

SPACE SHUTTLE COST ANALYSIS: A SUCCESS STORY?

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SPACE SHUTTLE EARLY COST ESTIMATION HISTORY

- THIS PRESENTATION WILL TELL A TRUE COST ESTIMATING SUCCESS STORY (OK, AND A SIGNIFICANT FAILURE):
 - DESCRIBE THE DEFINING POLITICAL AND ECONOMIC CONDITIONS WHICH WERE FORMATIVE TO THE PROGRAM
 - DESCRIBE HOW ESTIMATES WERE MADE
 - SHOW HOW THE BUDGET CHANGES SHAPED THE CONFIGURATION
 - EXPLAIN THE COST COMMITMENTS MADE TO THE NATION
 - DEMONSTRATE THE SUCCESS NASA HAD IN MEETING THE COMMITMENTS
 - DISCUSS WHY THIS SUCCESS HAPPENED, OR DIDN'T
 - DISCUSS SOME LESSONS LEARNED

SPACE SHUTTLE BACKGROUND

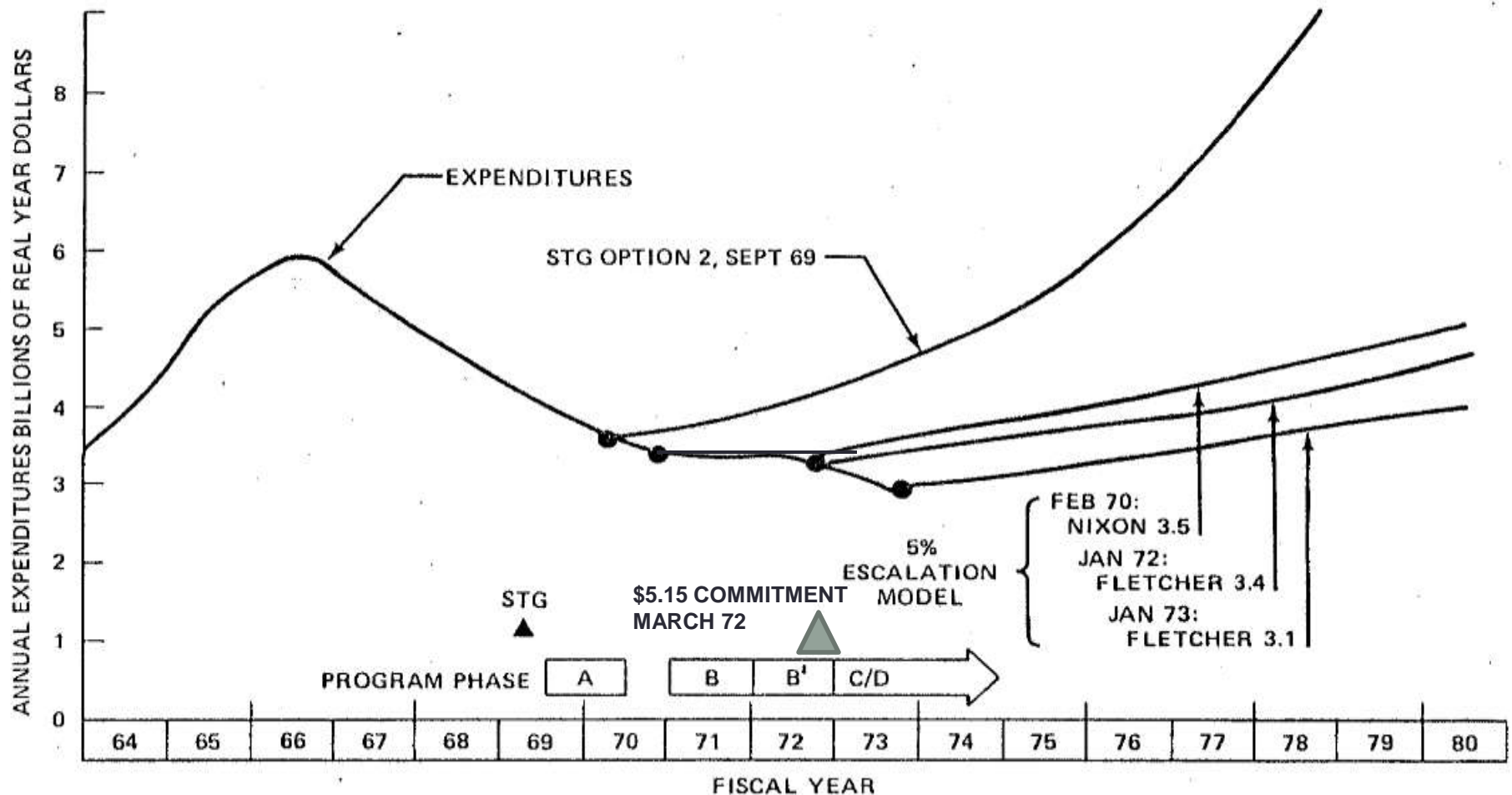
- FIRST LUNAR LANDING IN 1969
- EVEN BEFORE THAT DAY, NASA WAS LOOKING FOR “WHAT’S NEXT”
- CONSTRAINTS;
 - MUST SUPPORT THE LONG RANGE NEEDS OF HUMAN EXPLORATION OF THE MOON, MARS, AND BEYOND
 - SHOULD LOWER THE COST OF SPACE TRANSPORTATION
 - MUST BE CONSISTENT WITH THE POLITICAL CONSTRAINTS OF THE NEW NIXON ADMINISTRATION, THE OMB, AND THE CONGRESS
- CANDIDATES:
 - SPACE SHUTTLE
 - SPACE STATION
 - HUMAN MARS EXPLORATION
- ISSUES
 - PROGRAM LEAD TIMES LED TO STARTING BEFORE BUDGETS WERE SETTLED
 - COST ANALYSTS DID NOT AT FIRST HAVE THE TOOLS TO COPE WITH THE CHANGING DESIGNS AND POLITICAL ENVIRONMENT

THE NASA BUDGET CHRONOLOGY 1969-1972

- SPACE TASK GROUP (STG) REPORT SEPT 16 1969:
 - CHAIRED BY V.P. SPIRO AGNEW, GAVE NIXON 5 OPTIONS
 - UPPER BOUND OPTION: PEOPLE ON MARS BY 1981
 - OPTION I: SHUTTLE AND SPACE STATION OPERATIONAL BY 1976, MARS 1986,
 - OPTIONS II, III: SHUTTLE AND SPACE STATION OPERATIONAL BY 1977. MARS?
 - NASA INITIALLY ASSUMED OPTION II FOR SHUTTLE PLANNING

