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SATELLITE SERVICING PRICE ESTIMATION INSTRUCTION BOOKLET

prepared by

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FOREWORD

This report documents the results of a brief study to develop a possible methodology for estimating the price to non-U.S. Government users for satellite servicing. This study was conducted between November 1986 and January 1987 under Contract NAS9-17207 (Gordon Rysavy - Technical Monitor) as part of a follow-on effort to other studies performed under this contract. The results are intended to assist NASA planners in the development of a Satellite Services System Program Plan.

Stephen J. Hoffman served as the Project Manager for this effort with significant contributions by Deanna Limperes, Terri Ramlose, John Soldner, and Dan Spadoni.

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1. INTRODUCTION

The cost criteria for a satellite servicing mission from the customer's perspective were assessed in an earlier phase of this contract by distributing a detailed survey to individuals within both the civilian and military user groups. An objective of the questionnaire was to make the results available to NASA for consideration when formulating a pricing policy in this area. We have subsequently taken this study one step further by developing one possible price estimating methodology for **non-U.S. Government users**, based upon the desires of the user community and the official NASA guidelines at the time of the Challenger accident. Since an official satellite servicing pricing policy is still pending within NASA, the methodology presented here is only one of several potential paths the official policy may take.

One important result of our cost criteria survey is that non-U.S. Government users consider knowledge of the overall pricing policy more important than knowledge of the availability or capabilities of a servicing option. Consequently, the formulation of an official pricing policy is a high priority among non-U.S. Government users, since pricing alone may determine whether servicing will be done at all.

The NASA Retrieval/Revisit policy as presented in November 1985 pertains only to cooperative spacecraft, i.e., those spacecraft in Shuttle-compatible orbits (160 nmi x 28.5° inclination) that are specifically designed to be retrieved/serviced. Examples of cooperative spacecraft cited in the NASA presentation are EURECA, Leasecraft, and Omnistar. Examples of non-cooperative spacecraft include Long Duration Exposure Facility (LDEF), the Solar Maximum mission spacecraft, and the Hubble Space Telescope. Servicing missions to these non-cooperative spacecraft were to have been negotiated on a case-by-case basis. Based upon the desires of the user community, it is the intent of this document to provide a methodology whereby the user can estimate a rough order-of-magnitude price for any kind of servicing/retrieval/exchange mission, whether it is cooperative or non-cooperative.

The desires of the user community are reflected in the price estimating methodology presented in this report. First, the users requested fixed price ranges for each service or activity as a starting point for negotiation.

Second, the users would prefer to pay for only those services or activities used rather than one lump sum based upon the total time for the servicing mission. These two desires are reflected in the fixed price ranges for optional services developed later in this report. The methodology presented here assumes that NASA owns general purpose servicing hardware (e.g., satellite holding devices, propellant tankers, etc.) and that NASA has borne the development costs for this hardware. Any unique hardware will be supplied by the user, and associated costs will be additional to the estimate provided by this algorithm.

The costs quoted are all in **FY 1982 million dollars** (unless otherwise noted), and are taken from the **NASA Retrieval/Revisit Policy** as presented in November 1985, and also NASA document JSC-20109 "**National Space Transportation System Optional Services Pricing Manual**," dated October 1984.

Appendix A to this report contains a set of worksheets designed to help users ensure that they have included all factors in estimating costs for a satellite servicing mission. Appendix B includes completed price estimation worksheets for five sample missions.

2. PRICE ESTIMATION ALGORITHM

A strong desire was expressed by the user community for establishing satellite servicing prices as a minimum/maximum range for each service or activity offered, and then negotiating the final price (within that range) on a case-by-case basis. The objective of the following methodology is to provide the user with a rough order-of-magnitude estimate of the final price by applying minimum/maximum ranges for the appropriate servicing activities.

The total price for a satellite servicing mission can be approximated by the sum of three components:

1. The fixed price for mission planning (independent of spacecraft geometry)
2. The variable price for Shuttle transportation (dependent on spacecraft geometry)

3. The price for all other optional services (if required)

The methodology for estimating the price of each component is discussed in detail below.

Part I. Fixed Price for Mission Planning

The mission planning package covers a required set of services provided to a customer requesting transportation service to replace, retrieve, or service a previously deployed, orbiting payload. Specific tasks provided in this fixed-price package include as a minimum the following:

- Rendezvous/proximity operations
- Plume impingement and contamination analysis
- Ku-band rendezvous radar analysis
- Flight design
- Crew and ground personnel training
- Use of remote manipulator system
- Simulator time for mission planning, analysis, and training
- Payload berthing/stowing in the Orbiter

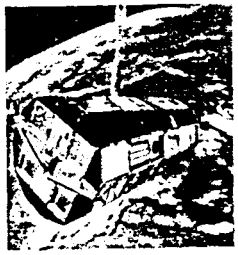
The price of the mission planning package depends on the individual user payload requirements; i.e., the servicing mission may be required in one of three degrees of complexity: simple, intermediate, and complex. The **simple mission planning package** generally applies to missions consisting of a routine repeat launch of the Orbiter to the payload orbit to retrieve the payload and return to the ground. This package uses standard flight design and crew activity procedures. The **intermediate mission planning package** generally applies to missions requiring payload servicing associated with the changeout of parts or the replenishment of consumables. The **complex mission planning package** would apply to a retrieval from a first-of-a-kind rendezvous orbit and/or to more extensive on-orbit payload support such as stationkeeping, payload observation, payload checkout, or payload verification (see Figure 1).

