two weeks prior to the Flight Readiness Review (FRR) (if appropriate)

5. Payload configuration change that requires an IP control weight change.

2.1.5 Weight Uncertainty.- The customer shall provide the composite and element weights with an accuracy at least as precise as that determined from figure 2-2 (Shuttle payload weight and c.g. uncertainties requirements).

2.2 Mass Property Data

2.2.1 General.- The customer shall define the mass properties for all payload elements in the cargo bay. The mass property data noted in the annex shall represent the payload launch/landing weight, mass, center of gravity (c.g.), moments of inertia and products of inertia in both English and Metric units as shown in figure 2-3 (sheet 1 of 2). Appropriate conversions between metric (SI) and English (U.S. Customary Units) are defined in figure 2-3 (sheet 2 of 2). The weight data will be appropriately compensated for mean sea level and buoyancy as determined from a weight measurement test noted below. Sequential mass properties shall be defined at each major flight event when a change in the payload configuration occurs. Mass property data will also be provided for each major appendage element. Payload/element structural configuration examples are shown in figure 2-4.

The customer shall exclude from the payload weight data all SSP integration hardware and Orbiter mission kits noted in the PIP/MIP section 7.0 except where the hardware is incorporated into the payload.

2.2.2 Format.- The payload mass properties shall be referenced to the PAS as described in section 1.1.2f and as shown in figure 2-3, Weight, c.g., and inertia sketch example. The origin of the PAS shall be annotated in the figure with respective dimensions from the origin to the c.g. (X, Y, and Z axis) clearly shown. The payload mass property data shall be provided for each of the categories noted below.

2.2.3 Categories.- Sequential mass property data shall be provided for each payload configuration and categorized in a manner similar to the following:

a. Launch Configuration - Cargo bay - The mass properties of the payload within the Orbiter cargo bay at the time of launch.

The mass properties shall represent the composite payload supported by trunnions or a payload-provided carrier/pallet. Where a supporting Space Shuttle Orbiter sidewall carrier is supplied by the SSP as integration hardware, the mass properties of the carrier shall be excluded as noted above.

b. On-orbit Configuration

1. Nondeployable payloads - The specific mass properties of the payload shall be provided if a change exists from the launch configuration noted above.

2. Deployable spacecraft that the SSP will not retrieve - The specific mass properties of the deployed portion of the payload shall be provided. After deployment of the payload, mass property changes to that deployed portion of the payload need no longer be tracked. However, for payloads on which the SSP is responsible for flight analysis postdeployment from the Orbiter, the mass properties of the deployed portion of the payload must be tracked up to the point in the trajectory where SSP responsibility ends.

3. Deployable spacecraft that the SSP will retrieve - The specific mass properties shall be defined for the portion of payload at the time of retrieval.

4. Attached cradle/pallet/retrieval device - The specific mass properties shall be defined for that portion of the payload which remains attached to the Orbiter during any phase of the flight.

5. Appendage deployment - Payload mass properties shall be provided for each sequential appendage configuration while attached to the Orbiter. An example of an appendage deployment is shown in respective views of figure 2-4 (Configuration/element definitions example). The payload mass properties must be provided for each configuration as shown in figure 2-3. If extensive configurations are required, the respective presentation of a mass properties in figure 2-3 may be omitted in lieu of a table describing the mass properties. The format of the table is shown in figure 2-5 (Payload sequenced mass properties example).

c. End-of-Mission Configuration - Landing - The payload mass properties shall be defined at the time of landing. If the landing mass properties are the same as launch, the mass properties shall be expressed as both launch and landing mass properties. Where a minor difference exists; e.g., a weight loss due to fuel use or gas venting, a statement shall note the difference in launch and landing mass properties with an appropriate statement of explanation.

2.2.4 Mass Properties Uncertainties.- The customer shall provide the payload c.g., moments, and products of inertia as follows:

a. The composite and element c.g. shall be provided with accuracy values at least as precise as those determined from figure 2-2 for each of the three major axes.

b. The moments of inertia for each element shall be provided with an accuracy of +/- 5 percent about each of the three major axes through the payload c.g. as defined in the preceding paragraph. Moments of inertia shall be expressed in slug-foot-squared.

c. The products of inertia of each element shall be provided with an accuracy consistent with that of the other mass property information. Products of inertia shall be expressed in slug-foot-squared.

2.3 Weight and C.G. Measurement

2.3.1 General.- The customer shall perform a baseline measurement to establish the actual weight and c.g. of the payload. Where the payload is added to a generic supporting structure (carrier, pallet, modules, etc.), the previous baseline measurement of that supporting structure may be used if a weight and c.g. history is maintained.

2.3.2 Schedule.- The customer shall inform the Annex 1 Book Manager of the anticipated weight measurement test 15 working days prior to the scheduled test. A copy of the measurement results shall be forwarded to the Annex 1 Book Manager within 5 working days of test completion.

2.3.3 Weight and C.G. Determination.- The payload weight and c.g. determination shall be accomplished by actual measurement or through analytical calculation as agreed to in the PIP/MIP or as delineated in the annex by the customer and the Annex 1 Book Manager. The payload weight shall be provided in pounds as read from the weighing equipment and recorded in a weight log as described in section 2.4 below. The c.g. shall be calculated from the weight data and shall be referenced to an established payload origin and axis system as described in section 1.1.2f payload origin and coordinates. Where the c.g. determination of payload Z-axis (as reference to the Orbiter) is not feasible, an analytical calculation may be determined of this axis by agreement with the Annex 1 Book Manager prior to the weight and balance measurement.

