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OPERATIONAL COST ESTIMATES SPACE SHUTTLE

PREPARED BY THE
SUBCOMMITTEE ON SPACE SCIENCE
AND APPLICATIONS
OF THE
COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-FOURTH CONGRESS
SECOND SESSION
Serial MMM



DECEMBER 1976

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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., December 1976.

HON. OLIN E. TEAGUE,
*Chairman, Committee on Science and Technology,
House of Representatives, Washington, D.C.*

DEAR MR. CHAIRMAN: I am forwarding herewith a report prepared by NASA entitled "Operational Cost Estimates—Space Shuttle". This report is part of the continuing oversight activity of the Subcommittee.

As you know, at the outset of the Space Shuttle development program, the National Aeronautics and Space Administration made specific commitments for the program. Key among these commitments was to provide an operational system of five orbiter vehicles with an out-of-pocket operating cost of \$10.5 million per flight (1971 dollars). As the program has progressed, NASA has refined the estimates associated with these commitments and has recently proposed a pricing or "reimbursement" policy for the Space Shuttle operational flights. This report details these estimates as currently defined by NASA, and summarizes the evolution of the pricing. The companion volume, previously submitted to you entitled "Space Shuttle—1977" details the current cost, performance, and schedule aspects of the Space Shuttle development program.

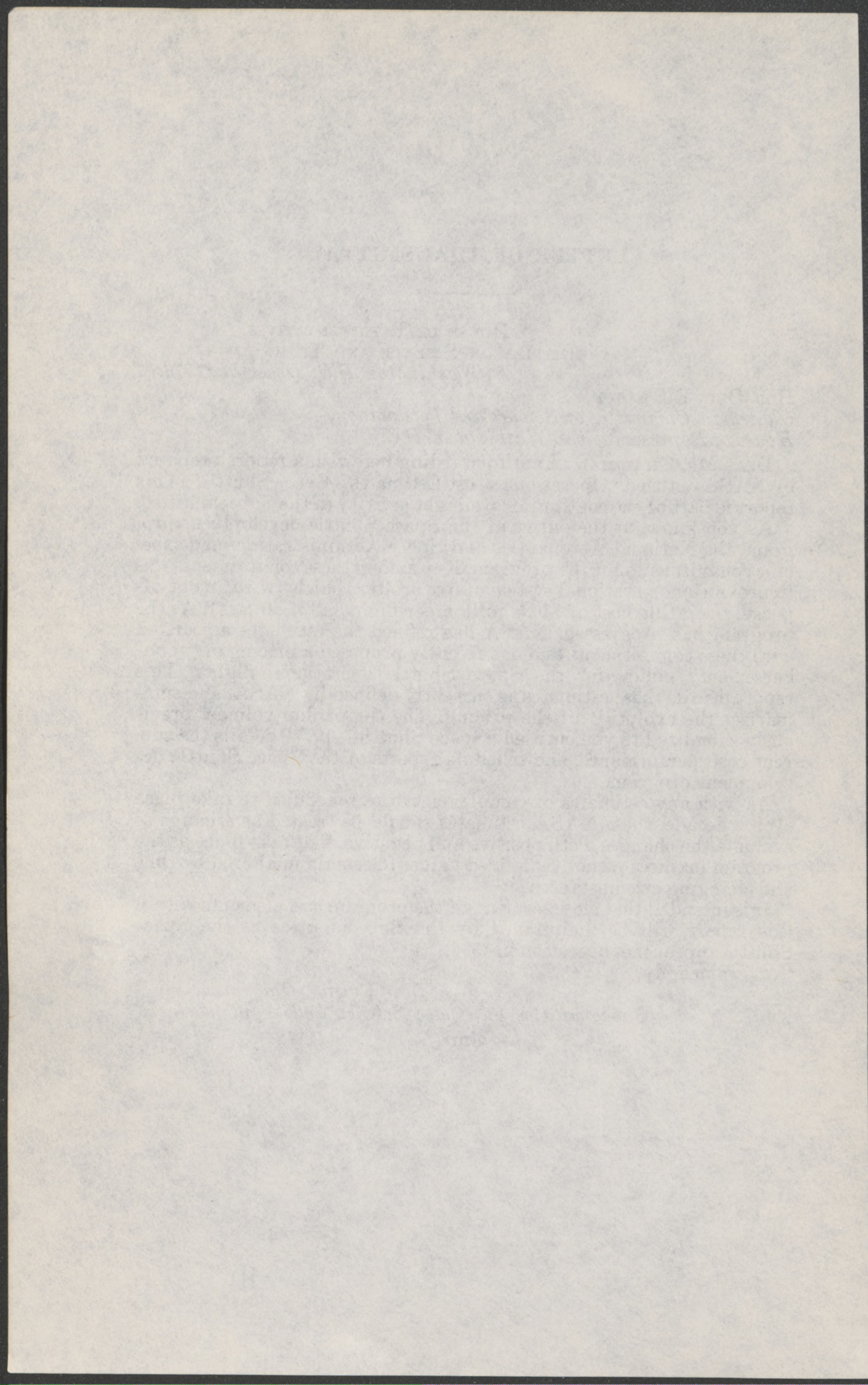
As with any estimates of complex activities scheduled to take place over a decade, these NASA estimates should be treated as a gauge to evaluate the changes, both positive and negative, that take place as the program matures rather than fixed values to remain unaltered by time and changing circumstances.

It is intended that close scrutiny of the program cost elements within this report will be maintained by the Subcommittee as the Space Shuttle approaches operation in 1980.

Sincerely,

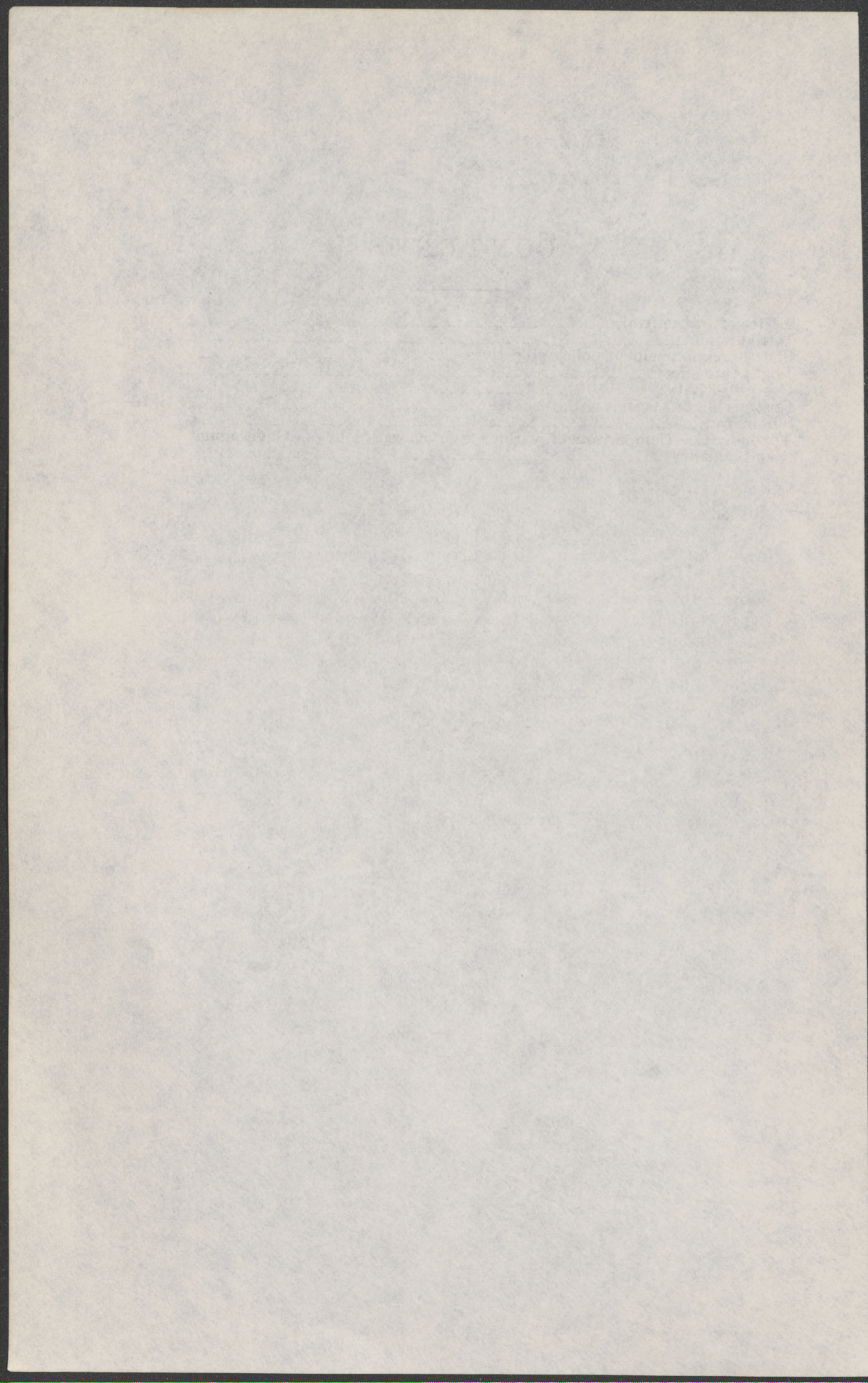
DON FUQUA, *Chairman,
Subcommittee on Space Science and Applications.*

(III)



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INTRODUCTION

Three major Congressional commitments were made by the National Aeronautics and Space Administration at the outset of the program to develop a low cost, earth orbital transportation system—the Space Shuttle:

A. A research and development program not to exceed \$5.2 billion (1971 dollars).

B. A system capable of an “out of pocket” cost of \$10.5 million (1971 dollars) per flight cost at flight rates of 60 missions per year.