In general, NASA will schedule retrieval/revisit missions not sooner than six months after deployment, and will assign a 90-day retrieval window for

Figure 1

Example of activities associated with the categories of payload revisit

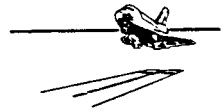
Simple



GRAPPLE PAYLOAD WITH REMOTE MANIPULATOR SYSTEM (RMS)

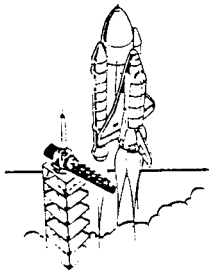
PLACE PAYLOAD INTO PAYLOAD BAY

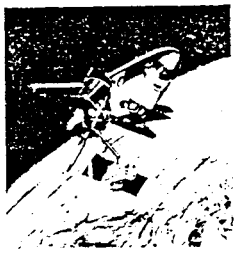
LAUNCH



LANDING

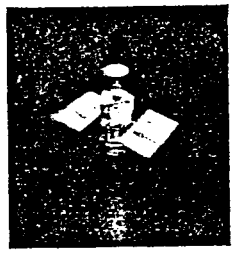
Intermediate





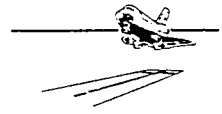
GRAPPLE PAYLOAD WITH RMS

PARTS CHANGEOUT WHILE PAYLOAD IS BERTHED IN PAYLOAD BAY



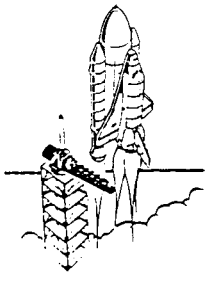
RELEASE PAYLOAD BACK INTO ORBIT

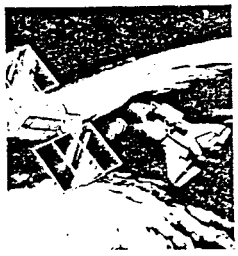
LAUNCH



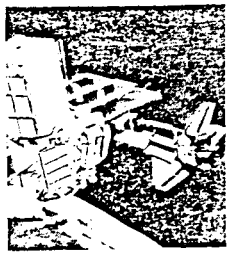
LANDING

Complex





ORBITER STATION-KEEPING WITH PAYLOAD

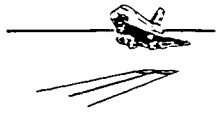


MANNED MANEUVERING UNIT (MMU) GRAPPLE WITH PAYLOAD

PARTS CHANGEOUT IN PAYLOAD BAY

RELEASE PAYLOAD BACK INTO ORBIT

LAUNCH



LANDING

planning flexibility. The customer will be required to maneuver the spacecraft to be serviced into the vicinity of the orbiter, i.e., 160 nmi and 28.5° inclination.

Part II. Variable Price for Shuttle Transportation

The user will be charged a percentage of the dedicated flight price for Shuttle transportation. The exact percentage charged is based upon the maximum of four weight and length load factors for both the up and down legs of the mission. The **up-leg length factor** is calculated in the same way as the standard Shuttle pricing policy, i.e., payload length (plus 6 inches for dynamic clearance) as a fraction of the cargo bay length (60 feet). The **up-leg weight factor*** is also calculated in the same manner as the standard Shuttle pricing policy, i.e., payload weight as a fraction of the cargo bay weight capability, but the up-weight includes an additional 1,500 pounds of propellant for rendezvous. The down-leg provisions include no charge for cargo up to 20,000 pounds, and a dedicated flight price for cargo of 32,000 pounds, the maximum down-weight capacity. The **down-leg weight factor** is calculated as a linear variation in price for cargo weights between these limits. For a payload length of 20 or more feet, the **down-leg length factor** is calculated using the standard method. For payload length less than 20 feet, a discount is applied as follows:

$$\text{down-leg length factor} = \frac{\text{down-length}}{60} \times \frac{\text{down-length}}{20}$$

The Shuttle transportation charge factor is the maximum of these four load factors divided by 0.75. (The effective charge factor is never greater than 1.0.) The transportation charge is the price of a dedicated flight multiplied by the calculated charge factor. As of January 1987, a dedicated flight launched after FY1988 will cost 74 million dollars (FY82 dollars).

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* See page 12 for modifications to this calculation for missions to nonstandard altitudes.

Part III. Optional Services

The following sections contain fixed prices and rates for services, in addition to the standard Space Shuttle services, commonly required by NSTS customers for a wide variety of satellite servicing missions. The fixed prices charged for the optional services listed in this section are taken from the "National Space Transportation System Optional Service Pricing Manual" (JSC-20109, October 1984), and the reader is referred there for further details.

1. Extravehicular Activity - Each NSTS mission includes, as a standard service, the extravehicular mobility unit (EMU) and support hardware for two EVA crew members to support one Orbiter contingency EVA and two payload support system contingency EVAs. All payload EVA requirements exceeding the standard service EVA capability are considered optional services; i.e., **all planned payload EVAs are charged as an optional service.** A planned EVA requires extensive crew training and includes the cost of EMU refurbishment and expendables.