THE NASA BUDGET WAS CHANGING WITH EACH GOVERNMENT CYCLE

NASA BUDGET PREDICTIONS



NASA BUDGET CHRONOLOGY, 2

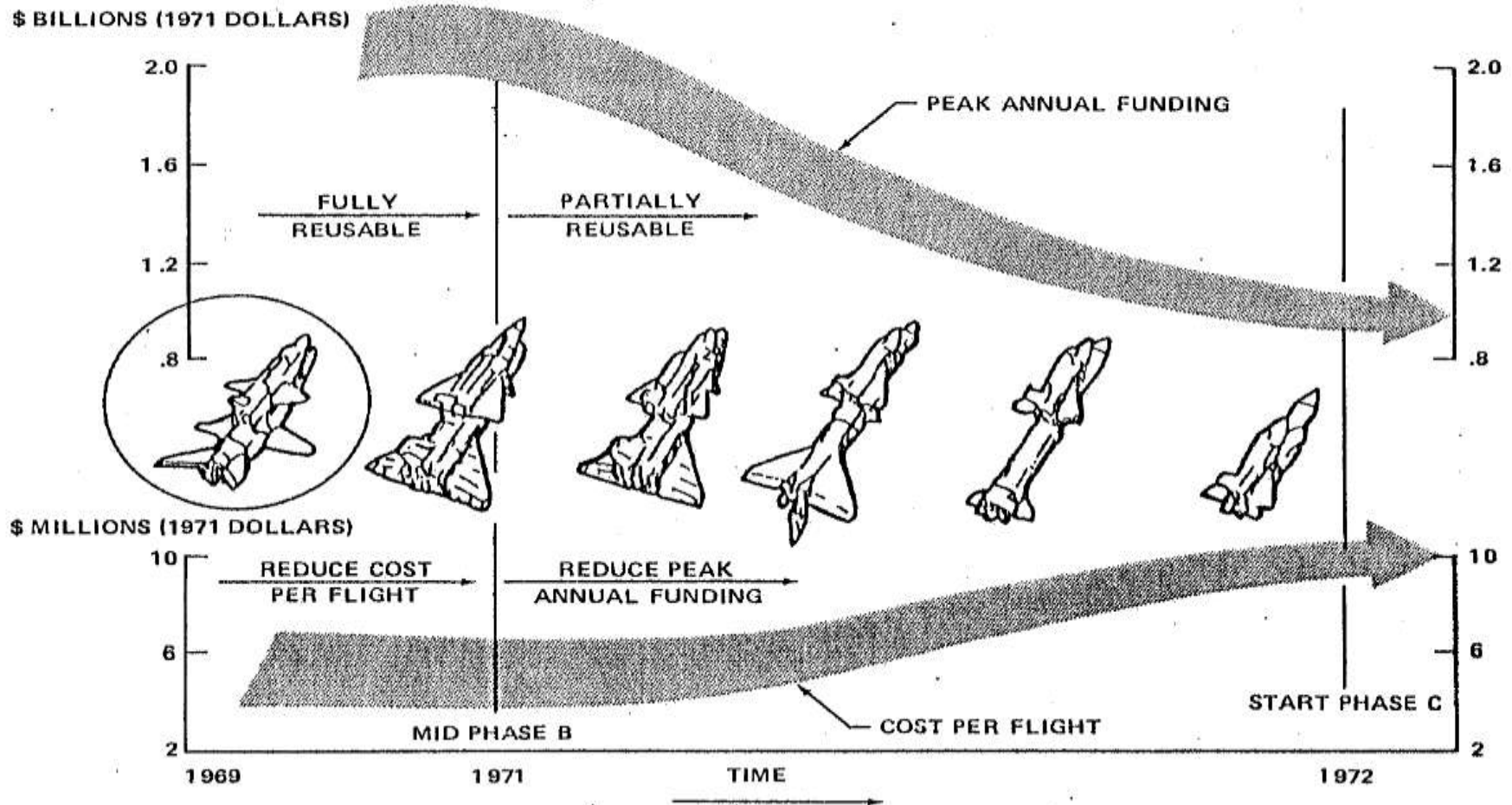
- FEBRUARY 1970 (END SHUTTLE PHASE A): NIXON OMB GAVE NASA TOTAL \$3.5 BILLION ANNUAL BUDGET, WITH 5% ESCALATION INDEFINITELY.
- MARCH 1970: PRESIDENT'S SCIENCE ADVISORY COUNCIL (PSAC) RECOMMENDED AGAINST MARS, ENDORSED SPACE SHUTTLE. (LEE DUBRIDGE)
- MARCH 7, 1970: NIXON ANNOUNCEMENT: ENDORSED SPACE SHUTTLE AS THE DOMINANT PROGRAM. NO MARS PROGRAM.
- JANUARY 1972 (MID PHASE B PRIME): OMB AND NASA ADMINISTRATOR FLETCHER NEGOTIATED \$3.4 BILLION, WITH 5% ESCALATION
- JANUARY 1973 (EARLY IN PHASE C): OMB AND FLETCHER NEGOTIATED \$3.1 BILLION, WITH 5% ESCALATION

NASA BUDGET CHRONOLOGY, 3

- SUMMER 1971 (~END PHASE B), OMB CUTS SHUTTLE TO \$6 BILLION TOTAL.
- CONFIGURATION HEAVILY INFLUENCED BY CHANGING *PEAK ANNUAL* FUNDING (NOT AS MUCH BY TOTAL COSTS)
- AS CONFIGURATION EVOLVED, ESTIMATES WERE REVISED, REVIEWED EXTENSIVELY BY THE NASA ADMINISTRATOR, THE GAO, AND THE OMB
- **COMMITMENTS WERE FIRST MADE IN MARCH OF 1972 (~END OF B PRIME)**
- **DDT&E COMMITMENT WAS FOR \$5.15 BILLION IN 1971\$. LATER RAISED TO \$5.2 BILLION BECAUSE OF IMPOSED SCHEDULE DELAY.**
- THERE WERE ESCALATION MISUNDERSTANDINGS BETWEEN HQ AND OMB