C. A supporting facilities construction program not to exceed \$300 million (1971 dollars).

A recent review of the current status of commitments A. and C. above are contained in “Space Shuttle—1977” published by the Committee and which examines the current cost performance and schedule aspects of the Space Shuttle development program.

Commitment B. above, is the subject of the information contained in this report, as prepared by NASA. The underlying rationale for the estimates for costs associated with an operational Shuttle system is presented. The effects of various cost elements are evaluated as to their effect on costs and the total operational costs are traced back to the commitment of B. above.

OPERATIONAL COST ESTIMATES—SPACE SHUTTLE

NASA is in the process of establishing the initial prices for users of the Space Shuttle based on the projected costs incurred to operate the system. The purpose of this document is to summarize the present estimate of the cost of operating the Shuttle based on the flight model used in formulating the proposed user charge policies.

SHUTTLE REIMBURSEMENT POLICY OBJECTIVES

The Space Shuttle is being developed as the prime vehicle of a transportation system designed to give the United States and cooperating nations the capability for routine access to space. The Shuttle reimbursement policy has been conceived to encourage full and effective use of space, to effect early transition from expendables, and to recover the operating costs incurred in providing the launch services. Early transition from the expendable launch vehicles (ELV's) to the Shuttle will result in lower user costs for all users and will benefit the U.S. by advancing and improving space technology. NASA is planning an orderly transition from the expendable launch vehicles to the Shuttle at the Kennedy Space Center (1980-1983) and at Vandenberg Air Force Base (1983-1986). This early transition to Shuttle will be advantageous to the users because the firm, fixed Shuttle price is less than that for expendable vehicles. NASA has estimated that the savings to all users in transportation costs is estimated at approximately \$500 to \$600 million in 1975 dollars, when comparing early transition to the Shuttle with a three year delay in transition.

To assure that these savings can be realized while still maintaining an effective self-supporting system, NASA has included several considerations in the charge policy for Shuttle. They are:

NASA will recover all operations costs from all user categories over the total span of the Flight Model.

From commercial users, and non U.S. government users NASA will recover the pro-rata share of depreciation for the use of facilities and equipment and the amortization for the investment in the Space Shuttle fleet.

Since operating costs decrease over time, there would be a tendency by those users who are able to do so, to delay Shuttle utilization as long as possible in order to take advantage of lower prices. It is presently planned to peg the first three years fixed price to the average price of the total twelve year period. This will assure that all users—early or late—are treated on an equitable basis.

NASA will maintain price stability for the system through fixed price quotations to the users in subsequent years which will remain fixed for any contractual flight year. Adjustments in price for flights in subsequent years will be made as required to recover all applicable costs.

All users of a particular category will be treated equally for Shuttle flights and services, i.e., all commercial users will pay the same price for equal services in a given year.

In essence, NASA's approach to STS pricing (reimbursement) is to establish a comprehensive cost recovery policy that will obtain reimbursement of all Space Transportation Systems operating costs

(direct and indirect) for all users. The policies main objectives are to encourage space users to convert to Shuttle based on lower prices on Shuttle versus expendable vehicles.

APPROACH

- DEVELOP DATA BASE FOR OPERATIONS COST AND MANPOWER
- EVALUATE COST DATA AGAINST CURRENT ELV POLICY AND ALTERNATIVES
- ESTABLISH RECOMMENDED CHARGE POLICY FOR VARIOUS USER CLASSES
- ASSESS IMPACT OF USER CHARGE POLICY ON NASA OPERATIONS FUNDING REQUIREMENT

FIGURE A

As shown in Figure A, NASA developed a comprehensive cost data base for operations cost and manpower that was built up from detailed data at the lowest level of the NASA work breakdown structure, e.g., the food supply for each Shuttle mission is a cost included in the data base. This cost data base has been submitted for analysis and review by NASA organizations, Office of Management and Budget, General Accounting Office and committees of the Congress. It has been evaluated against the current expendable launch vehicle policy as well as other policies used by other organizations—private, public and government.

PROJECTED SHUTTLE LAUNCHES 1980 - 1991

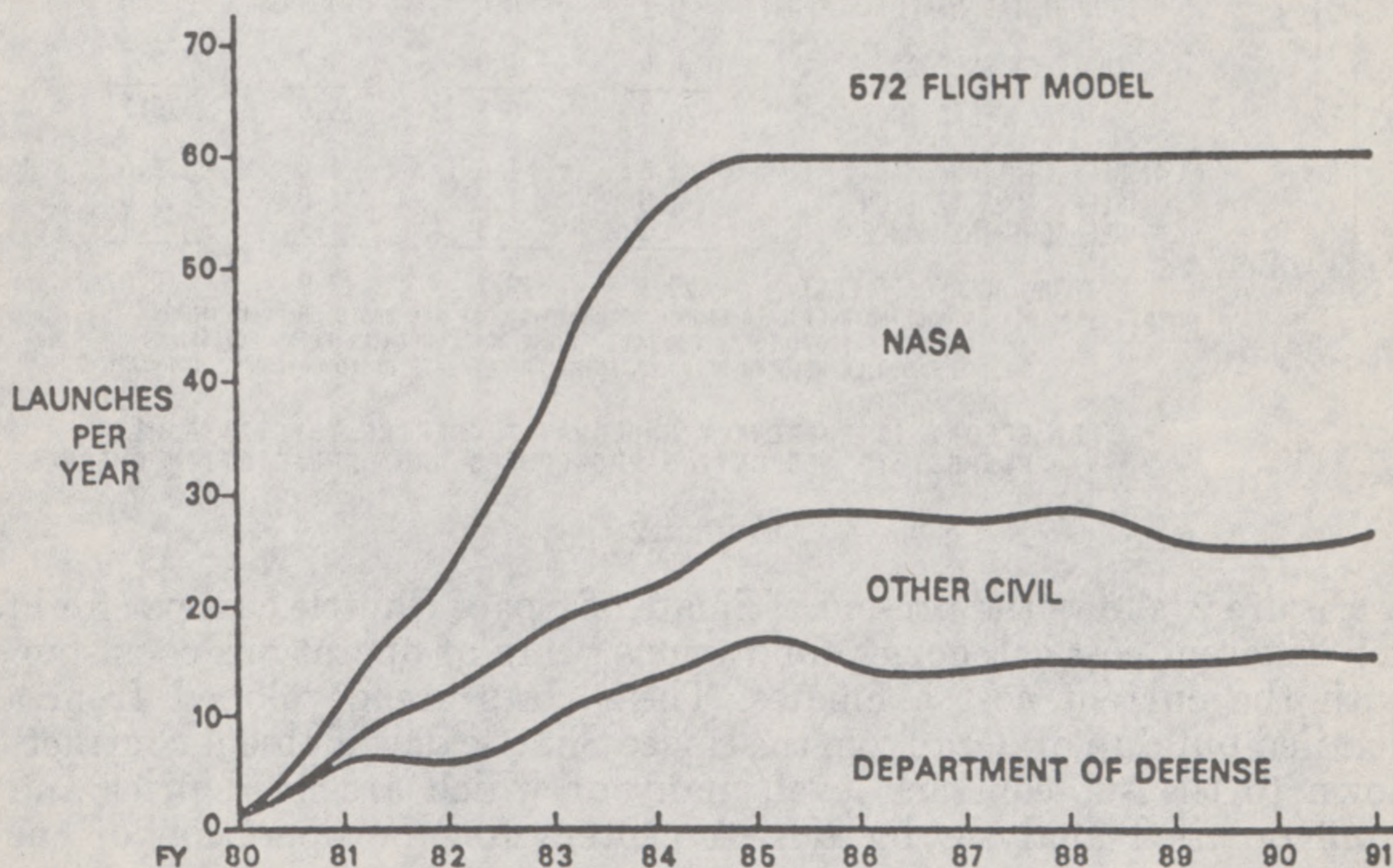


FIGURE 1

Figure 1, shows graphically the basic flight model used by NASA to develop the estimated costs to operate the system. The model begins in fiscal year 1980 with three operational flights and projects a level of 60 flights per year by fiscal year 1985. NASA considers the fiscal year 1980 through 1983 time frame to be an Operations Development period and the subsequent years, fiscal year 1984-1991) as the Full Operations period.