   Requirements for EVA are divided into three levels of complexity: simple, intermediate, and complex, as defined in Table 1. In addition to the costs quoted here, any development costs of new payload-unique tools and equipment will be borne by the user.

Table 1
COMPLEXITIES OF EVA

Complexity	Characteristics	Costs (FY 1982 $M)
Simple	• No unique tools, mockups, mobility aids • Existing procedures and techniques • One 2-person EVA	.424
Intermediate	• New payload-unique tools and equipment • Greater modification to existing procedures and techniques • One or two 2-person EVAs	.567
Complex	• New payload-unique tools and equipment • Mobility aids • Access or restraint problems • New, one-of-a-kind procedures and techniques • One or two 2-person EVAs	1.077

Ref: JSC-20109, p. 8

2. Payload Specialist - The payload customer will notify NASA of his requirement/desire to fly a payload specialist. It is then the decision of NASA Headquarters to determine whether a payload specialist position will be available on any given STS flight, to award that position to a specific payload customer, and to decide if the customer will be charged for the flight of the payload specialist.

The prices quoted below are for NASA-provided **non-payload-related** training which will provide experience in those flight crew tasks necessary for any orbiter crew member to function effectively and safely. The customer is responsible for providing the payload specialist with any payload training required, at a cost additional to the price quoted below.

	FY 1982 $M
Payload Specialist	
Non-Spacelab	.071
Spacelab	.086

3. Additional STS Support - One day of on-orbit operations is included in the standard services to a payload customer as part of the basic Space Shuttle transportation charge. For dedicated flights, one day of on-orbit operations is defined as a 24-hour period from launch to landing. For shared flights, a theoretical mission duration for each payload will be determined, based upon how much time the individual payload would require if it were on a dedicated flight. This theoretical mission duration will define the time accountable for each payload. Serial impact time is the number of hours added to the standard mission timeline due to a customer request for additional ground processing time at the launch site for payload processing. An additional day on orbit is defined as the continued use of the orbiter and ground facilities to maintain mission support posture for an extra 24-hour period. Any situation needing more than the one standard day of STS on-orbit support or requiring additional serial hours of payload ground processing will dictate the purchase of additional STS support optional service at the rates quoted below:

	FY 1982 $M
Additional STS Support	
Serial Impact Time	.028/hour
Additional Days on Orbit	.807/day

4. Payload Engineering Analyses - A variety of engineering services are available to the payload user community on a fixed price basis. Fixed-price **loads analyses** and design **thermal analyses** that cover all phases of the mission may be obtained through NASA. Depending on the optional services selected (or required) and the scope and content of the analyses performed, the prices charged can be estimated by the complexity of the mission:

	FY 1982 $M
Payload Engineering Analyses	
Simple	.050
Intermediate	.200
Complex	.500

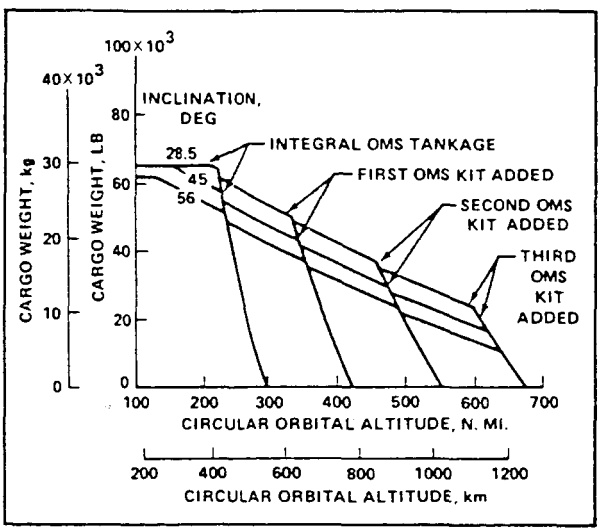
5. Payload Mission Planning Analyses - The price of all mission planning activities to produce a flight profile is assumed to be included in the fixed price mission planning package already discussed in this document. Activities included in this package are:

- Flight profile integration
- Ascent analysis
- Attitude and pointing
- Proximity operations
- Payload handling
- Rendezvous analysis
- Navigation analysis
- Consumables analysis
- Descent analysis

For this preliminary pricing methodology, this activity is identified in the worksheets as a no-cost (N/C) item.

6. Nonstandard Altitude - The standard operational altitude for an orbiter launch from KSC is 160 nautical miles. Customers requesting nonstandard altitudes (i.e., servicing on non-cooperative spacecraft) will be charged for the additional mission planning required. Customers requiring a nonstandard altitude will also be charged the transportation price for delivery of the payload to the required orbit. This transportation price is based on the loss of vehicle performance in launching to the higher altitude. For the purposes of a rough order-of-magnitude price estimate, calculate the **up-leg weight factor** by replacing the 65,000 in the denominator with the appropriate value from the figure below. The corresponding increase in the Shuttle transportation charge reflects the "surcharge" for the transportation cost to the nonstandard altitude.

	FY 1982 $M
Nonstandard Altitude	
Mission Planning	.061



Maximum cargo weights at various circular orbital altitudes for flights with delivery only.