SYSTEM CONCEPT EVOLVED AS PEAK SHUTTLE FUNDING WAS REDUCED

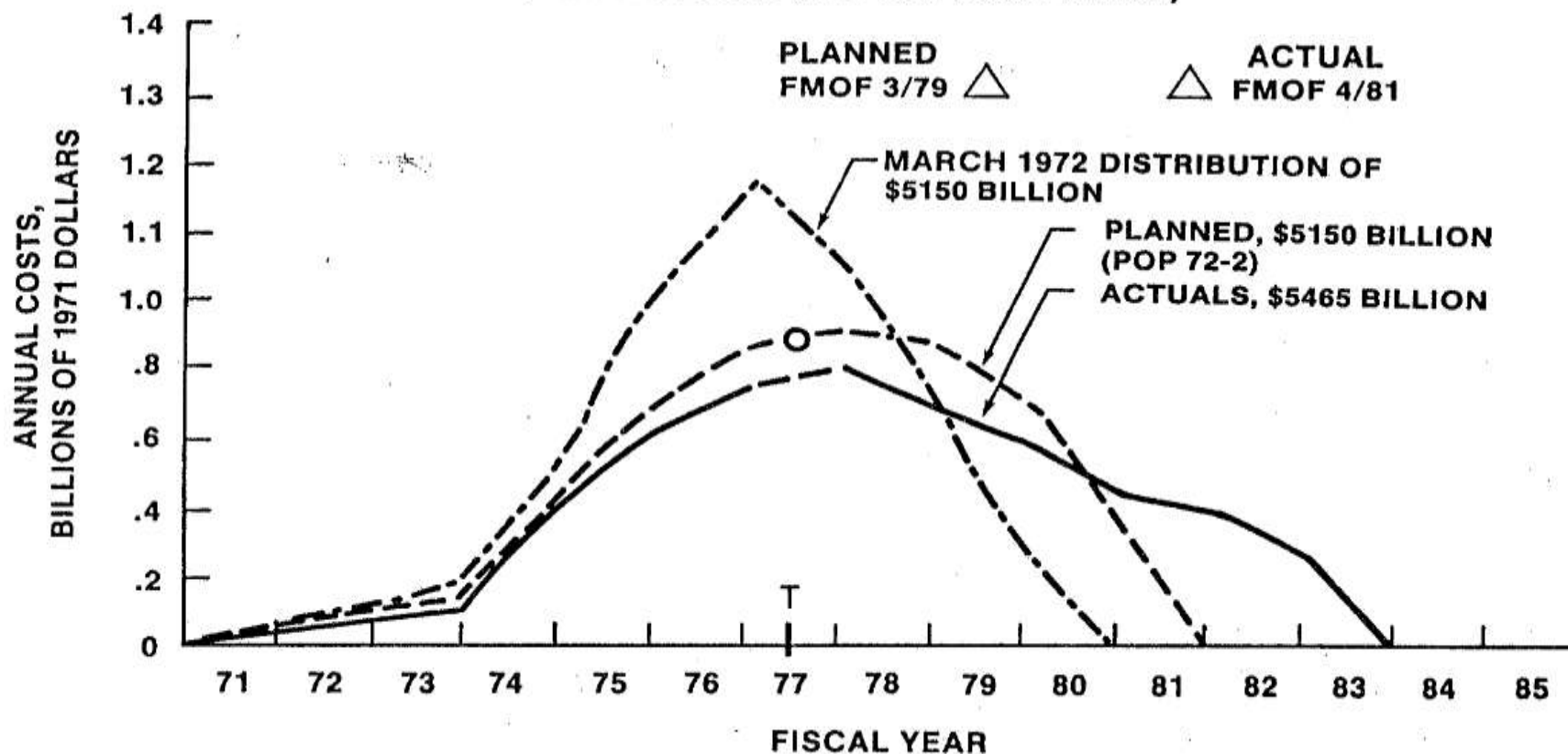
FUNDING GUIDELINE EFFECT ON SYSTEM CONCEPTS



PROGRESSION OF SHUTTLE BUDGET

Comparison of Space Shuttle Commitment *Estimates VS Actuals*

DDTE, 1971 DOLLARS (ACTUAL ESCALATION)



THE SHUTTLE ESTIMATION PROCESS

- THE COMMITMENT ESTIMATES WERE MADE BY AN INTER-CENTER TEAM, USING MOSTLY AIRCRAFT AND APOLLO DATA AS ANALOGS.
 - PROCESS LASTED THROUGHOUT PHASE B AND SOME OF B PRIME (1969-1972)
 - FIRST ESTIMATES COMPLETED TOWARD END OF PHASE B (1971), PRIOR TO TIME OF COMMITMENT (\$10-15B?)
 - COMMITMENTS MADE IN MARCH OF 1972 TO OMB, GAO, CONGRESS

THE SHUTTLE ESTIMATION PROCESS-2

- FEW EXISTING TOOLS OR MODELS!
- NASA CULTURE WAS “ENGINEERING,” WITH LITTLE REGARD FOR THE NEED FOR COST ESTIMATORS
- THE SEARCH FOR COST ESTIMATORS (~1968)
 - BY TODAY’S STANDARDS, NASA HAD NO COST ESTIMATORS
 - A FEW PEOPLE WE KNEW AT NASA CENTERS DABBLING
 - JOHNSON SPACE CENTER (3)
 - MARSHALL SPACE FLIGHT CENTER (SEVERAL)
 - LANGLEY RESEARCH CENTER (1)
 - LAUNCH CENTER (LATER KENNEDY SPACE CENTER) (1)
 - INDUSTRY: ROCKWELL, MCDONNELL DOUGLAS, GRUMMAN (ESTIMATORS WERE GRASS ROOTS GUYS))

THE SHUTTLE ESTIMATION PROCESS-3

- THE SEARCH FOR COST AND MANAGEMENT DATA:
 - NASA AWARE OF HIGH APOLLO COSTS: ACTIVELY SOUGHT LOWER COST MANAGEMENT METHODS, ESPECIALLY FROM COMMERCIAL AND STREAMLINED COMPANIES
 - BOEING
 - LOCKHEED SKUNK WORKS
 - INDUSTRY INTERVIEW PROGRAM:
 - ALL MAJOR AEROSPACE COMPANIES VISITED
 - DISCUSSED HOW TO MANAGE SUCCESSFUL PROGRAMS AND
 - WHAT DATA MIGHT BE AVAILABLE
 - MOST WERE UNWILLING TO SHARE COMMERCIAL DATA
 - BOEING MILITARY AIRCRAFT: AIRCRAFT OF THE SIZE RANGE OF THE SHUTTLE: B-47 AND B-52 GOVERNMENT DATA AVAILABLE

THE SHUTTLE ESTIMATION PROCESS-4: PRIMARY DATA POINTS

- AIRFRAME COSTS: BOEING B-52
- INTERNAL SPACE SUBSYSTEMS FROM
 - MERCURY
 - GEMINI
 - APOLLO
 - SKYLAB
- FOR THE FOLLOWING:
 - ENVIRONMENTAL CONTROL
 - ELECTRICAL POWER
 - PROPULSION
 - STABILIZATION
 - COMMUNICATIONS
 - GUIDANCE, NAVIGATION, AND CONTROL
 - THERMAL PROTECTION (LATER FROM VENDORS)

SO HOW DID NASA DO?