The present flight model is based on a representative future payload program published by NASA in October 1973 and reviewed by Congressional Committees at that time. However, the frequency and distribution of these payloads have been adjusted to be more consistent with current user objectives and budget constraints. On the basis of the data available from the many organizations' planning for Shuttle use, a 572 Flight Model was projected as the baseline Space Shuttle flight activity level through 1991.

In considering future flight levels, adequate margin was provided for growth in program requirements, for new uses of space as yet undefined, and flight aborts.

SPACE SHUTTLE OPERATIONS COST AVERAGE COST ESTIMATES				
COST CATEGORY	\$ MILLIONS		1975\$	
	FY 80-83 81 FLTS	FY 84 56 FLTS	FY 85 60 FLTS	FY 80-92 572 FLTS
EXTERNAL TANK	4.0	3.4	3.1	3.0
SOLID ROCKET BOOSTER	5.9	4.2	3.7	3.6
MAIN ENGINES	.5	.3	.3	.3
CREW EQUIPMENT	.3	.3	.3	.2
PROPELLANTS	.8	.7	.7	.7
SPARES (ORBITER/GSE)	.9	.7	.7	.8
CONTR. ADMIN./SYS. MGMT.	.3	.2	.2	.2
SUBTOTAL CONSUMABLES	12.7	9.8	9.0	8.8
FLIGHT OPERATIONS	2.6	1.2	1.1	1.4
(1) LAUNCH OPERATIONS	6.1	2.8	2.6	3.0
CARGO INTEG./NETWORK SUPT.	.7	.3	.3	.3
OPERATIONS MANAGEMENT	.7	.3	.3	.3
SUBTOTAL DIRECT SUPPORT	9.1	4.6	4.3	5.0
INDIRECT SUPPORT	4.4	1.9	1.7	2.3
TOTAL OPERATIONS	26.2	16.3	15.0	16.1
(2) DEPRECIATION	1.6	1.6	1.6	1.6
FLEET AMORTIZATION	1.0	1.0	1.0	1.0
REFLIGHT INSURANCE	.3	.3	.3	.3
TOTAL AGGREGATE COST	29.1	19.2	17.9	19.0

NOTE: (1) DIRECT AND INDIRECT VAFB LAUNCH OPERATIONS COST ARE BASED ON PRELIMINARY COST ESTIMATES PROVIDED BY THE DOD. THESE ARE CURRENTLY BEING REVISED BY THE DOD AND WILL NEED TO BE ADJUSTED AS APPROPRIATE BASED ON FORMAL DOD INPUTS

(2) EFFORT IS CURRENTLY UNDERWAY TO REFINE THIS DATA WITH RESPECT TO ACCOUNTING PROCEDURES AND DEPRECIATION CHARGES.

FIGURE 2

Figure 2, shows the present estimate of Space Shuttle cost per flight for different cost categories for various years of operations consistent with the current cost estimates. These costs are developed from a detailed buildup of data from the Space Shuttle development contracts down to the sub-contract level, many of which are fixed price and from detailed analyses by NASA centers for the operation of the system.

A number of factors were considered in deriving the cost data as shown on Figure 2. Past experience with the launch and flight support systems at Kennedy Space Center and Johnson Space Center used for the Apollo, Skylab and Apollo/Soyuz Test Project Programs provided a background for Shuttle that is significant. The derivation of operations costs assumed the existence of the capability derived from the Shuttle Design, Development, Test and Evaluation and the completion of the Orbital Flight Test program (flights 1 thru 6).

The effect of learning experience (i. e., the historically documented decrease in unit cost as the number of units produced increases) and efficient procurement strategies were applied when deriving the operations cost for Shuttle. Further, the procurement approach to major hardware can and will have a significant impact on the price of production units for the operational system. Lot buys of hardware were made consistent with program requirements.

Basic Shuttle operations costs provide only specifically defined standard mission services to the user. These include:

- Orbiter Flight Planning.

- Payload Safety Review.

- Payload Installation Verification and Compatibility.

- Three Man Flight Crew.

- One Day of Mission Operations.

- On-Orbit Payload Handling.

- Transmission of Payload Data.

- Development of Free Flyer.

- Standard Mission Destinations: Altitude 160 N. Mi.; Inclination 28.5°, 56°.

Cost associated with optional or special services were not included in the operations costs and would be passed on to the user in the form of additional charges for the specific services required. Examples of these optional or special services are listed below:

- Payload Mission Planning.

- Non-Standard Orbit Flight and Planning.

- Launch Window Constraints.

- Special Integration and Test.

- Special Crew Training.

- Short Term Call Up.

- Upper Stages and Services.

- Mission Kits.

- Spacelab, Long Duration Exposure Facility, Special Equipment.

- Revisit and Retrieval.

- Extra Vehicular Activity.

- Additional Time On Orbit.

- Payload Data Processing.

- Western Test Range Launch 90° and 104° Inclination Standard Mission Available.

The cost data base includes: all direct costs for hardware, launch and mission operations, and overhead costs related to Shuttle operations. Also, included in the cost data base is the depreciation of facilities and equipment and the amortization of the investment in the five orbiter fleet. These costs are included in the Aggregate Cost and are charged to all non-U.S. government users of the system (except for foreign countries making a major development contribution to the Space Transportation System). This point is very important to the user because through the payment of their share of the use for facilities, equipment and fleet amortization, they are entitled to the patent and data rights evolving from their use of space. As stated, Figure 2 shows on the left side margin a break-out of cost categories. These categories are: "Aggregate Cost" which is applicable to a foreign government or commercial user; "Total Operations" which provides the basis for determining the price charged to all civil government users both U.S. and participating foreign governments (European Space Agency and Canada) who have made a substantial contribution to the Space Transportation System; "Direct Costs" which represent all costs associated directly with a Shuttle mission, i.e., this category essentially covers the cost of all material and services that are directly associated with operation of the system; "Consumables" which are defined as those items or activities that can be identified as expended for each flight. This last category for example, includes the external tank which is consumed on each flight since it is not a reusable item of the Shuttle. The Solid Rocket Booster is partially consumed because even though it is recovered, it must be refurbished, reloaded and re-supplied to the system. The same situation is true for the Main Engines spares, Orbiter spares and Government Support Equipment spares and Crew Equipment.

FLIGHT RATE EFFECT

The right side of Figure 2 shows the estimated average costs associated with the various periods of Shuttle operations based on the 572 flight model, Figure 1. The first column covers the 81 flights for the fiscal year 1980-83 time period (from the 572 Mission Model—Figure 1). The second column indicates the estimated effect of an additional 56 flights in fiscal year 1984. The difference shows in part the impact of increased flight rate cost. In fiscal year 1985, the flight rate of 60 flights per year is reached and from that point to 1992 a steady state flight rate of 60 flights per year is maintained. Although the effect of flight rate on the annual cost of operations per flight can be seen from comparing the data under the column heads: fiscal year 1980-83, fiscal year 1984 and fiscal year 1985 in Figure 2, it is more apparent in Figure 3 where the annual average operations cost is plotted against the annual flight rate.