7. Nonstandard Inclination - The standard inclination for an orbiter launch from KSC is 28.5°. Customers requesting a nonstandard inclination will be charged for the additional mission planning required. The fixed price includes the charge for planning a nonstandard inclination for a dedicated flight due to the low probability that other payloads on a shared flight would require the same unique nonstandard inclination.

	FY 1982 $M
Nonstandard Inclination	
Mission Planning	0.402

8. Launch Site Support Services - Launch site support services and facilities not included in the standard service price are available at KSC. For satellite servicing missions these activities may include some, or all, of the following items which pertain specifically to deployable satellites.

Fixed-price optional services package	Scope of service
1. Aircraft support	Use of skid strip; loading/unloading
2. Payload processing facility	8-week occupancy
3. Hazardous processing facility	1-week occupancy
4. Transportation	Intrasite using existing equipment
5. Handling ground-support equipment	Use of existing equipment
6. Communications	Between customer's ground station/HPF/CITE/pad
7. Data analysis	None
8. Security	Normal 24-hr perimeter escort, 8-hr facility
9. Environmental control	See K-STSM-14.1 for specific facility
10. Propellants, gases, ordnance	Minor quantities of liquid nitrogen, gaseous hydrogen, and gaseous nitrogen; hazardous disposal
11. Sampling and analysis	As many as 25 samples
12. Photographic services	As many as 100 black-and-white photographs and prints and 61 m (200 ft) of 16-mm color film
13. Office space	Pro rata basis per facility assignment
14. Safety	Hazardous operations monitoring
15. Emergency medical and fire protection	Provided
16. Test equipment	Use as available
17. Calibration	As many as 10 components can be calibrated on a noninterference basis
18. Technical shops	As many as 10 hr of unplanned shop support available on a noninterference basis
19. Hazardous operations suits	5 persons for two 8-hr shifts
20. Propellant handling and storage	Storage and delivery of propellants to HPF
21. Ordnance handling and storage	3-month storage and delivery to HPF
22. Technical library	Use included
23. Launch site support management	Coordination and planning of support

For rough order-of-magnitude estimation purposes the price charged for launch site support services can be approximated by the degree of complexity of the mission:

	FY 1982 $M
Launch Site Support Services	
Simple	0.100
Intermediate	0.300
Complex	0.600

This approach and corresponding charges were derived from the "NSTS Optional Services Pricing Manual." It is anticipated that all servicing missions will incur a launch site support service charge.

APPENDIX A

SATELLITE SERVICING PRICE ESTIMATION WORKSHEETS

The worksheets on the following pages are designed to help users ensure that they have included all factors in estimating costs for a satellite servicing mission. This is not an official NASA form, but is rather an estimate based on the best current information.

SATELLITE SERVICING PRICE ESTIMATION WORKSHEET
(All prices FY82 $M)

PART I. FIXED PRICE FOR MISSION PLANNING

Mission Complexity	Price
a. Simple	1.4
b. Intermediate	1.7
c. Complex	2.1

Select a, b, or c(*) and enter price here → [ ] (I)

(*) See instruction booklet page 3 to determine mission complexity category.

PART II. VARIABLE PRICE FOR SHUTTLE TRANSPORTATION

A. Up-Leg Provisions

1. Enter payload length (ft): _____ (A1)

2. Calculate length load factor: $\frac{A1 + 0.5}{60}$ = _____ (A2)

3. Enter payload weight (lbm): _____ (A3)

4. Calculate weight load factor: $\frac{A3 + 1500}{65000}$ = _____ (A4)

B. Down-Leg Provisions

5. Enter payload length (ft): _____ (B5)

6. Calculate length load factor:

   if B5 $\geq$ 20: $\frac{B5 + 0.5}{60}$ = _____

   or

   if B5 < 20: $\frac{B5}{60} \cdot \frac{B5}{20}$ = _____

   } _____ (B6)

7. Enter payload weight (lbm): _____ (B7)

8. Calculate weight load factor: $\frac{B7 - 20000}{32000} \times 0.75$ = _____ (B8)

C. Price Computation

9. Enter maximum of A2, A4, B6 or B8 = _____ (C9)

10. Calculate charge factor: C9 ÷ 0.75 = _____ (C10)
    If C10 > 1.0, set C10 = 1.0
    Enter 1.0 for a dedicated mission.

11. Transportation Charge = C10 • 74 = ⟶ [ ] (II)

PART III. OPTIONAL SERVICES

1.	Extravehicular Activity	_____
2.	Payload Specialist	_____
3.	Additional STS Support	_____
4.	Payload Engineering Analysis	_____
5.	Payload Mission Planning Analysis	N/C
6.	Nonstandard Altitude	_____
7.	Nonstandard Inclination	_____
8.	Launch Site Support Services	_____

[ ] (III)

Total Price (FY'82 $M) = (I) + (II) + (III) = [ ]

To convert FY82 $ to FY86 $, multiply by 1.165

APPENDIX B

SAMPLE SATELLITE SERVICING MISSIONS

PRICE ESTIMATION CALCULATIONS

Completed price estimation worksheets are included for five sample satellite servicing missions in this section. The missions included in this set cover not only the upper and lower extremes of mission complexity (and thus cost), but also are representative of typical, well-defined servicing missions. Reference data for various servicing hardware are included in Table B-1.