2.3.4 Weight and Balance Measurement Procedure.- The customer shall provide a copy of the anticipated weight and c.g. measurement procedure 10 working days prior to the test. At a minimum, the procedure shall describe the weight and c.g. determination technique, certification of test equipment, and accuracy of the test equipment, and for which axes the c.g. will be established.

2.3.5 Measurement Uncertainty.- The resultant uncertainty of the overall payload weight and c.g. shall be provided and documented in the above test procedure prior to the actual test. The weight uncertainty shall be expressed in +/- pounds. The c.g. uncertainty shall be expressed in +/- inches. The accuracy of the weighing equipment shall be less than the maximum uncertainty described in figure 2-2 by a minimum ratio of 2:1.

2.4 Weight Log

2.4.1 General.- The customer shall maintain a Weight Log starting at the time and place of the baseline weight measurement through the return of the payload to the customer. Weight Log entries of payload nonflight items shall be annotated to qualify the current weight data. An addendum to the log shall be provided which describes the anticipated payload items (and their respective weights) to be added or removed (subsequent to the baseline measurement).

2.4.2 Format.- An example of a Weight Log format is shown in figure 2-6 (Weight Log reporting format example). The specific format of the log shall be developed by the customer with concurrence of the Annex 1 Book Manager 10 days prior to the payload weight measurement noted above. All additions and/or deletions of hardware shall be recorded in excess of 1 lb.

2.4.3 Schedule.- The customer must make available to the Annex 1 Book Manager and the respective KSC launch integration/processing organizations a copy of the current weight log upon delivery of the payload and/or supporting carrier as follows:

a. Integration via VPF

1. Two working days prior to delivery to the VPF

2. At the time of transfer to the PAD

3. At the time of final configuration in the Orbiter for flight

b. Integration via HPF (Operations and Checkout (O&C) Building)

1. Two working days prior to delivery to the HPF (unless payload buildup assembly occurs in the O&C Building)

2. At the Payload Readiness Review (PRR) or no later than one day prior to installation into the Orbiter

3. At the time of Orbiter PLBD closure (for transfer of the Orbiter to the PAD)

4. At the time of final configuration in the Orbiter for flight

c. Integration via OPF

1. Two working days prior to delivery to the OPF

2. At the time of Orbiter PLBD closure (for transfer of the Orbiter to the PAD)

3. At the time of final configuration in the Orbiter for flight

2.4.4 Quality Assurance.- All data entries in the payload Weight Log (and corresponding weight test measurement procedures) shall be certified by the customer's quality control organization.

2.4.5 Update.- If the updated Weight Log does not correspond to the flight weight (launch and landing with appropriate compensation for the payload weight at mean sea level and buoyancy) as described in Annex 1, the customer shall resolve the error by an update to Annex 1, which reflects the weight as noted in the Weight Log and addendum. Any discrepancy which exceeds the allowed tolerance between the Annex 1 weight data and the Weight Log (as described in paragraph 2.3.5 and figure 2-2) must be resolved between the customer and the Annex 1 Book Manager.

2.5 Weight and Mass Properties Certification

The final weight and mass properties shall be certified by the payload representative through the payload Certification of Flight Readiness (COFR) process in conjunction with the FRR held approximately 2 weeks prior to flight. Payload flight readiness statements will be worked directly with the PIM.

Table 2-1.- PAYLOAD WEIGHT STS-(TBD)

Payload items	Control weight as of (date)	Current weight as of (date)	Weight basis, percent			Supplier	
			Est	Cal	Act	P/L	SSP
TBD:							
TBD:							
Subtotal							
TBD:							
TBD:							
TBD:							
Subtotal							
TBD:							
Subtotal							
Total							

Note: Individual breakdowns of payload and SSP items will be tracked such that their subtotals and overall total will correspond directly to control weights specified in section 4.1.3 of the corresponding PIP.

Figure 2-1.- Payload weight reporting format example.