DO 1971\$ = 1973\$?

- COST COMMITMENT ESTIMATE WAS MADE IN 1971 TOWARD END OF PHASE B, USING CONSTANT 1971 DOLLARS
- COMMITMENT TO OMB WAS MADE MARCH 1972, DURING FY73 BUDGET CYCLE
- ESTIMATES PORTRAYED BY NASA HQ AS “CURRENT \$”
- BUT TWO YEARS OF HIGH ESCALATION HAD HAPPENED IN THE MEAN TIME
- NO ATTEMPT WAS MADE TO CORRECT THIS WITH OMB FOR FEAR OF DAMAGING THE AGENCY’S CREDIBILITY, AND PERHAPS ENDANGERING THE ENTIRE PROGRAM

REFERENCE: LETTER FROM DEPUTY COMPTROLLER MACK STEEL TO AA GENERAL ABRAHAMSON DATED 3/20/84

*
FIGURE 4-2

SPACE SHUTTLE ACTUAL DDT&E COSTS *

<u>PROJECT</u>	<u>1971 DOLLARS</u>		<u>COST</u>
	<u>ACTUAL</u> <u>ESCALATION</u>	<u>NASA/OMB</u> <u>ESCALATION</u>	<u>REAL DOLLARS</u>
ORBITER	2646.1	3288.3	4560.0
JSC (Program) Supp.	687.9	877.7	1413.1
SPACE SHUTTLE MAIN			
ENGINE	751.4	964.8	1411.8
SOLID ROCKET BOOSTER	332.8	391.2	603.4
EXTERNAL TANK	342.0	412.0	628.0
MSFC SYSTEMS			
MANAGEMENT	88.6	114.4	186.8
LAUNCH AND LANDING	463.5	600.3	1059.4
NASA HEADQUARTERS	152.3	169.8	198.8
<u>TOTALS</u>	5464.7	6818.5	10061.3

*Costs in millions of dollars. See Appendix F for details of the actual costs by fiscal year, as well as the escalation indices employed.

* CHARTS FROM 1984 HCM DISSERTATION

Space Shuttle DDT&E Cost Actuals

(1971 Dollars, Millions)

	<u>1971 ESTIMATE</u>	<u>ACTUAL DDT&E COSTS</u>	
		NASA HQ/OMB ESCALATION	ACTUAL ESCALATION
ORBITER	3750.0	3288.3	2646.1
JSC (PROGRAM) SUPPORT	470.0 (NOTE 1)	877.7	687.9
SPACE SHUTTLE MAIN ENGINE (SSME)	580.0	964.8	751.4
SOLID ROCKET BOOSTER (SRB)	350.0	391.2	332.8
EXTERNAL TANK (ET)	(NOTE 2)	412.0	342.0
MSFC SUPPORT	(NOTE 1)	114.4	88.6
LAUNCH & LANDING	(NOTE 3)	600.3	463.5
NASA HEADQUARTERS	(NOTE 4)	169.8	152.3
OMB ALLOWANCE FOR INDUCED SCHEDULE SLIPPAGES	50.0	N/A	N/A
TOTALS	5200.0	6818.5	5464.7
PERCENT GROWTH	—	31.1%	5.1%