Table B-1

SERVICING HARDWARE REFERENCE DATA

HARDWARE NAME	DRY WT (LB)	MAX WET WT (LB)	PAYLOAD BAY LENGTH (FT)
PAYLOAD BERTHING SYSTEM	1,000	1,000	4.75
FSS A' CRADLE	3,300	3,300	1.5
MONOPROPELLANT TANKER (OSCRS Ref. Design)	2,792	7,792	3.5
ORU CARRIER (Spacelab Pallet)	2,800	2,800	10
RMS	905	905	N/A
MFR	102	102	N/A
MODULE SERVICING TOOL	70.5	70.5	N/A
MMU	338	338	N/A
MMU SUPPORT STATION	253	253	N/A
TPAD	106.5	106.5	N/A
ORU CARRIER (Payload Bay Sill)	75 (EST)	75 (EST)	4.3
MISC. HAND TOOLS AND LIGHTING FIXTURES	50 (APPROX)	50 (APPROX)	N/A

SAMPLE MISSION #1: LARGE OBSERVATORY SPACECRAFT

- **SCENARIO:** An observatory-type spacecraft is scheduled for routine servicing including propellant resupply and exchange of a defective module. Two EVAs are required to connect and disconnect the propellant transfer line and to exchange the module. This module is of the MMS-type and is designed for on-orbit replacement. The spacecraft itself is cooperative and will use its propulsion system to meet the STS in a designated location. This is not a dedicated mission.

- **ADDITIONAL SPACECRAFT DATA**

  Vehicle Mass = 14,000 kg (Dry), 16,000 kg (Wet)

  Propellant Type = Hydrazine Monopropellant

  Propellant Mass Required = 1,500 kg (additional 500 kg held in reserve)

  Module Dimensions (LxWxH in cm) = 120 x 50 x 140

  Module Mass = 500 kg

  Mechanical Interfaces Available = RMS Grapple Fixture, FSS 3-point Latch

  Electrical Interfaces Available = 28 V DC; 1.00 kw; Standard FSS Connector

  Data/Communications Interfaces Available = 1 kbps Command Rate; Standard FSS Connector

  Fluid Interfaces Available = Fairchild Fluids Connector

  Special Considerations = Stow and Redeploy HGA and Solar Arrays

- **ON-ORBIT TIME REQUIRED** = 48 hours (2 days)

- **SERVICING HARDWARE REQUIRED**

	Length (ft)	Weight (lbm)
(1) Payload Berthing System	4.75	1000
(2) Monopropellant Tanker	3.5	7202
(3) RMS		905
(4) MFR		102
(5) Misc. Hand Tools and Lighting Fixtures		50
(6) ORU Carrier and Gas-type Sill Fixture		75
(7) Module Servicing Tool (for MMS Module)		---
(8) Module		1103
	8.25	10437

SATELLITE SERVICING PRICE ESTIMATION WORKSHEET
(All prices FY82 $M)

PART I. FIXED PRICE FOR MISSION PLANNING

Mission Complexity	Price
a. Simple	1.4
➤ b. Intermediate	1.7
c. Complex	2.1

Select a, b, or c(*) and enter price here → 1.7 (I)

(*) See instruction booklet page 3 to determine mission complexity category.

PART II. VARIABLE PRICE FOR SHUTTLE TRANSPORTATION

A. Up-Leg Provisions

1. Enter payload length (ft): 8.25 (A1)

2. Calculate length load factor: $\frac{A1 + 0.5}{60}$ = 0.146 (A2)

3. Enter payload weight (lbm): 10437 (A3)

4. Calculate weight load factor: $\frac{A3 + 1500}{65000}$ = 0.184 (A4)

B. Down-Leg Provisions

5. Enter payload length (ft): _____ (B5)

6. Calculate length load factor:

   if B5 $\geq$ 20: $\frac{B5 + 0.5}{60}$ = _____

   or

   if B5 < 20: $\frac{B5}{60} \cdot \frac{B5}{20}$ = _____

   _____ (B6)

7. Enter payload weight (lbm): _____ (B7)

8. Calculate weight load factor: $\frac{B7 - 20000}{32000} \times 0.75$ = _____ (B8)

C. Price Computation

9. Enter maximum of A2, A4, B6 or B8 = 0.184 (C9)

10. Calculate [illegible] factor: C9 ÷ 0.75 = 0.245 (C10)
    If C10 > 1.0, set C10 = 1.0
    Enter 1.0 for a dedicated mission.

11. Transportation Charge = C10 • 74 = → 18.1 (II)

PART III. OPTIONAL SERVICES

1.	Extravehicular Activity	0.567
2.	Payload Specialist	---
3.	Additional STS Support	0.807
4.	Payload Engineering Analysis	0.200
5.	Payload Mission Planning Analysis	N/C
6.	Nonstandard Altitude	---
7.	Nonstandard Inclination	---
8.	Launch Site Support Services	0.300

1.9 (III)

Total Price (FY'82 $M) = (I) + (II) + (III) = 21.7

To convert FY82 $ to FY86 $, multiply by 1.165

SAMPLE MISSION #2: LARGE OBSERVATORY SPACECRAFT: DEDICATED MISSION

- **SCENARIO:** An observatory-type spacecraft is scheduled for routine servicing consisting of an exchange of three modules. Two EVAs will be required to complete all activities. The spacecraft is non-cooperative requiring the STS to rendezvous at 600 km (320 nmi) altitude. The spacecraft will require a reboost to 700 km (380 nmi) altitude upon completion of servicing activities. This is a dedicated mission.