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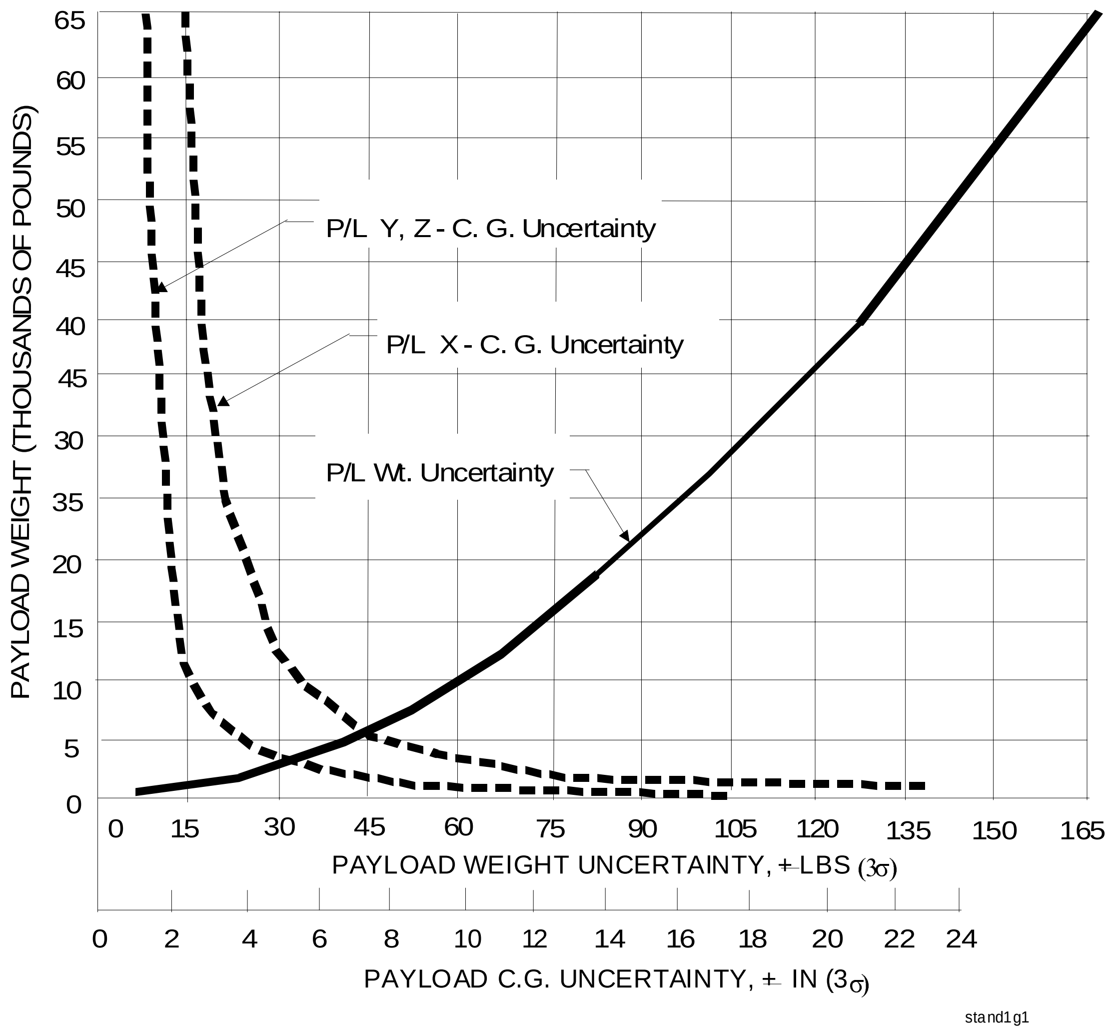
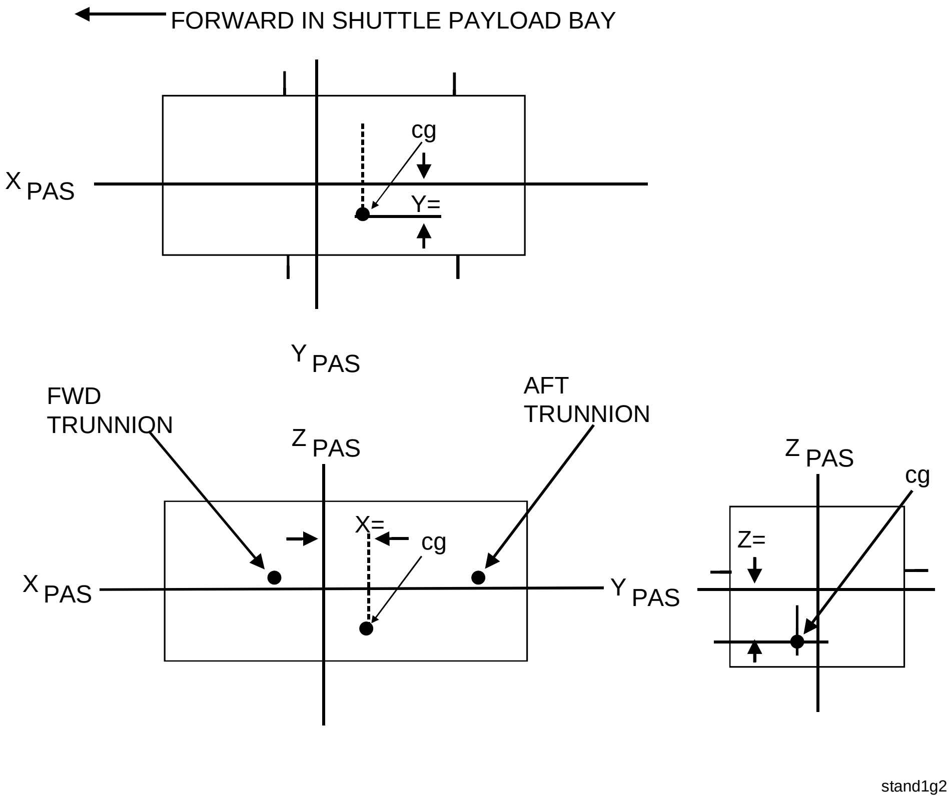


Figure 2-2.- Shuttle payload weight and c.g. uncertainties requirements.



WEIGHT DATA

Weight: (---) lb, (---) N
Mass: (---) slug, (---) kg

c.g.: X = (---) in., (---) cm
       Y = (---) in., (---) cm
       Z = (---) in., (---) cm
(PAS)

MASS PROPERTY DATA

Moments of Inertia
Ixx = (---) slug-ft-sq, (---) kg-m-sq
Iyy = (---) slug-ft-sq, (---) kg-m-sq
Izz = (---) slug-ft-sq, (---) kg-m-sq

Products of Inertia
Ixy = (---) slug-ft-sq, (---) kg-m-sq
Iyz = (---) slug-ft-sq, (---) kg-m-sq
Izx = (---) slug-ft-sq, (---) kg-m-sq

Notes:
1. All mass properties are centroidal.
2. Weight and mass properties are provided for each payload element in PAS coordinates.
3. Production of inertial terms are based on positive or negative) integrals; e.g., Ixy equals plus integral xydm.
4. The above mass properties data only include cargo bay elements.

Figure 2-3.- Weight, c.g., moment and product of inertia example (sheet 1 of 2).