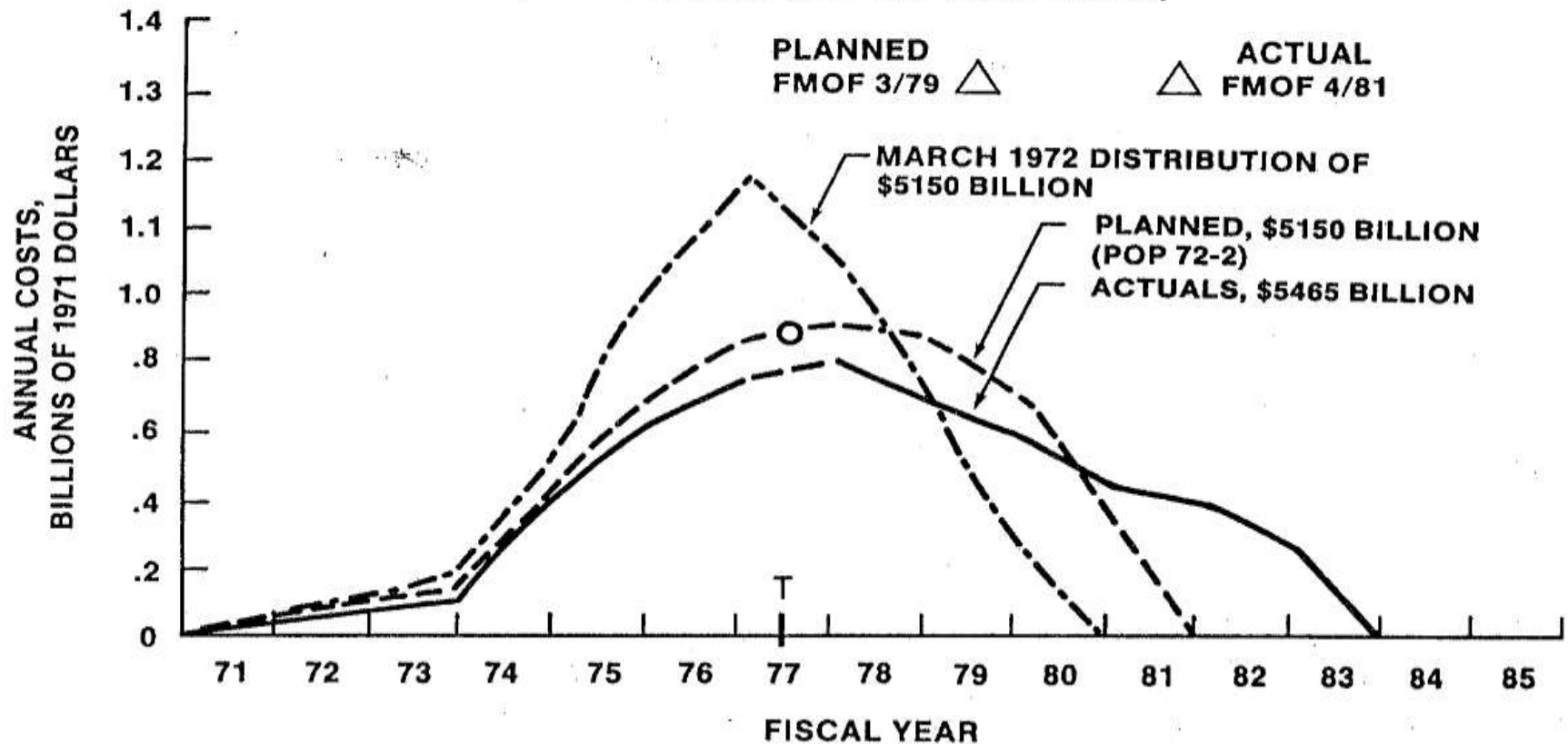
NOTES

1. ESTIMATE FOR SUPPORT ACROSS TOTAL PROGRAM (JSC, MSFC, KSC SUPPORT NOT INDIVIDUALLY ESTIMATED); ALSO SEE pp. 198-202.
2. WAS A PART OF THE ORBITER WHEN ORIGINAL ESTIMATES PREPARED
3. WAS INCLUDED PARTIALLY IN PROJECT ESTIMATES AND PARTIALLY IN PROGRAM SUPPORT (NOTE 1)
4. WAS AN UNEXPECTED CHARGE TO THE PROGRAM

HOW IT PLAYED OUT OVER TIME

Comparison of Space Shuttle Commitment *Estimates VS Actuals*

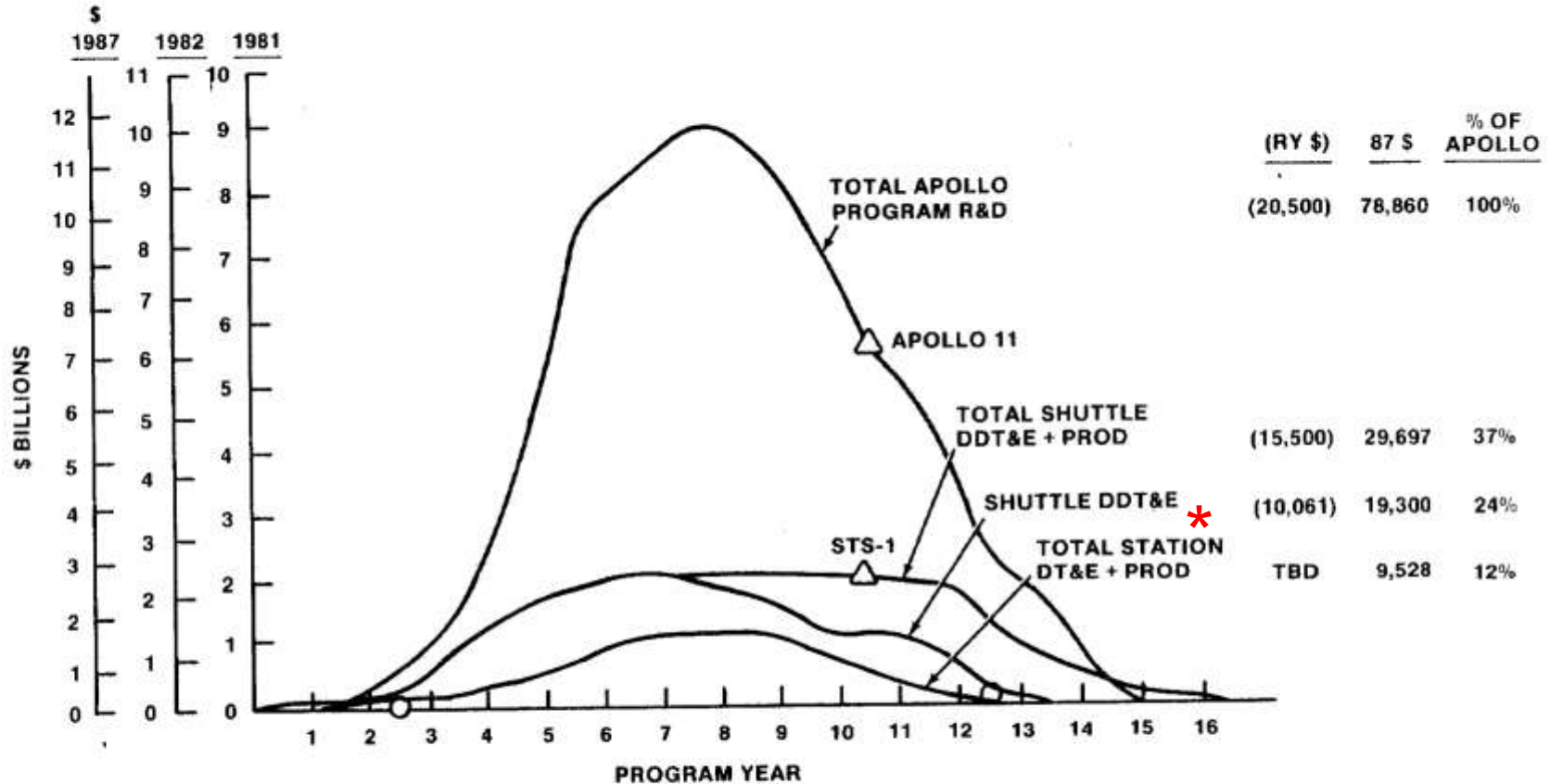
DDTE, 1971 DOLLARS (ACTUAL ESCALATION)





S-87-02851

Program Cost Comparison Apollo vs Shuttle vs Station



APOLLO	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
SHUTTLE	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
SPACE STATION	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98

* Space Station as of 1987. Grew considerably after this chart made.

HOW WE REALLY DID

- FROM THE TIME OF THE COMMITMENT TO THE END OF THE PROGRAM, A NUMBER OF CONDITIONS CHANGED:
 - NASA ACCOUNTING PRACTICES REDUCED THE AMOUNT OF UNDERLYING PROGRAM SUPPORT AVAILABLE TO THE SHUTTLE PROGRAM (ADDED \$430 MILLION)
 - NASA HQ ASSESSED THE PROGRAM FOR A SHARE OF THE AGENCY AUDITING COSTS (ADDED \$91 MILLION)
 - CONFIGURATION CHANGES: AIR BREATHING ENGINES REPLACED BY CARRIER AIRCRAFT, ETC, ETC.
- WITH THESE ADJUSTMENTS (PLUSES AND MINUSES), PROGRAM OFFICE ANALYSIS IN 1974 SHOWED AN ACTUAL DDT&E UNDERRUN OF 0.8% *

*Schomburg, R., "Reconciliation of POP 74-2 mark to the agency commitment. NASA JSC, Program Resources Office, Sept. 20, 1974.