SPACE SHUTTLE OPERATIONS COST 572 MODEL VS 323 MODEL

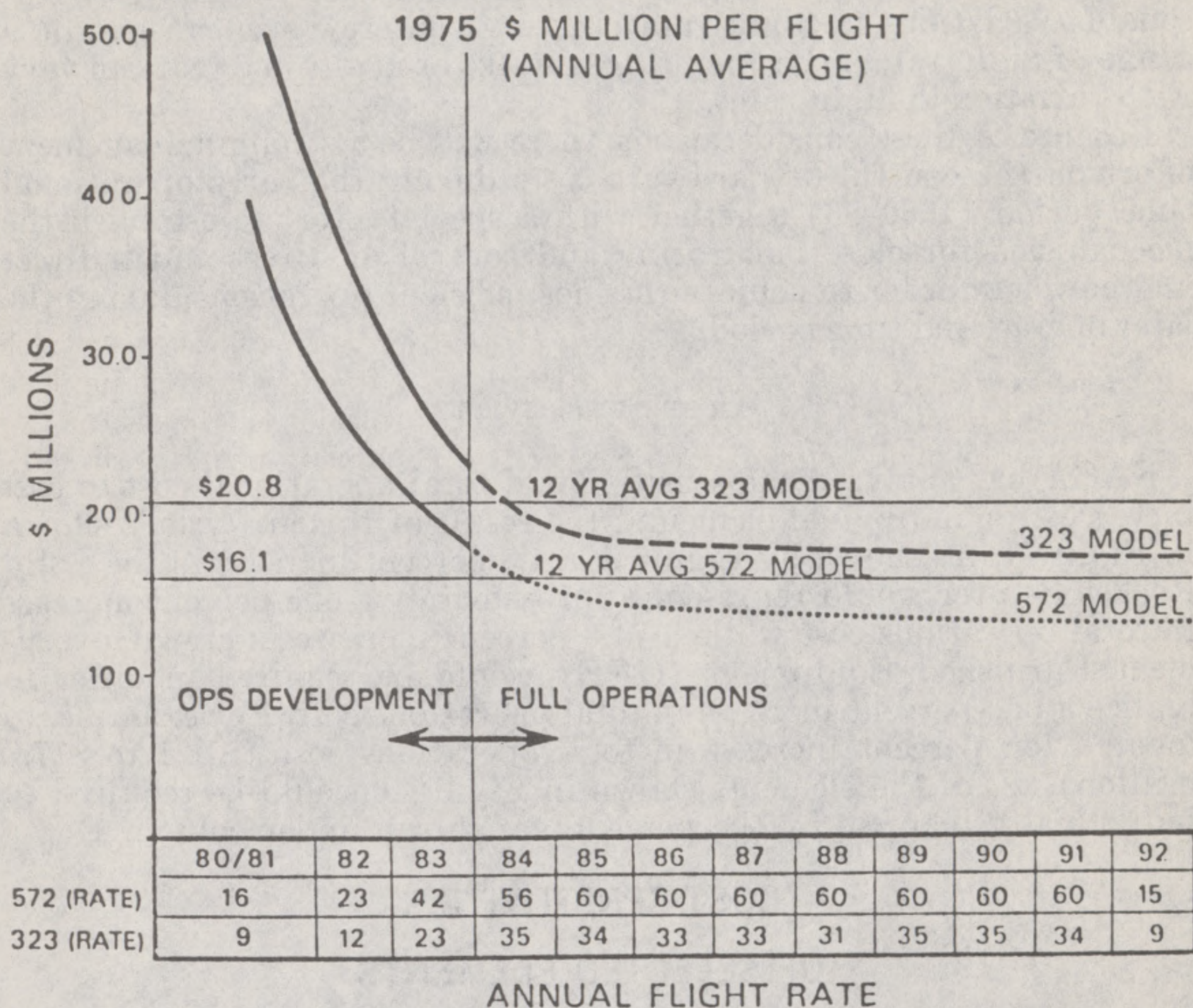


FIGURE 3

Figure 3, while showing the effect of flight rate on costs, also has another important element in that it also indicates the cost of operations per flight if the 572 flight model is reduced to 323 flights, a reduction of approximately 45 percent, which results in an increase of only 29 percent in the estimated cost of the average flight.

Figure 3 shows the flight rate for each year from 1980 to 1991 with a partial year shown for 1992. When cost sensitivities are considered for various elements of the Shuttle program, it is important to recognize the three major factors affecting costs. These major factors are flight rate, hardware and manpower. The planned flight rate shown in Figure 3 for the operations development period (80-83) is conservative since it only meets the presently identified user launch requirements.

The variation in the annual average operations cost shown in Figure 3 is influenced by the relative impact of learning experience on unit hardware costs and flight rate effect on manpower costs. The relative cost reductions in unit hardware costs is more pronounced during the early phases of production, thereby causing the majority of the decrease in the operating costs depicted in the early years. Variations in the flight rates in any one year during the early time period will therefore have a minimal impact on the operating costs shown.

During the later years, the effect of learning has a smaller impact on hardware costs and the relative proportion of cost for manpower increases. Since yearly manpower costs are not overly affected by reasonable variations in flight rate (i.e., a given crew size can handle a range of flight rates) the operating cost/flight in any one year can vary with variation in flight rates.

Because of these considerations, there will be a strong management effort on the control of hardware costs during the early operational time period (1980-83) together with a special effort to establish the mechanisms for close monitoring and control of direct and indirect manpower in order to achieve the most efficient operations during the later operational time period.

COST SENSITIVITY

NASA has analyzed the sensitivity of total operational cost to cost increases for individual elements; the result of this analysis is shown in Figure 4. As shown by Figure 4, a 4.5 percent increase in the Solid Rocket Booster would represent approximately a one percent increase in total operations cost while a 71.6 percent increase in crew Government Furnished Equipment (GFE) would be required in order to realize a one percent increase in total operations cost. For example, to incur a ten percent increase in total operations cost (\$16.1 to \$17.7 million), *all* of the elements shown in Figure 4 would be required to individually increase by the percentages shown under column 1.

COST SENSITIVITIES OF SELECTED ELEMENTS

<u>ELEMENT</u>	<u>REQ'D PERCENT RISE BY ELEMENT FOR 1% INCREASE IN TOTAL OPS COST</u>	<u>PERCENT OF TOTAL COST BY ELEMENT</u>
SOLID ROCKET BOOSTER	4.5	23.3
EXTERNAL TANK	5.3	19.8
DIRECT & INDIRECT C. S.	7.6	13.8
DIRECT & INDIRECT S. C.	7.7	13.6
KSC & VAFB GROUND OPS/GSS	8.4	12.5
JSC PROGRAM SUPPORT	17.9	5.8
KSC & VAFB PROPELLANTS	21.7	4.8
ORBITER SPARES	36.0	2.9
SSME	52.5	2.0
CREW RELATED GFE	71.6	1.5

FIGURE 4

Another way to view the sensitivity is to consider column 2 in Figure 4. Column 2 shows that, for example the Solid Rocket Booster accounts for almost one fourth of the total cost to operate the system while crew GFE accounts for only 1.5% of the cost. Therefore, the Solid Rocket Booster is about 15 times more significant in terms of cost control than the crew GFE.

Column 2 provides a ranking of the sensitivity of the elements to total operations cost. Based upon this analysis, NASA has established a preliminary user charge price range which allows for some growth in operations costs. For example, the Total Aggregate Cost \$19.0 million associated with the right hand column of Figure 2 is planned to be quoted to a commercial user as being within the range of \$19.0 to \$20.9 million.

COST RECOVERY RANGES

USER CLASS

PRICE/FLT. M 75\$

COMMERCIAL AND FOREIGN

AVG. OPS. COST THRU '92
PLUS DEPRECIATION

19.0 - 20.9

CIVIL U.S. GOVERNMENT

AVG. OPS. COST THRU '92

16.1 - 18.0

FIGURE 4a

The final price within such a range will be set at the time of contract negotiation for a flight. Figure 4a shows the presently contemplated ranges for U.S. government, commercial and foreign users of the Space Shuttle.

USER CHARGE SENSITIVITIES

FLIGHT RATE vs COST PER FLIGHT

(12 YR TIME PERIOD)