The Shuttle Operational Data Book (SODB) (Volume II, Mission Mass Properties, Section 1-6 of NSTS 08934 outlines the method of converting English (U.S. Customary Units) to the Metric System (SI) as follows:

Physical quantity	To convert from	To	Multiply by
Mass	pounds	kilograms (kg)	0.45359237
Length	inches	centimeters (cm)	2.54
Inertias	slug*ft^2	kg*m^2	1.35581768

It follows that the appropriate Annex 1 conversion factors for converting from the Metric System (SI) to the English (U.S. Customary Units) are therefore as follows:

Physical quantity	To convert from	To	Divide by
Mass	kilograms (kg)	pounds	0.45359237
Length	centimeters (cm)	inches	2.54
	millimeters (mm)	inches	25.4
Inertias	kg*m^2	slug*ft^2	1.35581768

Figure 2-3.- Weight, c.g., moment and product of inertia example (sheet 2 of 2).

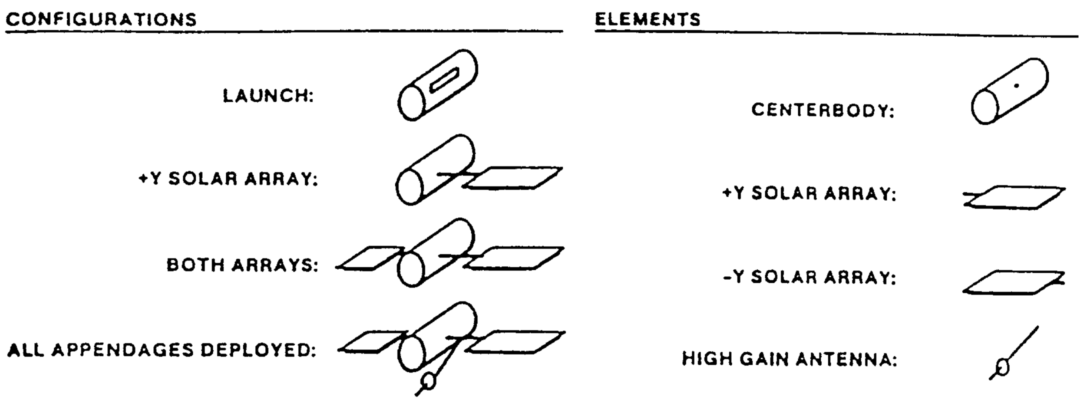


Figure 2-4.- Configurations/element definitions example.

Payload Config	Weight (lb)	Center of mass from PAS origin (in.)			Moments of inertia about CM (slug-ft-sq)			Products of inertia about CM (slug-ft-sq)		
		X	Y	Z	IXX	Iyy	Izz	Ixy	Ixz	Iyz

Notes: 1. Weight and mass properties shall be provided for each payload element.

2. Production of inertial terms must indicate whether defined as positive or negative integrals; e.g., Ixy equals plus integral xydm.

Figure 2-5.- Payload sequenced mass properties example.

WEIGHT AND BALANCE HISTORY LOG

PAYLOAD:		IDENTIFICATION NO:		LOCATION:		
Entry No.	Date	Item Description	Document No. (and Line No.)	+/-	Weight in lbs.	QC BY
REMARKS/COMMENTS:						

Figure 2-6.- Weight Log reporting format example.

3.0 PAYLOAD PHYSICAL FUNCTION DATA

These data are required on those payloads which require Space Shuttle retrieval, those that require special handling by the payload deployment and retrieval system, those that perform some function onboard the Orbiter that could perturb or endanger the Space Shuttle, or those that require the SSP to train the crew in a simulator to perform a specific function.

3.1 Payload Deployment and Retrieval System Data Requirements

The following data are required from all payloads that use the Payload Deployment and Retrieval System (PDRS). All coordinates are expressed in right-hand Cartesian coordinate systems.

3.1.1 Reference Frames.-

a. The GFAS is the standard coordinate system which defines the position and orientation of GF's mounted to the payload structure. The origin of the GFAS is located at the base of the grapple pin as depicted in figure 3-1. The location and orientation of the payload GFAS are defined with respect to the PAS and the payload structure as dimensionally depicted in figure 3-2. The location of the GFAS is described as follows:

$$\begin{matrix} X_{GFAS} = 0 \\ Y_{GFAS} = 0 \\ Z_{GFAS} = 0 \end{matrix} \quad \text{at} \quad \begin{matrix} X_{PAS} = \text{---} \text{ in.} \\ Y_{PAS} = \text{---} \text{ in.} \\ Z_{PAS} = \text{---} \text{ in.} \end{matrix}$$

The transformation matrix defining the orientation of the GFAS is as follows:

$$\begin{matrix} X \\ Y \\ Z \end{matrix}_{GFAS} = \begin{vmatrix} \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \\ \text{---} & \text{---} & \text{---} \end{vmatrix} \begin{matrix} X \\ Y \\ Z \end{matrix}_{PAS}$$

b. The Principal Axis (PA) is defined for payloads utilizing the RMS. The location and orientation of the payload PA are defined with respect to the PAS and the payload structure. The location of the PA is described as follows:

$$\begin{matrix} X_{PA} = 0 \\ Y_{PA} = 0 \\ Z_{PA} = 0 \end{matrix} \quad \text{at} \quad \begin{matrix} X_{PAS} = \text{---} \text{ in.} \\ Y_{PAS} = \text{---} \text{ in.} \\ Z_{PAS} = \text{---} \text{ in.} \end{matrix}$$

The transformation matrix defining the orientation of the PAS is as follows:

```
 X          |--- --- ---    |X
 Y     =    |--- --- ---    |Y
 Z          |--- --- ---    |Z
  PAS                        PA
```

3.1.2 Structural Characteristics.-

a. The port RMS is assumed unless specified in the PIP.

b. The standard or special purpose end effector must be specified.