AND THEN THERE WAS COST PER FLIGHT

- COST PER FLIGHT ESTIMATES WERE BASED ON
 - TRAFFIC RATE OF 50+ PER YEAR (WHAT ENGINEERS AND ECONOMISTS WERE SAYING, BASED ON ESTIMATED DEMAND).
 - ASSUMPTION OF SELF-CHECKOUT FOR THE VEHICLES
 - INTEL 386 CHIP ARCHITECTURE FOR COMPUTERS
 - MAJOR CULTURAL CHANGES IN PRE-LAUNCH PROCESSING FROM THE APOLLO PROGRAM
 - TOTALLY REUSABLE THERMAL PROTECTION SYSTEM
 - LONG MAIN ENGINE LIFE
 - COST PER FLIGHT ESTIMATED AT \$10.5 MILLION 1971\$ (BY NASA, CONTRACTORS, AND ECON)

AND THEN THERE WAS COST PER FLIGHT-2

- WHAT ACTUALLY HAPPENED
 - TRAFFIC RATES WERE FROM ZERO TO 9 (AVE 4.3 PER YEAR)
 - STATE OF THE ART IN SELF CHECKOUT DID NOT MATERIALIZE
 - CULTURAL INERTIA RESULTED IN USING SAME PRACTICES AS APOLLO, PLUS ADDED PROCESSES FOR SHUTTLE-UNIQUE SYSTEMS (LIKE THE THERMAL PROTECTION)
 - COMPUTER STATE OF THE ART CHANGE MADE 386-BASED ARCHITECTURE TRANSIENT
 - THERMAL PROTECTION SYSTEM HAD TO BE 100% INSPECTED AND TESTED (THOUSANDS OF TILES) EACH MISSION
 - MAIN ENGINES AT FIRST WERE CHANGED FREQUENTLY
 - ACTUAL COST PER FLIGHT AS MUCH AS \$300 MILLION (1971 DOLLARS)

COST PER FLIGHT LESSONS LEARNED

- NO ONE CAN PREDICT THE FUTURE: EVEN THE BEST MINDS (ECON, NASA) TOTALLY MISCALCULATED
- OVER-OPTIMISM: ALMOST EVERYONE ASSUMED BEST CASE SCENARIOS
- CULTURAL CHANGE: WILL NOT OCCUR IN THE ABSENCE OF A MAJOR THREAT (WHICH DID NOT EXIST FOR SHUTTLE)

SO WHAT DID WE LEARN? (EXAMPLES)

- STARTING A MAJOR PROGRAM WITHOUT FIRM BUDGETS AND TARGET SCHEDULES IN PLACE WILL COST TIME AND MONEY
- BETTING ON THE COME WITH TECHNOLOGIES IS VERY EXPENSIVE (e.g., THERMAL PROTECTION, MAIN ENGINES)
- NASA BADLY NEEDED TO IMPROVE ITS ESTIMATION AND COST REPORTING CAPABILITIES, BUILT ON SHUTTLE EXPERIENCES
- NASA NEEDED MORE DATA AND MORE ESTIMATORS
- CULTURAL INERTIA AND RESISTANCE TO CHANGE LED TO LARGE OVERRUNS IN OPERATIONS COSTS
- GEOGRAPHICAL SEPARATION OF PROJECT MANAGEMENT FOR POLITICAL REASONS WAS COSTLY.

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- Mandell, H.C., “Management Lessons Learned from the Space Shuttle Program,” NASA Johnson Space Center, Sept. 30, 1985.

DETAILED HISTORICAL REFERENCES

THE BUDGET INFLUENCED THE CONFIGURATION

- EARLY ESTIMATES (1969-1970 ERA) WERE BASED ON TWO STAGE FULLY REUSABLE VEHICLES
- AS FUNDING CONSTRAINTS WERE LEVIED BY THE OMB AND CONGRESS, THE CONFIGURATION ADAPTED TO THE AVAILABLE **PEAK ANNUAL** FUNDING

Shuttle DDT&E Cost (Actual Inflation Rates)