1975 \$

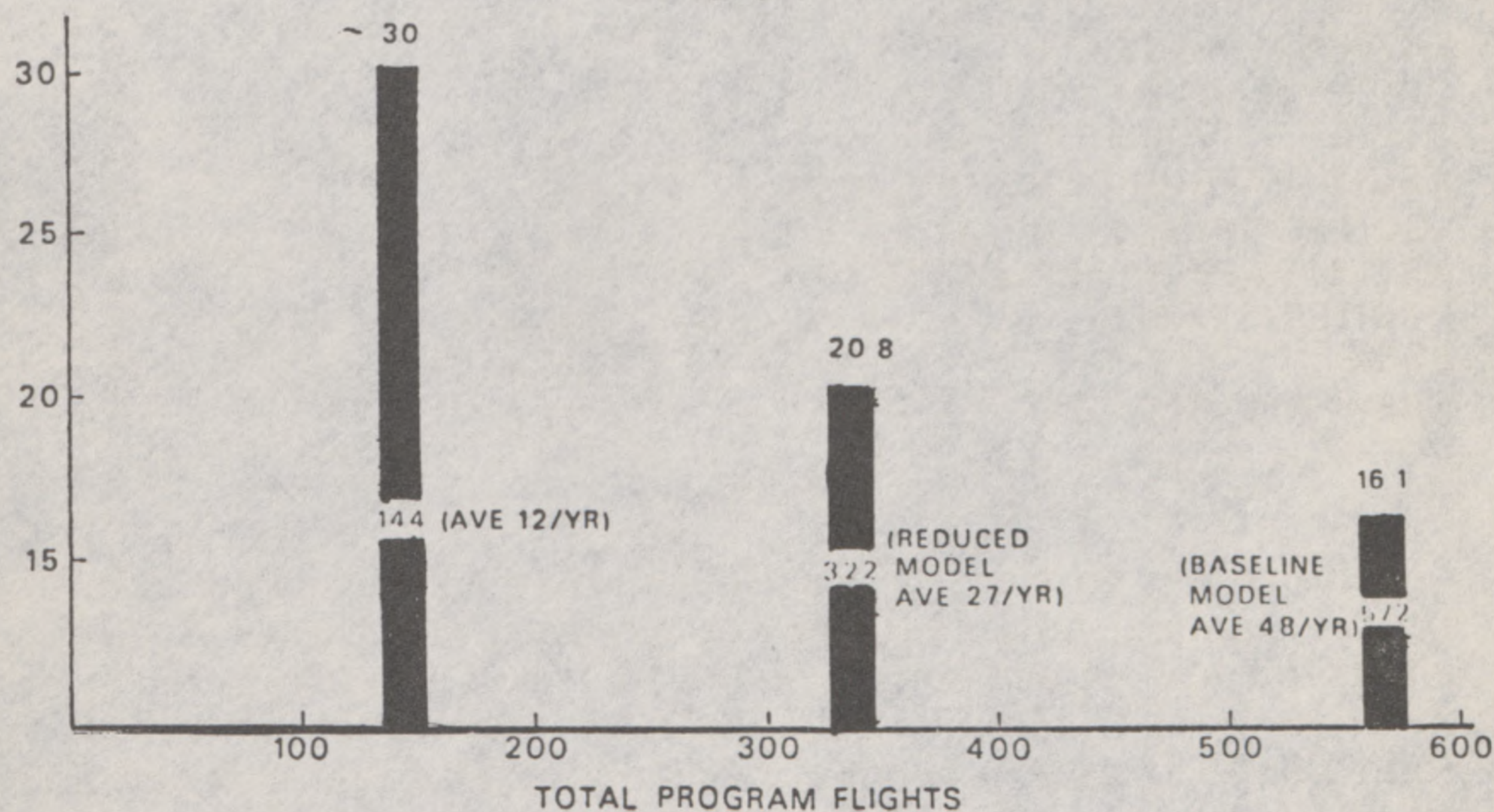


FIGURE 5

An indication of the cost sensitivity to flight rate is shown on Figure 5 which shows the average flight cost for three different flight levels carried out during the 1980-92 time period. It is significant to recognize that even at the low flight rate (144), the cost of a Shuttle flight is about the same as the cost of the expendable Atlas-Centaur launch vehicle. The Shuttle cost at this low launch rate plus the estimated cost of an upper stage, which will do the equivalent mission of an Atlas-Centaur would cost the user about \$21 million (75 \$'s) because the user pays only for his share of Shuttle use which in this case is two thirds of a dedicated Shuttle flight. Therefore, even at this very low flight rate (12/year) for the Shuttle, it is still competitive with expendable launch systems.

Figure 5 again indicates the relative insensitivity of the average cost per flight to Mission Model size assumption. The 572 Mission Model could decrease by approximately 100 flights before a 10% increase in average cost per flight is exceeded.

COST PER FLIGHT TARGET

In developing the operations cost for Shuttle, NASA has been very conscious of its original target for Shuttle cost per flight. A comparison of the original target of cost per flight to the current estimate contained in the User Charge Data Base is shown in Figure 6. This figure shows a list of the cost elements used to develop the original cost per flight target of \$10.45M in 1971 dollars and compares those elements with the current values from the 1976 User Charge Data Base. The dollar values in the User Charge Data Base were developed against the 572 Flight Model that spans a twelve year time period (1980-1992), whereas, the original target of cost per flight was developed against a 439 Flight Model spanning ten years. The User Charge Data Base has been adjusted to approximate the 439 flight level of the original target.

SPACE SHUTTLE COST PER FLIGHT
ORIGINAL TARGET vs USER CHARGE
\$ MILLION-1971\$-439 FLIGHTS

	ORIGINAL TARGET MARCH 1972	USER CHARGE MAY 1976
EXTERNAL TANK	2.31	2.76
SOLID ROCKET BOOSTER	4.28	3.28
MAIN ENGINES	.23	.27
SPARES	1.40	.68
PROPELLANTS	.20	.33
GROUND OPS	.27	.97 *
PROGRAM SUPPORT	.26	.58 *
OPERATING BASE	1.50	1.52 *
TOTAL	10.45	10.39

* THESE ITEMS ARE IDENTIFIED IN USER CHARGE AS:

CREW EQUIPMENT
FLIGHT OPS
LAUNCH OPS

FIGURE 6

As can be seen in Figure 6, the major hardware cost elements have undergone change between March 1972 and May 1976. The External tank has increased in cost while the Solid Rocket Booster has decreased by \$1 million per flight. In total, the present estimate of the cost per flight has dropped from the original target of \$10.45 per flight to \$10.39 million in 1971 dollars. This small change is due to the fact that the original cost per flight as well as the development cost of the Shuttle are the two major cost control elements in the design-to-cost approach which is used in the day-to-day evaluation of the development program. As has been stated in the past, changes proposed by the development contractors are evaluated on the basis of their impact on the development costs and their impact on the cost per flight.

A recent activity, now underway, is an analysis of a 560 twelve year flight model. This model represents an update of the NASA and DOD projections for Shuttle traffic in the 1980-1991 time frame and will be completed in the near future. Since there are very limited deviations in the traffic levels between the 560 and 572 flight models, the operations cost per flight discussed in this document will be substantially unchanged with the exception of the Vandenberg costs and the depreciation of facilities and equipment costs which, as indicated on Figure 2 are currently undergoing a more thorough analysis.

SUMMARY

The Operations Cost for the Shuttle is the basis for developing the User Charge Policy for the system. The policy contains several elements that are significant to the user and to NASA. It will encourage the full use of the system to the benefit of the U.S. The charge policy will encourage early transition from the expendable launch vehicles to the Shuttle and this will result in lower costs for government as well as commercial users. The relationship between the charge policy and the utilization of the Shuttle is critical to the economic efficiency of the system. NASA recognizes the challenging relationship between pricing, the cost of using the reusable space system, and the need to make sure it is re-used often.

Comparison of Various User Charge Policies, Government and Industry

SUMMARY TABLE

Basic Pricing Program	Comparison to Proposed User Charge Directives	
	Civil Government*	Non-U. S. Government
<u>Implications for STS</u>		
<u>Analog - ELECTRIC UTILITIES</u>		
o Hopkinson two-part tariff: 1. Energy charge equal to variable costs per kilowatt hour. 2. Demand charge equal to the cost per kilowatt demanded.	o Two-part charge may be applied to: 1. A capacity used charge plus, 2. A performance charge on crew time and/or other variables.	o Basic charge is for fraction of fixed capacity used on shared flight plus an additional charge for optional services demanded.
o Non-coincident demand charge, i.e. user's peak not necessarily the system's peak.	o Discriminate among users on the basis of demand elasticity.	o Does not discriminate on the demand elasticity, but does allow lower prices for small, self-contained packages.
o Foreign providers, e.g. France and Great Britain.	o Some rationale for charging rates below average.	o Charge is below total average cost.
<u>Analog - TELEPHONE SERVICES</u>		
o Local calls are either flat charge per month or message rates. 1. Large users subsidized by small users with flat rate. 2. Message rate system provides no incentive to users to smooth peak demands.	o Do not charge flat rate; distinguish among classes of users.	o Basic charge is distinctive for this class (forecast aggregate costs).

*Includes European Space Agency users and Canadian Government users.

APPENDIX A

Comparison to Proposed User Charge Directives		Non-U. S. Government	
Basic Pricing Program	Implications for STS	Civil Government*	
o Long distance calls vary by use and by peak demand.	o Price discriminate by user elasticity if possible.	o Does not discriminate on the basis of demand elasticity but does allow lower prices for small, self-contained packages.	o Does not discriminate on the demand elasticity, but does allow lower prices for small self-contained packages and for users having payloads of great value to the U.S. public.
	o Average the incremental capital investment in the fleet.	o No amortization of fleet investment.	o Fleet investment amortized over 12-year forecast.
Analog - INTERNATIONAL TELECOMMUNICATIONS			
o Regulated rates vary by type of service provided, foreign agreement, geographic area, and competition, but overall, they should cover costs plus a rate of return.	o Competition should be considered in pricing the STS.	o Charges are competitive with expendable launch vehicles on dedicated flights and comparable or less than competition on shared flights. Competitiveness as a research facility varies by application.	o Shared flights will be comparable to or less than expendable launch vehicles. Some dedicated flights would be more expensive but none are anticipated for this user class.
Analog - COMSAT			
o Revenue requirements based on reverse sum-of-the-years digits depreciation. Rate of return starts low but increases over time.	o Set early rates lower than later rates possibility through implicit price discounting, e.g. provision of additional front-end services.	o Per flight charge for first 3 years is fixed at a 12-year forecast operating cost level below total forecast aggregate costs. Twelve-year forecast costs after first three years can be updated yearly. No implicit price discounting.	o Per flight charge for first three years is fixed at a 12-year forecast aggregate cost level. Actual costs per flight may exceed or fall below this level, but intent is to protect user from actual costs above forecast. Twelve-year forecasted costs after first three years can be updated yearly. No implicit price discounting.
o Charges among users determined by type of service and peak loading.	o Set rates competitive with expendable launch vehicles.	o Charges are competitive with expendable launch vehicles on dedicated flights but comparable or less than on shared flights.	o Shared flights will be comparable to or less than expendable launch vehicles. Some dedicated flights would be more expensive, but none are anticipated for this user class.