c. The flight releasable, electrical, or rigidize-sensing GF's must be specified.

d. A standard camera target, when required, is to be attached to the base of the payload for viewing by the keel-mounted camera (figure 3-3). The location of the Keel Target (KEEL TARG) expressed in PAS coordinates is

```
 X    =  0                       X    = --- in.
 Y    =  0            at         Y    = --- in.
 Z    =  0                       Z    = --- in.
  KEEL TARG                       PAS
```

e. The first three major structural vibration frequencies of the GF interface and cargo element are required when the payload is cantilevered from the GF. Detailed analysis and/or simulation will be required for payloads weighing 35K lb or less with frequencies lower than 0.2 Hz and for payloads weighing greater than 35K lb with frequencies lower than 0.5 Hz per paragraph 14.4.5.4 of ICD 2-19001. If there are no resonant frequencies below 0.2 Hz for payloads ≤ 35K lb or below 0.5 Hz for payloads > 35K lb, only the lowest natural frequency need be noted. Otherwise, the first three major frequencies for the payload when cantilevered from the GF are required to be provided as follows:

Mode no.	Freq (Hz)	Description
1	----	(Description of mode)
2	----	. . . .
3	----	. . . .

f. The payload designer should provide to NASA a rigid-body stiffness coefficient matrix as defined in section 9.3.5 of NSTS 07700 Volume XIV, Appendix 8 for the following categories of payloads:

1. Payloads weighing less than or equal to 35K lb with a major structural vibration frequency below 0.2 Hz

2. Payloads weighing greater than 35K lb with a major structural vibration frequency below 0.5 Hz

Payloads with multiple GF's should provide a stiffness matrix for each GF.

In order to be compatible with NASA's simulation capability, the rigid-body (lumped mass) payload model should include six degrees of freedom at the payload CM defined with respect to PAS. The payload model should be cantilevered from the base of the GF pin, and include GF attachment stiffness.

The equations of motion for this rigid-body system are defined by the equation

[M] {x} plus [C] {x} plus [K] {x} = {F}

where

{x}, {x}, {x} are the six dimensional vectors of accelerations, velocities, and displacement/rotations of the payload CM in PAS coordinates.

[M] is the 6 by 6 rigid-body damping matrix about the CM with respect to PAS. This matrix can be constructed from the mass property data provided in the previous section.

[C] is a 6 by 6 rigid-body damping matrix with respect to PAS. For analyses, one-half percent viscous damping (L = 0.005) will be assumed unless the payload designer indicates there are compelling reasons to apply another value or another form of damping.

[K] is the 6 by 6 rigid-body stiffness matrix which defines the stiffness characteristics between the GF and the payload CM. This matrix should account for GF attachment stiffness and payload structural stiffness. Terms should be defined with respect to PAS.

[F] is a six dimensional vector of external forces and torques (Fx, Fy, Fz, Mx, My, Mz) applied at and about the CM.

The stiffness matrix [K] should be provided in the format:

$$
[K]\{x\} = \begin{vmatrix} Kxx & Kxy & Kxz & Kx0x & Kx0y & Kx0z \\ Kyx & Kyy & Kyz & Ky0x & Ky0y & Ky0z \\ Kzx & Kzy & Kzz & Kz0x & Kz0y & Kz0z \\ K0xx & K0xy & K0xz & K0x0x & K0x0y & Kx0x \\ K0yx & K0yy & K0yz & K0y0x & K0y0y & K0y0z \\ K0zx & K0zy & K0zz & K0z0x & K0z0y & K0z0z \end{vmatrix} \begin{vmatrix} X \\ Y \\ Z \\ Ox \\ Oy \\ Oz \end{vmatrix}
$$

Units for linear and torsional stiffnesses should be lbf/in and in-lbf/rad, respectively. Cross-coupled (off-diagonal) terms in the matrix should be included.

Stiffness matrices may also be requested by NASA to model flexibility between the centerbody CM (mass of payload minus appendage mass) and an external appendage CM. In this case, six degrees of freedom exist at the appendage CM such that {x} now defines the displacements and rotations of the appendage CM relative to the fixed centerbody CM (in PAS coordinated). The stiffness matrix which defines the centerbody-to-appendage stiffness should be modeled with the appendage CM cantilevered from the centerbody CM. In addition, individual mass property information for the centerbody and the appendage, and the appendage attachment location will also be required.

g. For payloads which may impart loads upon the RMS (i.e., Attitude Control System (ACS), fuel slosh, element jettison), the forces and moments which the RMS may experience must be supplied.

3.1.3 PDRS Automatic Trajectories.- Automatic trajectories are defined by a sequence of points (200 total on any one flight) which specify the position and orientation of the payload with respect to the Orbiter, while attached to the RMS. The following data are required to define the RMS automatic trajectory capabilities required by the payload.

a. The number of automatic trajectories required by the payload (maximum of 20 to be shared by all the payloads on a single flight).

b. Points of Resolution (POR) required by the payload (maximum of 5 to be shared by all the payloads on a single flight). The POR defines a reference location on the payload about which rotations are performed. Payload POR requirements are defined in table 3-1:

c. Automatic trajectory points are defined in the Orbiter flight software by the position and orientation of the POR with respect to the Orbiter Body Axis System (OBAS) as shown in figure 3-4 and the Orbiter Rotational Axis System (ORAS) as shown in figure 3-5, respectively. Automatic trajectory points are to be presented as in table 3-2.