Actuals Through FY 82; DDTE Ends FY 82

	FY71	FY72	FY73	FY74	FY75	FY76	TRAN	FY77	FY78	(PRIOR) FY79 (3752.8)	FY80	FY81	FY82	FY83	FY84	FY85	TOTAL
ORBITER																	
REAL YEAR \$	0.0	0.0	70.7	327.8	607.0	736.0	196.5	746.7	605.9	462.2	363.9	264.7	178.6	0.0	0.0	0.0	4560.0
INFLATION %	0.0	7.3	8.5	7.1	13.3	10.0	2.2	9.3	13.2	11.3	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	0.0	0.0	60.7	262.9	437.4	482.1	126.0	437.9	313.9	215.1	151.9	98.4	59.8	0.0	0.0	0.0	2646.1
ORB OTH+PROGSUPP																	
REAL YEAR \$	0.0	0.6	8.1	52.8	68.3	91.3	26.9	127.1	161.5	220.3	240.3	214.5	201.4	0.0	0.0	0.0	1413.1
INFLATION %	0.0	6.6	9.2	7.6	11.2	10.0	2.7	9.0	12.1	10.3	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	0.0	0.6	7.0	42.1	49.0	59.4	17.1	74.1	84.0	103.9	103.6	80.8	68.3	0.0	0.0	0.0	687.9
SSME																	
REAL YEAR \$	0.0	5.5	51.6	95.7	112.8	138.8	40.5	182.2	197.7	170.9	137.9	137.8	140.4	0.0	0.0	0.0	1411.8
INFLATION %	0.0	6.0	10.2	9.2	11.9	11.1	2.5	8.2	12.1	10.7	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	0.0	5.2	44.2	75.0	79.0	87.5	24.9	103.6	100.3	78.3	56.7	50.4	46.3	0.0	0.0	0.0	751.4
SRH																	
REAL YEAR \$	0.0	0.0	0.0	2.4	21.5	62.2	20.5	102.7	109.2	113.6	67.1	52.1	52.1	0.0	0.0	0.0	603.4
INFLATION %	0.0	4.7	6.1	7.8	8.9	9.9	2.6	11.3	9.2	6.3	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	0.0	0.0	0.0	2.0	16.5	43.4	13.9	62.8	61.1	59.8	31.7	21.9	19.7	0.0	0.0	0.0	332.8
EXTERNAL TANK																	
REAL YEAR \$	0.0	0.0	0.0	15.5	35.3	80.6	26.0	84.6	88.2	103.3	68.9	72.9	52.7	0.0	0.0	0.0	628.0
INFLATION %	0.0	5.2	8.4	10.5	9.4	9.3	2.5	6.6	8.3	10.2	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	0.0	0.0	0.0	12.3	25.6	53.5	16.8	51.4	49.5	52.6	31.4	29.6	19.3	0.0	0.0	0.0	342.0
MSFC SYS MGMT																	
REAL YEAR \$	0.0	0.0	0.0	0.7	2.0	5.0	3.1	25.0	44.1	32.8	28.1	24.9	21.1	0.0	0.0	0.0	186.6
INFLATION %	0.0	6.6	9.2	7.6	11.2	10.0	2.2	9.0	12.1	10.3	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	0.0	0.0	0.0	0.6	1.4	3.3	2.0	14.6	22.9	15.5	11.9	9.4	7.2	0.0	0.0	0.0	88.6
LAUNCH & LANDING																	
REAL YEAR \$	0.0	0.0	0.2	2.5	10.1	40.1	14.5	83.4	109.5	146.3	164.6	239.2	249.0	0.0	0.0	0.0	1059.4
INFLATION %	0.0	6.6	9.2	7.6	11.2	10.0	2.2	9.0	12.1	10.3	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	0.0	0.0	0.2	2.0	7.2	26.1	9.2	48.7	57.0	69.0	69.6	90.1	84.5	0.0	0.0	0.0	463.5
HEADQUARTERS																	
REAL YEAR \$	43.1	53.4	13.9	4.7	7.7	11.9	3.3	12.4	11.7	9.6	7.3	12.0	7.8	0.0	0.0	0.0	198.6
INFLATION %	0.0	6.6	9.2	7.6	11.2	10.0	2.2	9.0	12.1	10.3	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	43.1	50.1	11.9	3.7	5.5	7.7	2.1	7.2	6.1	4.5	3.1	4.5	2.6	0.0	0.0	0.0	152.3
SUBTOT R/Y\$																	
	43.1	59.5	144.5	502.1	864.7	1165.9	331.3	1364.1	1327.8	1259.0	1078.1	1018.1	903.1	0.0	0.0	0.0	10061.3
SUBTOT FY71\$																	
	43.1	55.8	124.0	400.6	621.7	763.1	212.1	800.3	694.8	598.6	457.9	385.1	307.7	0.0	0.0	0.0	5464.7
APA-UNALLOCATED																	
REAL YEAR \$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INFLATION %	0.0	6.6	9.2	7.6	11.2	10.0	2.2	9.0	12.1	10.3	11.5	12.3	11.0	9.6	9.0	9.0	
CONSTANT 71\$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRAND TOTAL																	
										(7062.0)							
REAL YEAR \$	43.1	59.5	144.5	502.1	864.7	1165.9	331.3	1364.1	1327.8	1259.0	1078.1	1018.1	903.1	0.0	0.0	0.0	10061.3
CONSTANT 71\$	43.1	55.8	124.0	400.6	621.7	763.1	212.1	800.3	694.8	598.6	457.9	385.1	307.7	0.0	0.0	0.0	5464.7

Shuttle DDT&E Cost (NASA/OMB Inflation Formula)

Actuals Through FY 82; DDTE Ends FY 82

	(PRIOR)																
INFLATION %	FY71	FY72	FY73	FY74	FY75	FY76	THAN	FY77	FY78	FY79	FY80	FY81	FY82	FY83	FY84	FY85	TOTAL
ORBITER	(1752.8)																
REAL YEAR \$	0.0	0.0	70.7	327.8	607.0	736.0	196.5	746.7	605.9	462.2	363.9	264.7	178.6	0.0	0.0	0.0	4560.0
CONSTANT 71\$	0.0	0.0	70.7	306.4	523.8	581.1	155.1	541.7	410.8	286.2	202.1	130.9	79.6	0.0	0.0	0.0	3288.3
ORB OTH+PROGSUPP	(756.9)																
REAL YEAR \$	0.0	0.6	8.1	52.8	68.3	91.3	26.9	127.1	161.5	220.3	240.3	214.5	201.4	0.0	0.0	0.0	1413.1
CONSTANT 71\$	0.0	0.6	8.1	49.3	58.9	72.1	21.2	92.2	109.5	136.4	133.4	106.1	89.7	0.0	0.0	0.0	877.7
SSME	(995.7)																
REAL YEAR \$	0.0	5.5	51.6	95.7	112.8	138.8	40.5	182.2	197.7	170.9	137.9	137.8	140.4	0.0	0.0	0.0	1411.8
CONSTANT 71\$	0.0	5.5	51.6	89.4	97.3	109.6	32.0	132.2	134.0	105.8	76.6	68.1	62.5	0.0	0.0	0.0	964.8
SRB	(432.1)																
REAL YEAR \$	0.0	0.0	0.0	2.4	21.5	62.2	20.5	102.7	109.2	113.6	67.1	52.1	52.1	0.0	0.0	0.0	603.4
CONSTANT 71\$	0.0	0.0	0.0	2.2	18.6	49.1	16.2	74.5	74.0	70.3	37.3	25.8	23.2	0.0	0.0	0.0	391.2
EXTERNAL TANK	(433.5)																
REAL YEAR \$	0.0	0.0	0.0	15.5	35.3	80.6	26.0	84.6	88.2	103.3	68.9	72.9	52.7	0.0	0.0	0.0	628.0
CONSTANT 71\$	0.0	0.0	0.0	14.5	30.5	63.6	20.5	61.4	59.8	64.0	36.3	36.0	23.5	0.0	0.0	0.0	412.0
MSFC SYS NGMT	(112.7)																
REAL YEAR \$	0.0	0.0	0.0	0.7	2.0	5.0	3.1	25.0	44.1	32.8	28.1	24.9	21.1	0.0	0.0	0.0	186.8
CONSTANT 71\$	0.0	0.0	0.0	0.7	1.7	3.9	2.4	18.1	29.9	20.3	15.6	12.3	9.4	0.0	0.0	0.0	114.4
LAUNCH & LANDING	(406.6)																
REAL YEAR \$	0.0	0.0	0.2	2.5	10.1	40.1	14.5	83.4	109.5	146.3	164.6	239.2	249.0	0.0	0.0	0.0	1059.4
CONSTANT 71\$	0.0	0.0	0.2	2.3	8.7	31.7	11.4	60.5	74.2	90.6	91.4	118.3	110.9	0.0	0.0	0.0	600.3
HEADQUARTERS	(171.7)																
REAL YEAR \$	43.1	53.4	13.9	4.7	7.7	11.9	3.3	12.4	11.7	9.6	7.3	12.0	7.8	0.0	0.0	0.0	198.8
CONSTANT 71\$	43.1	53.4	13.9	4.4	6.6	9.4	2.6	9.0	7.9	5.9	4.1	5.9	3.5	0.0	0.0	0.0	169.8
SUBTOT R/Y\$	43.1	59.5	144.5	502.1	864.7	1165.9	331.3	1364.1	1327.8	1259.0	1078.1	1018.1	903.1	0.0	0.0	0.0	10061.3
SUBTOT FY71\$	43.1	59.5	144.5	469.3	746.2	920.5	261.6	989.6	900.3	779.6	598.7	503.5	402.3	0.0	0.0	0.0	6818.5
APA-UNALLOCATED																	
REAL YEAR \$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONSTANT 71\$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GRAND TOTAL	(7062.0)																
REAL YEAR \$	43.1	59.5	144.5	502.1	864.7	1165.9	331.3	1364.1	1327.8	1259.0	1078.1	1018.1	903.1	0.0	0.0	0.0	10061.3
CONSTANT 71\$	43.1	59.5	144.5	469.3	746.2	920.5	261.6	989.6	900.3	779.6	598.7	503.5	402.3	0.0	0.0	0.0	6818.5