*Includes European Space Agency users and Canadian Government users.

Comparison to Proposed User Charge Directives			
Civil Government*		Non-U. S. Government	
<u>Implications for STS</u>			
<u>Analog - NATURAL GAS</u>			
o Rates consist of commodity and demand costs similar to electric utilities' energy and demand charges.	o User charges should include a fixed charge plus charges for directly variable costs.	o Basic charge is for fraction of fixed capacity used on shared flight plus an additional charge for optional services demanded.	o Basic charge is for fraction of fixed capacity used on shared flight plus an additional charge for optional services demanded. Charge covers all fixed and all variable costs.
o Exhibits joint case characteristics.			
<u>Analog - RAILROAD FREIGHT TRANSPORT</u>			
o Value-of-service pricing where possible with competitive rates where necessary.	o Apply value-of-service pricing where they are a unique service provider, e.g. retrieval.	o Charges for unique services are additional but based on operations cost, not value-of-service.	o Charges for unique services are additional but based on aggregate cost, not value-of-service.
	o Value-of-service pricing maximizes the use of a given plant (operations) size.	o Charges for small, self-contained payloads are a surrogate for value-of-service.	o Charges for small, self-contained payloads are a surrogate for value-of-service.
<u>Analog - AMTRAK</u>			
o Prices competitively with short-haul competition from bus and airlines	o Price competitively where necessary.	o Charges are competitive with expendable launch vehicles on dedicated flights and comparable or less than on shared flights. Competitiveness as a research facility varies by application.	o Shared flights will be comparable to or less than expendable launch vehicles. Some dedicated flights would be more expensive, but none are anticipated for this user class. Competitiveness as a research facility varies by application.
o Minor attention to user's demand elasticities.	o Price on the basis of quality of service (risk reduction) where possible.	o Re-flight guarantee is available at additional cost to cover user if he is not at fault. User risk is reduced.	o All shuttle flights will receive reflight guarantee if user is not at fault. User risk is reduced.

*Includes European Space Agency users and Canadian Government users.

<u>Basic Pricing Program</u>	<u>Comparison to Proposed User Charge Directives</u> <u>Civil Government*</u> <u>Non-U. S. Government</u>	
o Does not recover total costs.	o Non-recovery of start-up costs.	o Start-up costs for initial research and development not charged.
<u>Analog - TRUCKING</u>		
o Closely resembles railroad freight rate structure because of frequent competition between the two.	o Price competitively and even below total cost to recover largest proportion of fixed costs if additional capacity is available.	o Shared flights will be comparable to or less than expendable launch vehicles. Some dedicated flights would be more expensive, but none are anticipated for this user class. Charges are equal to total aggregate costs and not constructed as an incentive if additional capacity is available.
<u>Analog - AIRLINE TRANSPORTATION</u>		
o Current interstate fares are complex but do emphasize some promotional fares.	o Do not make the user charge policy too complex.	o Policy is not too complex. Charges are fixed for first three years for all members of this user class and can be updated annually afterwards. All dedicated flights and shared flights relate to same rate per flight including all basic services. Only small, self-contained packages and payloads of great value to the U.S. public are different, but also single prices.
o Interstate fares provided early subsidization to stimulate demand.	o Use marginal cost pricing to attract more elastic users if additional capacity is available.	o Marginal cost pricing called additive cost for flights carrying payloads of great value to U. S. public. Otherwise, average cost pricing for dedicated and shared flights.

*Includes European Space Agency users and Canadian Government users.

Comparison to Proposed User Charge Directives	
Basic Pricing Program	Civil Government* Non-U. S. Government
o Intrastate fares set primarily by competitive marketplace.	o Charges based primarily on cost, not market consideration. o Charges based primarily on cost not market considerations.
Implications for STS	
Analog - INTERNATIONAL AIR TRANSPORT	
o Set by an international cartel.	o Set by NASA.
Analog - URBAN TRANSIT	
o Frequently flat fares, but can be based on zones, transfer charges, user classes, etc.	o Ability for users to share capacity makes STS least cost mode of transport. Some dedicated flights would be more expensive, but none are currently anticipated for this user class.
o Usually do not recover full costs.	o Start-up costs including initial research and development, fixed facilities, and fleet procurement not charged.
Analog - PETROLEUM PIPELINES	
o Rate of return standard using replacement costs rather than original cost.	o No fixed costs are charged.
o Historical price discrimination against independent users by vertically integrated oil companies minimized by legislation.	o All fixed costs in forecasted average are original, not replacement.

*Includes European Space Agency users and Canadian Government users.

<u>Basic Pricing Program</u>	<u>Implications for STS</u>	<u>Comparison to Proposed User Charge Directives</u> <u>Civil Government*</u>	<u>Non-U. S. Government</u>
<u>Analog - HIGHWAYS</u>			
o One of the three methods or a combination: 1. Direct toll charges. 2. Indirect taxes on motor fuels or vehicles. 3. General tax revenues.	o STS probably cannot set "tolls" high enough to recover all costs, but later cost recovery may be possible via a tax on space developed products, e.g. solar energy.	o Cost of fixed facilities, fleet procurement, and initial research and development not recovered.	o Cost of initial research and development not recovered.
<u>Analog - INTERNATIONAL SHIPPING</u>			
o Joint rate agreements among carriers based on: 1. Operating costs 2. Value-of-service 3. Competition 4. Cargo movement (demand) 5. Space available (supply)	o Apply value-of-service pricing where possible.	o Charges for unique services are additional but based on operations cost, not value-of-service. Charges for small, self-contained payloads are a surrogate for value-of-service.	o Charges for unique services are additional but based on aggregate cost, not value-of-service. Charges for small, self-contained payloads are a surrogate for value-of-service.
	o Meet competition where necessary.	o Charges are comparable to expendable launch vehicles on dedicated flights and comparable or less than competition on shared flights. Competitiveness as a research facility varies by application.	o Shared flights will be comparable to or less than expendable launch vehicles. Some dedicated flights would be more expensive, but none are anticipated for this user class. Competitiveness as a research facility varies by application.
<u>Analog - URANIUM ENRICHMENT</u>			
o Estimated recovery of total costs for a given volume of separative work units (SWU's) provided.	o Average costing over the estimated economic life of the system.	o Average operations cost over economic life estimated based on given volume of flights expected.	o Average aggregate cost over economic life estimated based on given volume of flights expected.
o Original research and development costs and excess capacity costs excluded.	o Not full cost recovery.	o Original research and development and most excess capacity costs excluded.	o Original research and development costs excluded.