3.2 Retrievable Payloads

For payloads that are to be retrieved by the Space Shuttle, the following items are required:

a. Transponder or other radar enchancement device information

b. Radar reflectivity/cross sectional area

c. Optical reflectivity/cross sectional area

d. Markings/paint patterns

e. Optical targets

f. Tracking lights/aids

g. Attitude control data to include:

   1. Expected attitude at retrieval

   2. Type of ACS, if any

   3. Stability limits, if any, or expected tumble rates

   4. Payload susceptibility to plume impingement

   5. Attitude control thruster data, if any, to include:

      (a) Magnitude of thrust

      (b) Duty cycle

      (c) Number and location of thrusters as well as their orientation

3.3 Spun-up Payloads

For payloads that will be spun up to a defined speed while attached to the Orbiter, detailed data shall be provided on the spin mechanism as follows:

a. Type of spin mechanism (spring, rocket (liquid or solid), or other)

b. Location (+/- three sigma) of spin mechanism and where torque will be applied to payload

c. Expected torque (+/- three sigma) to be applied

d. Duration (+/- three sigma) of torque

e. Spin velocity, rpm (+/- three sigma)

f. Time (+/- three sigma) of despin torque (if applicable)

g. Orientation (+/- three sigma) of axis about which the torque is applied

h. Torque time history (+/- three sigma)

3.4 Free-Flying Payloads Controlled by the Space Shuttle Crew

For free-flying payloads that will be controlled by the Space Shuttle crew, payload translation thruster data to include thrust and specific impulse shall also be provided.

3.5 Separation Mechanisms

For payloads that provide their own separation mechanism, the following items of information are required:

a. Force and/or torque time history (+/- three sigma)

b. Location and orientation of separation force vector (+/- three sigma)

c. Data indicating when (+/- three sigma) payload will be free of the Orbiter

d. Dimension the payload deployment envelope and indicate the payload orientation during the separation sequence.

3.6 Elevation Mechanisms

For payloads that provide their own elevating mechanism, the following data are required:

a. Torque time history (+/- three sigma)

b. Point of torque application and its direction (+/- three sigma)

3.7 Attitude Initialization

For payloads having a Star Tracker (ST), or similar device, which requires the Orbiter to perform pointing operations for attitude initialization, the following data are required:

a. ST position (+/- three sigma) and orientation (+/- three sigma) on the payload

b. ST FOV

c. Payload configuration and orientation during ST operations

d. Catalog of preferred stars

3.8 Thrust Characteristics

For those payloads (or payload carriers) which the SSP will have flight analysis responsibilities, the following data are required:

a. Thrust time histories (+/- three sigma)

b. Specific impulse (+/- three sigma) of thruster(s)

3.9 Hazardous Materials

A summary of payload hazardous materials located in the crew compartment or cargo bay (liquids, gaseous, chemicals, etc.) shall be provided.

Hazardous materials are those considered to cause an adverse physiological effect on the crew or result in a chemical reaction (exothermic, corrosive, material degradation, etc.) with other materials within the payload or Orbiter.

The data summary of hazardous materials shall be provided as follows:

a. State of each material (solid, liquid, gas, etc.)

b. Use of each material (fuel, oxidizer, propellant, collant, etc.)

c. Composition of each material, e.g. Hydrazine (N2H2), Hydrogen (H2), Ammonia (NH3)

d. Quantity of each material in weight (lb) or volume (gallons)

Table 3-1.- PDRS AUTO TRAJECTORY POINTS OF RESOLUTION

POR no.	- - - PAS to POR - - - (in.)		
	X	Y	Z
1			

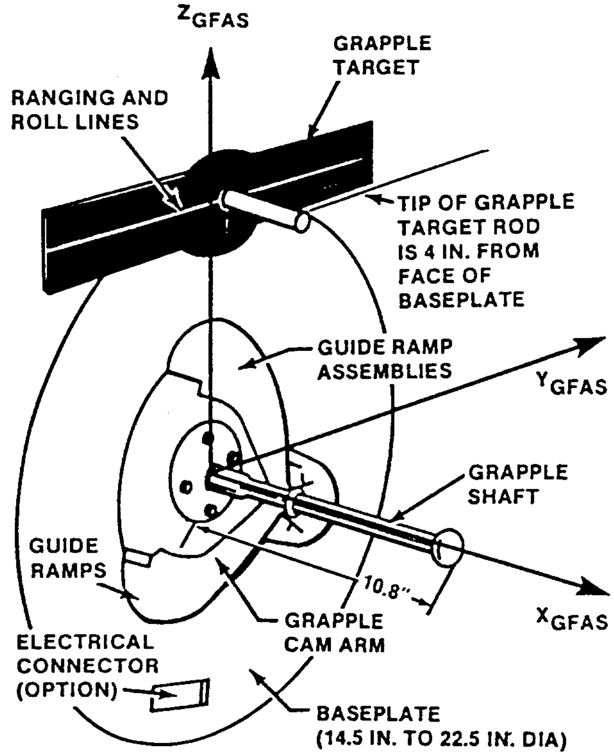
Table 3-2.- PAYLOAD/PDRS AUTOMATIC TRAJECTORIES

Sequence no. ___ POR no. ___							
	----OBAS to POR ----			--- Attitude in ORAS---			
Point no.	X (in.)	Y (in.)	Z (in.)	P (deg)	Y (deg)	R (deg)	Pause (0/1)

Note: 1. X, Y, Z is the vector from OBAS to the POR.

2. P, Y, R is the pitch, yaw, and roll Euler sequence defining the attitude of the POR with respect to ORAS. Pitch, yaw, and roll are also defined as positive rotations about local Y, Z, and X, respectively.

3. Pause points are indicated by a 2, otherwise 0 indicates fly-by.



NAME: Grapple Fixture Axis System (GFAS).

ORIGIN: On the centerline of the grapple shaft in the plane of union between the Grapple Fixture (GF) and the rigidized end effector.