- **ADDITIONAL SPACECRAFT DATA**

  Vehicle Mass = 11,600 kg (Dry)

  Propulsion System = None

Module	Dimensions (cm)	Mass (kg)
1	58 x 30 x 28	24
2	61 x 25 x 36	62
3	91 x 91 x 221	318

  Mechanical Interfaces Available = RMS Grapple Fixture, FSS 3-point Latch

  Electrical Interfaces Available = 28 V DC, 1.5 kw, Standard FSS Connector

  Data/Communications Interfaces Available = 1 kbps Command Rate; Standard FSS Connector

  Special Considerations = Possible Manual Stow and Redeploy of HGAs and Solar Arrays

- **ON-ORBIT TIME REQUIRED** = 120 hours (5 days)

- **SERVICING HARDWARE REQUIRED**

	Length (ft)	Weight (lbm)
(1) ORU Carrier (Spacelab Pallet)		
(2) FSS A' Cradle	DEDICATED MISSION	
(3) RMS		
(4) MFR		
(5) Misc. Hand Tools and Lighting Fixtures		

SATELLITE SERVICING PRICE ESTIMATION WORKSHEET
(All prices FY82 $M)

PART I. FIXED PRICE FOR MISSION PLANNING

Mission Complexity	Price
a. Simple	1.4
b. Intermediate	1.7
➤ c. Complex	2.1

Select a, b, or c(*) and enter price here → 2.1 (I)

(*) See instruction booklet page 3 to determine mission complexity category.

PART II. VARIABLE PRICE FOR SHUTTLE TRANSPORTATION

A. Up-Leg Provisions

1. Enter payload length (ft): _____ (A1)

2. Calculate length load factor: $\frac{A1 + 0.5}{60}$ = _____ (A2)

3. Enter payload weight (lbm): _____ (A3)

4. Calculate weight load factor: $\frac{A3 + 1500}{65000}$ = _____ (A4)

B. Down-Leg Provisions

5. Enter payload length (ft): _____ (B5)

6. Calculate length load factor:

   if B5 $\geq$ 20: $\frac{B5 + 0.5}{60}$ = _____

   or

   if B5 < 20: $\frac{B5}{60} \cdot \frac{B5}{20}$ = _____

   _____ (B6)

7. Enter payload weight (lbm): _____ (B7)

8. Calculate weight load factor: $\frac{B7 - 20000}{32000} \times 0.75$ = _____ (B8)

C. Price Computation

9. Enter maximum of A2, A4, B6 or B8 = _____ (C9)

10. Calculate charge factor: C9 ÷ 0.75 = 1.0 (C10)
    If C10 > 1.0, set C10 = 1.0
    Enter 1.0 for a dedicated mission.

11. Transportation Charge = C10 • 74 = → 74.0 (II)

PART III. OPTIONAL SERVICES

1.	Extravehicular Activity	1.077
2.	Payload Specialist	---
3.	Additional STS Support	3.228
4.	Payload Engineering Analysis	0.500
5.	Payload Mission Planning Analysis	N/C
6.	Nonstandard Altitude	---
7.	Nonstandard Inclination	---
8.	Launch Site Support Services	0.600

5.4 (III)

Total Price (FY'82 $M) = (I) + (II) + (III) = 81.5

To convert FY82 $ to FY86 $, multiply by 1.165

SAMPLE MISSION #3: MAN-TENDED RESEARCH FACILITY

- **SCENARIO:** A man-tended (i.e., pressurized) spacecraft is scheduled for a routine servicing flight which includes the exchange of a logistics module and IVA activities by the crew (in the Shuttle and the research facility). No EVA activity is anticipated. The "fresh" logistics module contains raw materials and other consumables. The returning logistics module contains finished products. Both modules are identical in terms of mass, dimensions, and interfaces. These modules are designed to be exchanged using only the RMS. Sufficient payload bay space must be reserved for two modules and will be utilized during the exchange process. The vehicle has no propulsion system and is thus non-cooperative. This is <u>not</u> a dedicated mission.

- **ADDITIONAL SPACECRAFT DATA**

  Vehicle Mass = 15,000 kg (est)

  Propulsion System = None (i.e., non-cooperative)

  Logistics Module Dimensions = 14.5 ft dia. x 8.5 ft length

  Logistics Module Mass (wet) = 8,000 lbm (3,600 kg)

  Mechanical Interfaces Available = RMS Grapple Fixture;
  Special Airlock Adapter

  Electrical Interfaces Available = 28 V DC, 2.00 kw, Standard FSS Connector

  Data/Communications Interfaces Available = Spacelab Data Bus

  Special Considerations = Circular Orbit at 250 nmi (460 km)

- **ON-ORBIT TIME REQUIRED** = 96 hours (4 days)

- **SERVICING HARDWARE REQUIRED**

	Length (ft)	Weight (lbm)
(1) Vehicle-unique Docking Adapter and Airlock (Customer-supplied) Mass = 800 kg (est)	10.0	1764
(2) RMS	---	905
(3) Misc. Hand Tools and Lighting Fixtures	---	50
(4) Logistics Module (Room for 2 in cargo bay)	17.0	8000
	27.0	10719

SATELLITE SERVICING PRICE ESTIMATION WORKSHEET
(All prices FY82 $M)

PART I. FIXED PRICE FOR MISSION PLANNING

Mission Complexity	Price
a. Simple	1.4
➤ b. Intermediate	1.7
c. Complex	2.1

Select a, b, or c(*) and enter price here → 1.7 (I)

(*) See instruction booklet page 3 to determine mission complexity category.