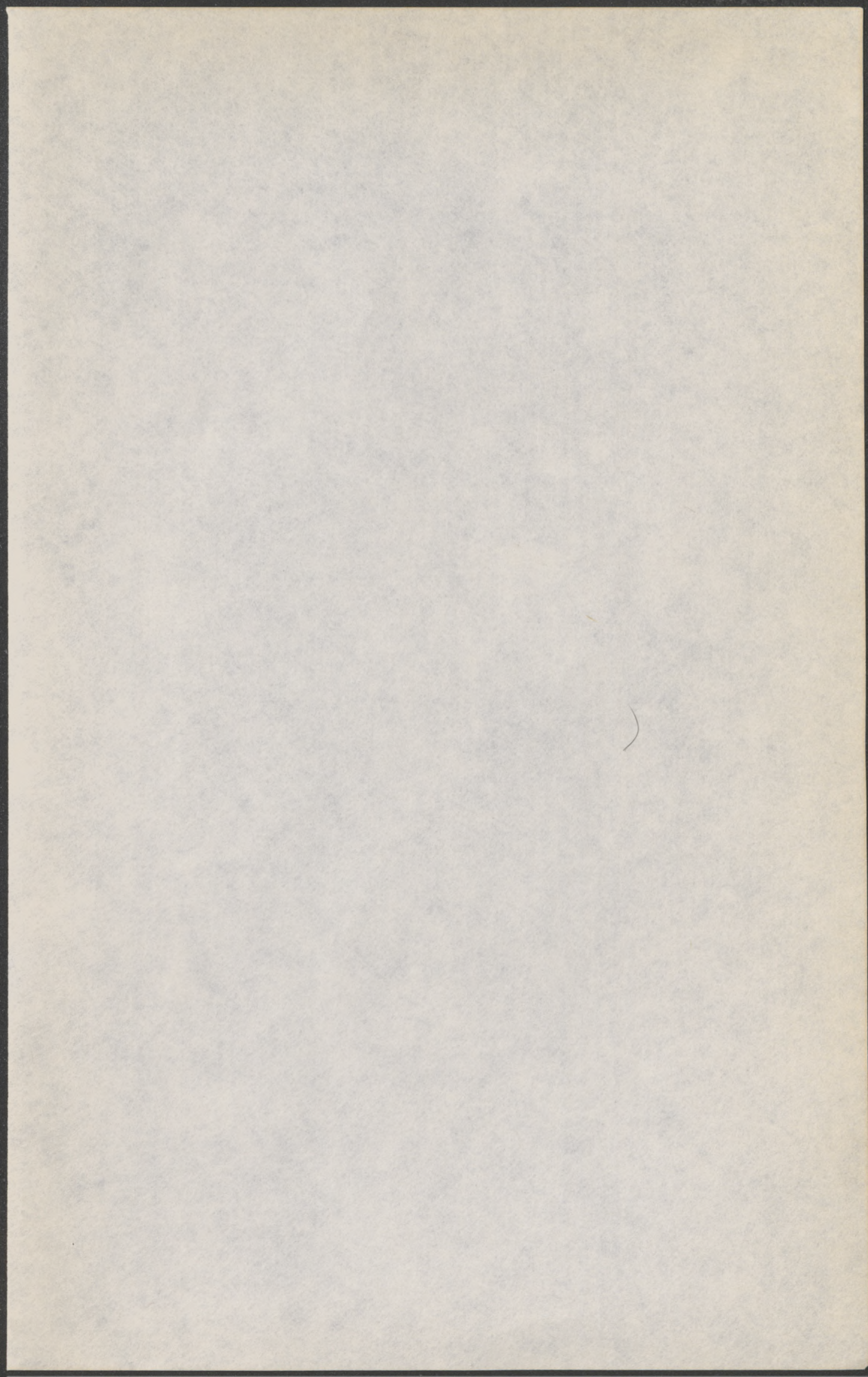
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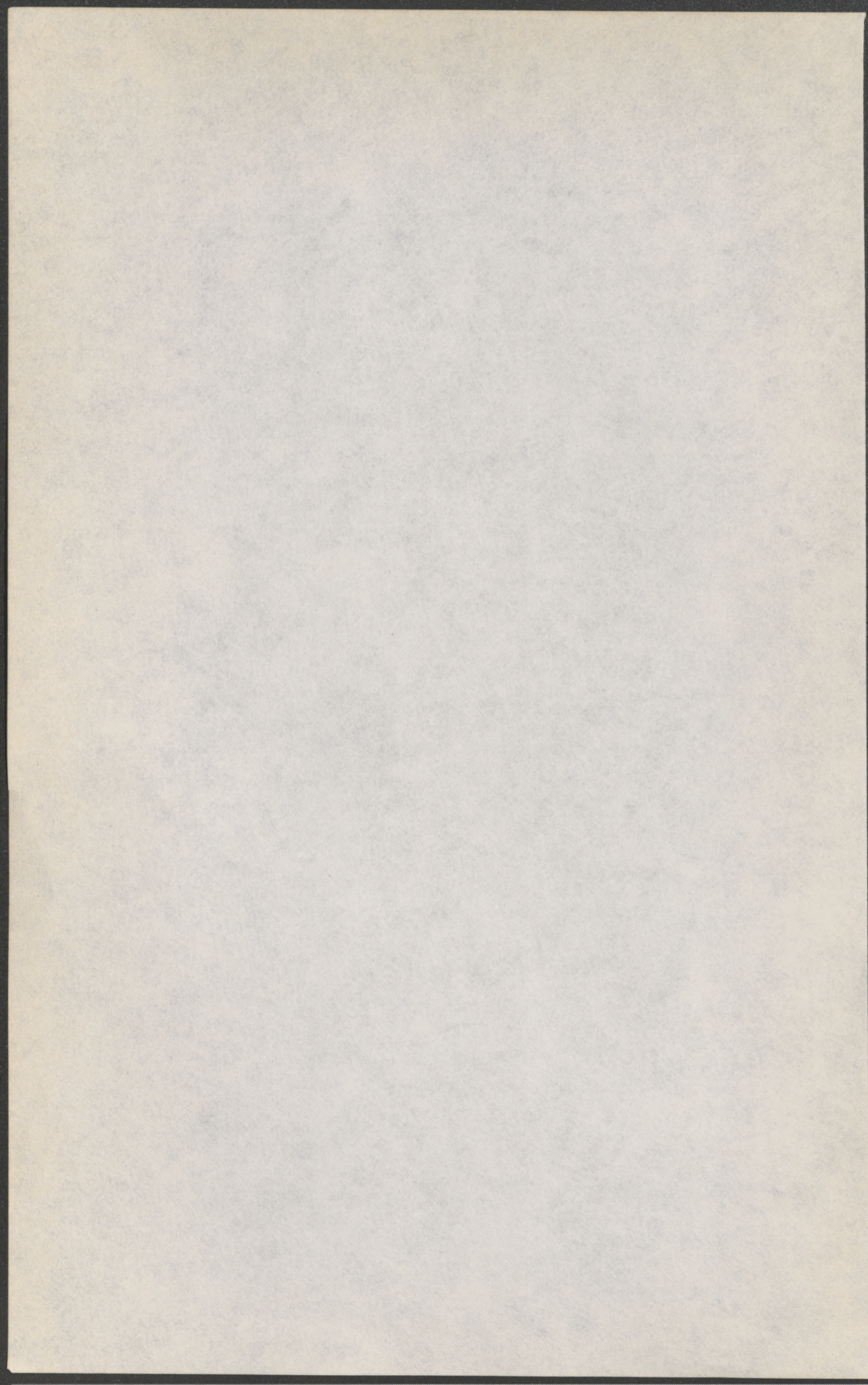
Comparison to Proposed User Charge Directives								
Civil Government*		Non-U. S. Government						
Basic Pricing Program		Implications for STS						
Analog - PANAMA CANAL								
o No recovery of original cost of constructing the canal.	o Recovery of all operating costs on the basis of net vessel tons of earning capacity.	o Non-recovery of "sunk" development costs.	o Recovery of all operating costs but no amortization of fixed facilities and fleet procurement.	o Research and development costs not recovered.	o Research and development costs not recovered.			
o Separate operating company.		o Establishment of a separate operating company.		o Operation by NASA.				
Analog - ST. LAWRENCE								
o Two-part tariff: 1. Gross ton charge roughly equal to the cost of providing service, plus. 2. Charge per ton of cargo roughly equal to the value of the service.		o Establish two-tier charge to encourage users for whom the STS cost is high in relation to payload cost.	o Charge is fixed regardless of payload cost except for small, self-contained packages.	o Charge is fixed regardless of payload cost except for small, self-contained packages and payloads of great value to the U. S. public.				
Analog - METROPOLITAN WASHINGTON AIRPORTS								
o Cost allocation among airlines in proportion to number of passengers (partial value-of-service).		o Apply a modified value-of-service price.	o Charges for unique services are additional but based on operations cost, not value-of-service.	o Charges for unique services are additional but based on aggregate cost, not value-of-service.				
o Landing fees based on landing weight of aircraft.		o Some value-of-service pricing like landing fees based on landing weight alone may encourage misuse of the system.	o Charges for small, self-contained payloads are a surrogate for value-of-service.	o Charges for small, self-contained payloads are a surrogate for value-of-service.				
			o Although not value-of-service, charges for shared flights based on weight and length.	o Although not value-of-service, charges for shared flights based on weight and length.				