NASA HQ EXPLANATION OF ESCALATION DIFFERENCES (HQ, MACK STEEL 3/20/84)

As background, the Shuttle DDT&E commitment was made in March 1972 during the FY 1973 budget process with the Congress. The agency portrayed the DDT&E commitment estimate (5.150 1971 \$ at that time) as "current", thus equating it with FY 1983 budget dollars. This meant that the estimate as portrayed was 18 - 24 months more current than was actually the case. There was no attempt to correct this anomaly in the estimate during the FY 1974 Budget cycle. There was concern that adjusting the DDT&E commitment for $2\frac{1}{2}$ to 3 years inflation, one year after the commitment was made, would hurt the agency's credibility and possible put the continuance of the program in jeopardy.

In addition to the difference in de-escalation methodology, the specific annual inflation rates used by Level II are significantly higher than the documented rates used by the agency. Using the Level II de-escalation methodology but substituting the agency inflation rates yields an overrun of the 5.2 billion commitment of 16.7% as opposed to the 5.1% claimed by Level II.

PROGRAM MANAGER'S LETTER, 1983

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas
77058



COMPARISON OF SPACE SHUTTLE PROGRAM DEVELOPMENT COST ESTIMATES WITH ACTUAL PROGRAM COSTS

Reply to AFR #: LA43-83-126

TO: Distribution

FROM: LA/Manager, National STS Program

SUBJECT: Cost Control of Shuttle Development

We recently had cause to review the total costs of the Space Shuttle program as measured against the original OMB commitment. The results are noteworthy and deserve NASA-wide understanding. In the Spring of 1969, a NASA inter-center working group began the development of a government cost estimate, which was completed in FY 71, and stated in FY 71 constant dollars, as shown in the first column, below (all values in thousands). A final assessment has been documented in a recently completed study (Assessment of Space Shuttle Cost Estimating Methods, H. C. Mandell, August 1983). Converted to 1971 dollars, actual costs for the program are shown in the second column, using actual inflation rates experienced by the program; the third column is the cost based on the NASA HQ/OMB negotiated inflation rates (which utilized estimated escalation rates and ignored the first two years of inflation). The last column presents the actual costs in real-year dollars (dollars of the year expended).

	(1971\$) Estimate	Actuals, 1971\$, Actual Escalation	Actuals, 1971\$, NASA HQ/OMB Escalation	Actuals, Real Year Dollars
Orbiter	3750	2646	3288	4560
Program Support	470	693	878	1413
SSME	580	751	965	1412
SRB	350	338	391	603
ET	*	342	412	620
HQS	**	152	170	199
KSC	***	465	600	1059
MSFC Systems Mgmt.	**	89	114	187
Subtotal	5150			
OMB sched. adjust.	50			
TOTALS	5200	5465	6819	10061
Percent over 5200		5%	31%	N/A

*was part of Orbiter **was not included in original estimates
***was included in project estimates and program support

Additionally, first order adjustments to make the actuals consistent with conditions which existed at the time the estimates were made (e.g., removal of support items not intended to be included in the original estimates) result in actuals of 5158.2 (million 71\$), or an underrun of .8%. Inflation calculation differences aside, this is a record of outstanding achievement.

Glynn S. Lunney

In the Spring of 1969, a NASA inter-center working group developed a government cost estimate of the Space Shuttle program in preparation for the procurement processes to be held in the 1970-71 time frame. The estimates were completed in FY 71, and were stated in the constant dollars of that time period (1971). Extensive reviews of the estimates were held at all levels of agency management, by the OMS, and later by the U.S. General Accounting Office. The estimates performed have been previously documented (see Mandell, H. C., Assessment of Space Shuttle Cost Estimating Methods, August 1983). In millions of 1971 dollars, the estimates were:

Orbiter (040C Configuration)	3750
Program Support	470
SSME	580
SRB	350
ET (was part of the Orbiter)	
HQS (was not considered)	
KSC (was included in project estimates and program support)	
Subtotal	5150 (\$ 1971)
OMB Adjustment for schedule impact	50
Total "commitment"	5200

Cost actuals for the program were (the first column uses actual cost escalation experienced on the program; the second column is the NASA/OMB negotiated escalation rate):

Orbiter	2646	3288
JSC Support	683	878
SSME	751	965
SRB	338	391
ET	342	412
MSFC Systems Mgt.	89	114
Launch & Landing (KSC)	464	600
Headquarters	152	170
Totals	5465	6819
Percent Over 5200	5%	31%

As documented in the above reference, first order adjustments to make the actuals consistent with conditions which existed at the time the estimates were made (e.g., removal of support items not included in the original estimates) resulted in actuals of 5158.2 (billion 1971 dollars), or an underrun of eight-tenths of one percent.