ORIENTATION: The X_{GFAS} axis lies along the centerline of the grapple shaft. Positive sense is from the base plate of the GF towards the tip of the grapple shaft.

The Z_{GFAS} axis is perpendicular to the X_{GF}- axis and passes through the center of the GF target. Positive sense is from the base plate of the GF towards the GF target.

The Y_{GFAS} axis completes a right-handed system.

CHARACTERISTICS: Right-handed, Cartesian.

Figure 3-1.- GFAS.

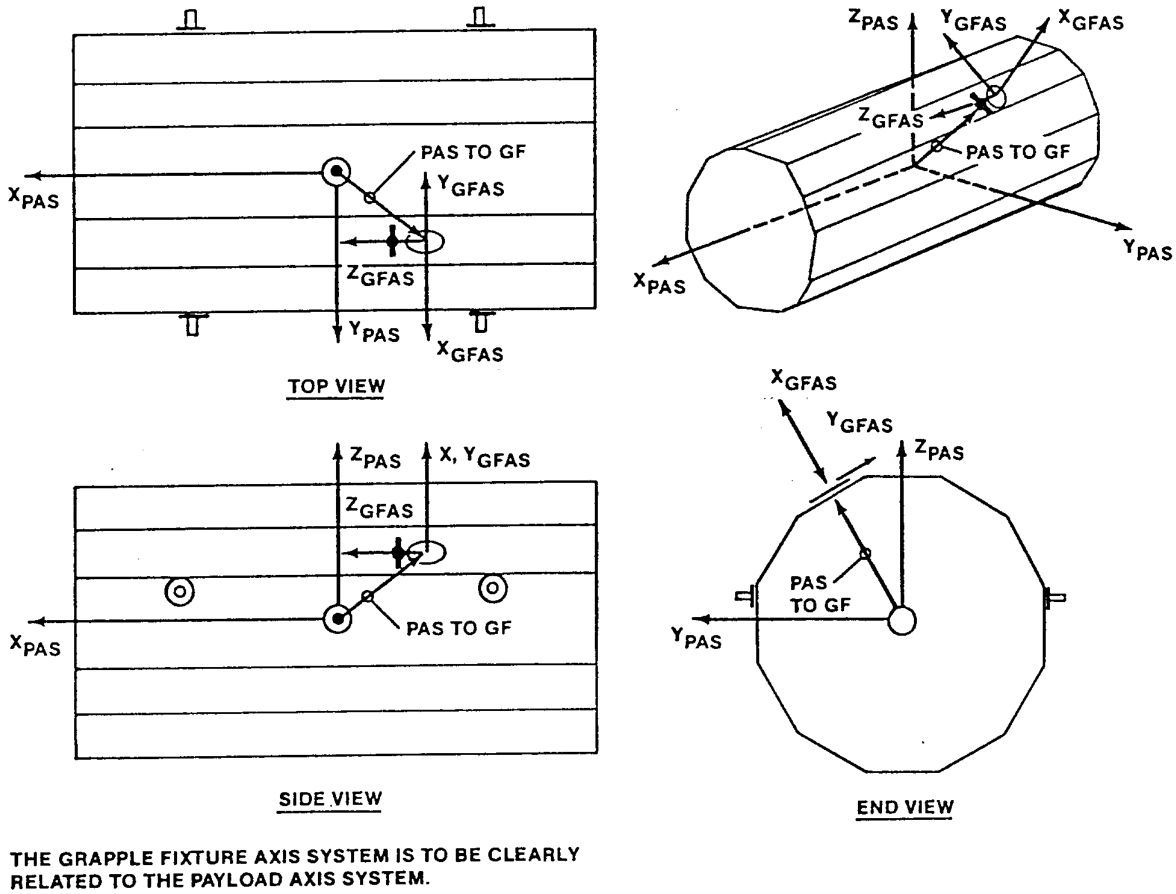


Figure 3-2.- GFAS example.

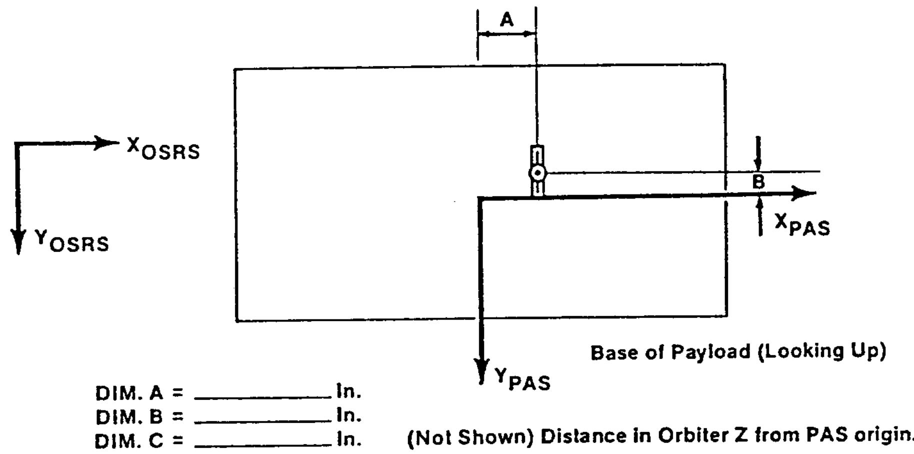
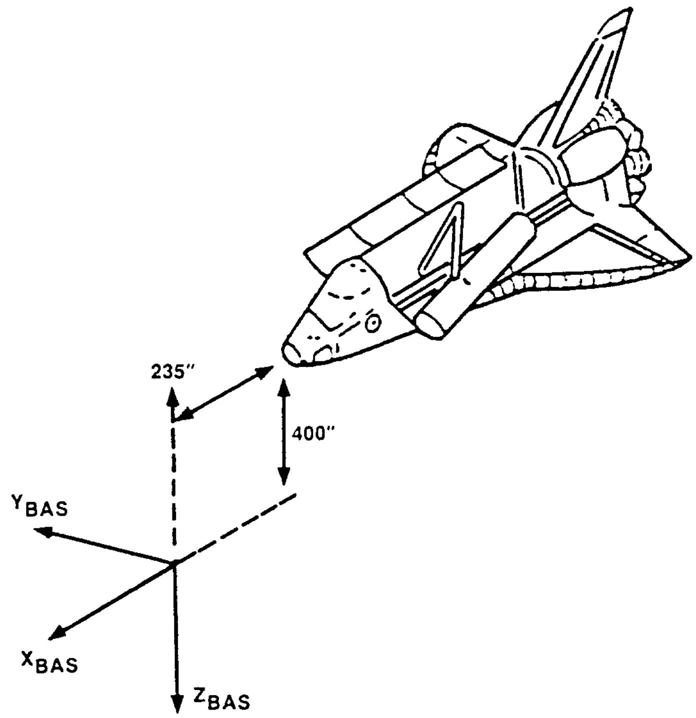