PART II. VARIABLE PRICE FOR SHUTTLE TRANSPORTATION

A. Up-Leg Provisions

1. Enter payload length (ft): 27.0 (A1)

2. Calculate length load factor: $\frac{A1 + 0.5}{60}$ = 0.458 (A2)

3. Enter payload weight (lbm): 10719 (A3)

4. Calculate weight load factor: (nonstandard altitude) $\frac{A3 + 1500}{40000}$ = 0.305 (A4)

B. Down-Leg Provisions

5. Enter payload length (ft): 27.0 (B5)

6. Calculate length load factor:

   if B5 $\geq$ 20: $\frac{B5 + 0.5}{60}$ = 0.458

   or

   if B5 < 20: $\frac{B5}{60} \cdot \frac{B5}{20}$ = _____

   } 0.458 (B6)

7. Enter payload weight (lbm): 10719 (B7)

8. Calculate weight load factor: $\frac{B7 - 20000}{32000} \times 0.75$ = 0 (B8)

C. Price Computation

9. Enter maximum of A2, A4, B6 or B8 = 0.458 (C9)

10. Calculate charge factor: C9 ÷ 0.75 = 0.611 (C10)
    If C10 > 1.0, set C10 = 1.0
    Enter 1.0 for a dedicated mission.

11. Transportation Charge = C10 • 74 = → **45.2** (II)

PART III. OPTIONAL SERVICES

1.	Extravehicular Activity	0
2.	Payload Specialist	0.142
3.	Additional STS Support	2.421
4.	Payload Engineering Analysis	0.200
5.	Payload Mission Planning Analysis	N/C
6.	Nonstandard Altitude	0.061
7.	Nonstandard Inclination	---
8.	Launch Site Support Services	0.300

3.1 (III)

Total Price (FY'82 $M) = (I) + (II) + (III) = 50.0

To convert FY82 $ to FY86 $, multiply by 1.165

SAMPLE MISSION #4: UNMANNED MPS SPACECRAFT

- **SCENARIO:** An unmanned MPS factory-type spacecraft is scheduled for routine servicing consisting of an exchange of logistics modules, the replacement of an MMS-type power control ORU and a resupply of the on-board propulsion system. Two EVAs are required to connect and disconnect the propellant transfer line and replace the ORU. The logistics module will be exchanged using the RMS. With an on-board propulsion system, the spacecraft is cooperative. This is a dedicated mission.

- **ADDITIONAL SPACECRAFT DATA**

  Vehicle Mass = 9,000 kg (Wet)

  Propellant Type = Hydrazine Monopropellant

  Propellant Mass Required = 3,000 kg

Module	Dimensions	Mass
Logistics	14.5 ft dia. x 20 ft	20,000 lb (9070 kg)
Power Control	47" x 20" x 55"	1,100 lb (500 kg)

  Mechanical Interfaces Available = RMS Grapple Fixture, FSS 3-point Latch

  Electrical Interfaces Available = 28 V DC, 1.0 kw, Standard FSS Connector

  Data/Communications Interfaces Available = 1 kbps Command, Standard FSS Connector

  Fluid Interfaces Available = Fairchild Fluids Connector

- **ON-ORBIT TIME REQUIRED** = 96 hours (4 days)

- **SERVICING HARDWARE REQUIRED**

	Length (ft)	Weight (lbm)
(1) FSS A' Cradle		
(2) Monopropellant Tanker (OSCRS Ref. Design)		
(3) RMS		
(4) MFR	DEDICATED MISSION	
(5) ORU Carrier (GAS-type Sill Fixture)		
(6) Module Servicing Tool		
(7) Misc. Hand Tools and Lighting Fixtures		

SATELLITE SERVICING PRICE ESTIMATION WORKSHEET
(All prices FY82 $M)

PART I. FIXED PRICE FOR MISSION PLANNING

	Mission Complexity	Price
	a. Simple	1.4
➤	b. Intermediate	1.7
	c. Complex	2.1

Select a, b, or c(*) and enter price here ⟶ [1.7] (I)

(*) See instruction booklet page 3 to determine mission complexity category.