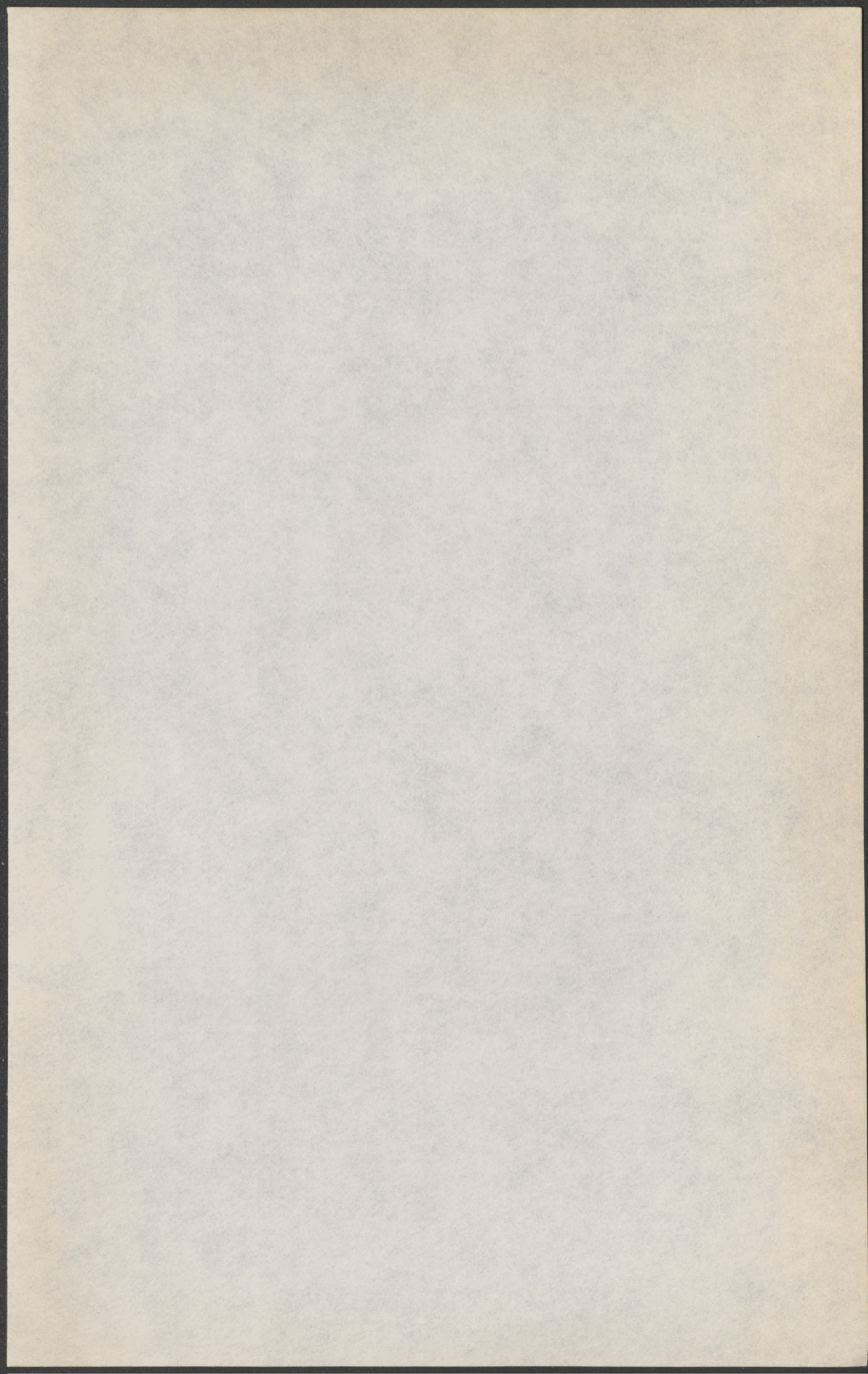
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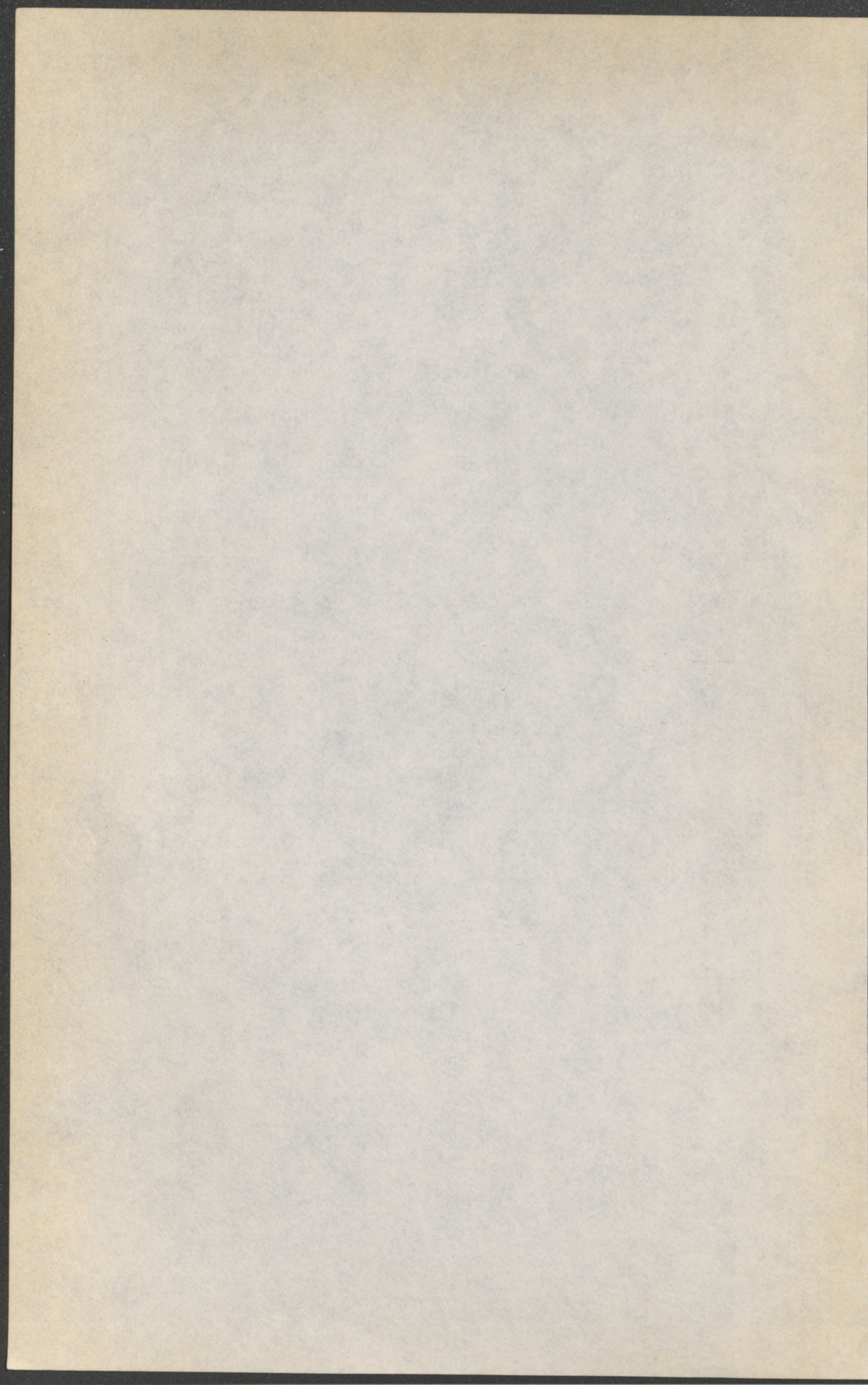
<u>Basic Pricing Program</u>	<u>Comparison to Proposed User Charge Directives</u>	
	<u>Civil Government*</u>	<u>Non-U. S. Government</u>
o Dulles Airport service prices set lower to stimulate demand.	o Set initial prices lower to stimulate demand.	o Per flight charge for first 3 years is fixed at a 12-year forecast aggregate cost level. Twelve-year forecast costs after first three years can be updated yearly.

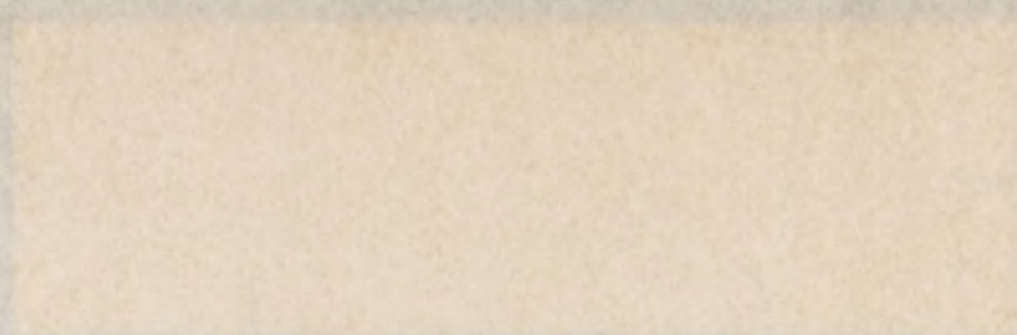
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