Figure 3-3.- Keel-mounted camera target location example.



NAME: Orbiter Body Axis System (OBAS).

ORIGIN: In the Orbiter plane of symmetry, 400 in. below the centerline of the cargo bay and 235 in. forward of the tip of the Orbiter nose fairing.

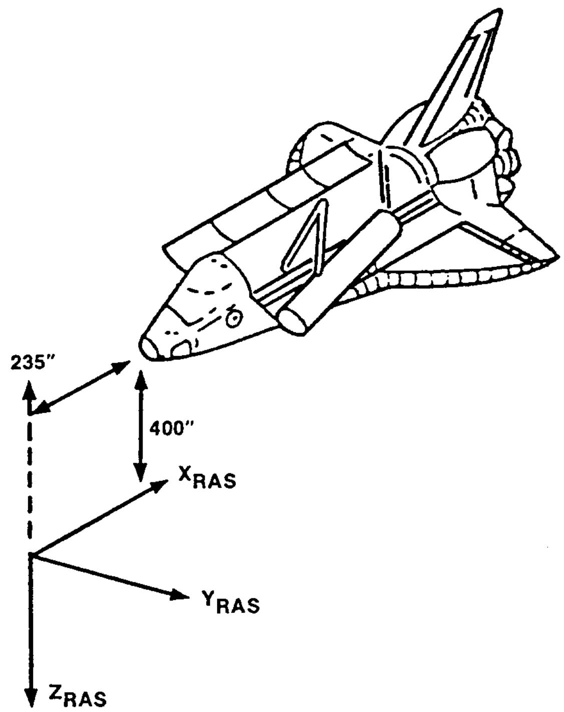
ORIENTATION: The X_{BAS} - axis is in the vehicle plane of symmetry, parallel to and 400 in. below the cargo bay centerline. Positive sense is from the tail of the vehicle toward the nose.

The Z_{BAS} - axis is in the vehicle plane of symmetry, perpendicular to the X_{BAS} - axis. Positive sense is down in the landing attitude.

The Y_{BAS} - axis completes a right-handed system.

CHARACTERISTICS: Right-handed, Cartesian.

Figure 3-4.- OBAS example.



NAME:	Orbiter Rotation Axis System (ORAS).
ORIGIN:	In the Orbiter plane of symmetry, 400 in. below the centerline of the cargo bay and 235 in. forward of the Orbiter nose fairing.
ORIENTATION:	The X_{RAS} - axis is in the vehicle plane of symmetry, parallel to and 400 in. below the cargo bay centerline. Positive sense is from the nose of the vehicle toward the tail. The Z_{RAS} - axis is in the vehicle plane of symmetry, perpendicular to the X_{RAS} - axis. Positive sense is down in the landing attitude. The Y_{RAS} - axis completes a right-handed system.
CHARACTERISTICS:	Right-handed, Cartesian.

Figure 3-5.- The ORAS.

4.0 EXAMPLES

The signature page (figure 4-1) and the preface (figure 4-2) are required with all data submissions made in response to this document.

PAYLOAD DATA PACKAGE ANNEX

(PAYLOAD NAME)

(DATE)

Date

____
PAYLOAD REPRESENTATIVE

Date

____
ANNEX MANAGER

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

Figure 4-1.- Signature page example.

PREFACE

This document contains the basic payload data on the (payload name) payload (abbreviation of name) and is issued as an annex to the Payload Integration Plan (PIP) for (payload name).

This annex is the single authoritative source for (payload name) payload data of the types designated herein. The payload is composed of the following major elements, located in the Orbiter cargo bay, and their respective configuration identification numbers are designated as follows: (to be supplied).

All data presented in this annex have been supplied and verified by the payload representative and his staff (or representatives if specified for each major element; e.g., spacecraft, booster, pallet, etc.). The weight data contained in this annex are also certified by the payload representative (as shown in figure 1-6) prior to each flight of the payload.

In case of any variation between this annex and the IP, the IP shall take precedence. Any requirements submitted in this document that are not within the scope of the PIP will not be considered binding on the NASA for implementation.

Comments and corrections to these data as well as requests for additional data should be directed to the United Space Alliance (USA) Annex Book Manager, [Book Manager Name], USA/USH-700E, 281-[insert appropriate phone number] or the following:

	Name	Address	Telephone
PAYLOAD REPRESENTATIVE			
PREPARED BY			

Figure 4-2.- Preface example.