PART II. VARIABLE PRICE FOR SHUTTLE TRANSPORTATION

A. Up-Leg Provisions

1. Enter payload length (ft): _____ (A1)

2. Calculate length load factor: $\frac{A1 + 0.5}{60}$ = _____ (A2)

3. Enter payload weight (lbm): _____ (A3)

4. Calculate weight load factor: $\frac{A3 + 1500}{65000}$ = _____ (A4)

B. Down-Leg Provisions

5. Enter payload length (ft): _____ (B5)

6. Calculate length load factor:

   if B5 $\geq$ 20: $\frac{B5 + 0.5}{60}$ = _____

   or

   if B5 < 20: $\frac{B5}{60} \cdot \frac{B5}{20}$ = _____

   } _____ (B6)

7. Enter payload weight (lbm): _____ (B7)

8. Calculate weight load factor: $\frac{B7 - 20000}{32000} \times 0.75$ = _____ (B8)

C. Price Computation

9. Enter maximum of A2, A4, B6 or B8 = _____ (C9)

10. Calculate charge factor: C9 ÷ 0.75 = 1.0 (C10)
    If C10 > 1.0, set C10 = 1.0
    Enter 1.0 for a dedicated mission.

11. Transportation Charge = C10 • 74 = → 74.0 (II)

PART III. OPTIONAL SERVICES

1.	Extravehicular Activity	0.567
2.	Payload Specialist	---
3.	Additional STS Support	2.421
4.	Payload Engineering Analysis	0.200
5.	Payload Mission Planning Analysis	N/C
6.	Nonstandard Altitude	---
7.	Nonstandard Inclination	---
8.	Launch Site Support Services	0.600

3.8 (III)

Total Price (FY'82 $M) = (I) + (II) + (III) = 79.5

To convert FY82 $ to FY86 $, multiply by 1.165

SAMPLE MISSION #5: SMALL OBSERVATORY SPACECRAFT

- **SCENARIO:** A preplanned servicing mission to an uncooperative satellite will replace two defective modules. Two EVAs will be required to complete this mission: the first to retrieve the spacecraft (using an astronaut with an MMU) and the second to complete the servicing. Assume for this example that this is not a dedicated flight and that the spacecraft is at the nominal STS orbit altitude.

- **ADDITIONAL SPACECRAFT DATA**

  Vehicle Mass = 5,000 lb (2,270 kg)

  Propulsion System = None

Module	Dimensions	Mass
ACS	47" x 20" x 55"	1,100 lb (500 kg)
Main Electronics Box	(Negligible)	100 lb (45 kg)

  Mechanical Interfaces Available = RMS Grapple Fixture, FSS 3-point Latch

  Electrical Interfaces Available = 28 V DC, 0.25 kw, Standard FSS Connector

  Data/Communications Interfaces Available = 32 bps Command, Standard FSS Connector

- **ON-ORBIT TIME REQUIRED** = 96 hours (4 days)

- **SERVICING HARDWARE REQUIRED**

	Length (ft)	Weight (lbm)
(1) FSS A' Cradle	1.5	3300
(2) RMS	---	905
(3) MFR	---	102
(4) Module Servicing Tool	---	70.5
(5) MMU + Support Station	---	591
(6) TPAD		106.5
(7) Misc. Hand Tools and Lighting Fixtures	---	50.0
(8) ACS Module	3.9	1100
(9) Main Electronics Box	---	100
	5.4	6325

SATELLITE SERVICING PRICE ESTIMATION WORKSHEET
(All prices FY82 $M)

PART I. FIXED PRICE FOR MISSION PLANNING

Mission Complexity	Price
a. Simple	1.4
b. Intermediate	1.7
➤ c. Complex	2.1

Select a, b, or c(*) and enter price here → 2.1 (I)

(*) See instruction booklet page 3 to determine mission complexity category.

PART II. VARIABLE PRICE FOR SHUTTLE TRANSPORTATION

A. Up-Leg Provisions

1. Enter payload length (ft): 5.4 (A1)

2. Calculate length load factor: $\frac{A1 + 0.5}{60}$ = 0.098 (A2)

3. Enter payload weight (lbm): 6325 (A3)

4. Calculate weight load factor: $\frac{A3 + 1500}{65000}$ = 0.120 (A4)

B. Down-Leg Provisions N/A

5. Enter payload length (ft): _____ (B5)

6. Calculate length load factor:

if B5 $\geq$ 20: $\frac{B5 + 0.5}{60}$ = _____

if B5 < 20: $\frac{B5}{60} \cdot \frac{B5}{20}$ = _____

_____ (B6)

7. Enter payload weight (lbm): _____ (B7)

8. Calculate weight load factor: $\frac{B7 - 20000}{32000} \times 0.75$ = _____ (B8)

C. Price Computation

9. Enter maximum of A2, A4, B6 or B8 = 0.120 (C9)

10. Vehicle charge factor: C9 ÷ 0.75 = 0.160 (C10)
If C10 > 1.0, set C10 = 1.0
Enter 1.0 for a dedicated mission.

11. Transportation Charge = C10 • 74 = 11.8 (II)

PART III. OPTIONAL SERVICES

1.	Extravehicular Activity	1.077
2.	Payload Specialist	---
3.	Additional STS Support	2.421
4.	Payload Engineering Analysis	0.500
5.	Payload Mission Planning Analysis	N/C
6.	Nonstandard Altitude	---
7.	Nonstandard Inclination	---
8.	Launch Site Support Services	0.600

4.6 (III)

Total Price (FY'82 $M) = (I) + (II) + (III) = 18.5

To convert FY82 $ to FY86 $, multiply by 1.165