

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

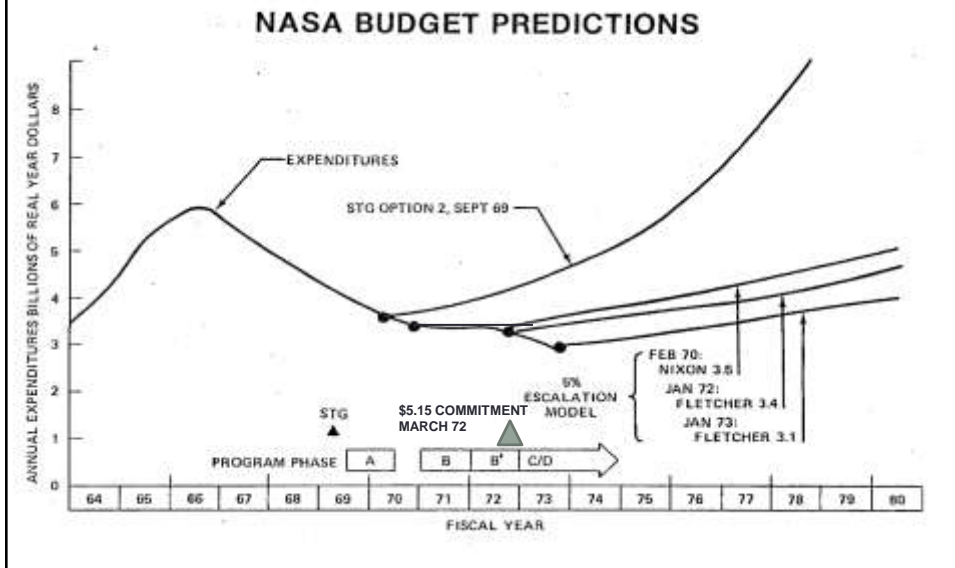
SPACE SHUTTLE BACKGROUND

- 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 CHRONOLOGY, 2

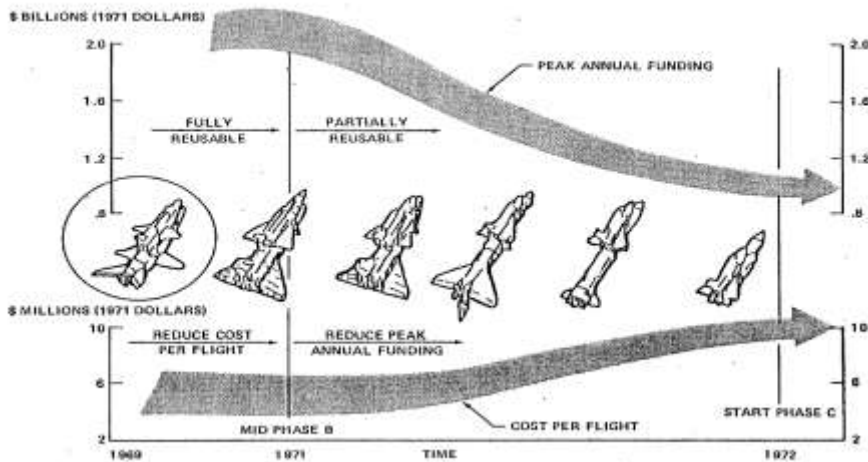
- FEBRUARY 1970 (END SHUTTLE PHASE A): NIXON OMB GAVE NASA TOTAL \$3.5 BILLION ANNUAL BUDGET, WITH 5% ESCALATION INDEFINITELY.
- MARCH 1970: PRESIDENT'S SCIENCE ADVISORY COUNCIL (PSAC) RECOMMENDED AGAINST MARS, ENDORSED SPACE SHUTTLE. (LEE DUBRIDGE)
- MARCH 7, 1970: NIXON ANNOUNCEMENT: ENDORSED SPACE 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

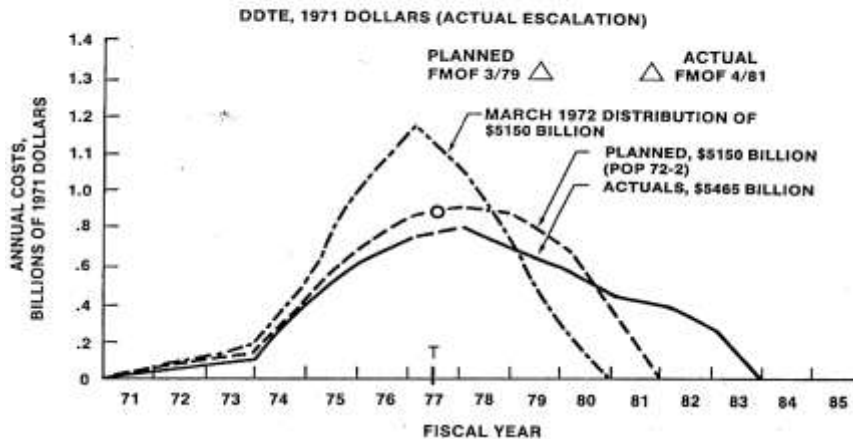
SYSTEM CONCEPT EVOLVED AS PEAK SHUTTLE FUNDING WAS REDUCED

FUNDING GUIDELINE EFFECT ON SYSTEM CONCEPTS



PROGRESSION OF SHUTTLE BUDGET

Comparison of Space Shuttle Commitment *Estimates VS Actuals*



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 *

PROJECT	1971 DOLLARS		REAL DOLLARS
	ACTUAL ESCALATION	NASA/OMB ESCALATION	
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

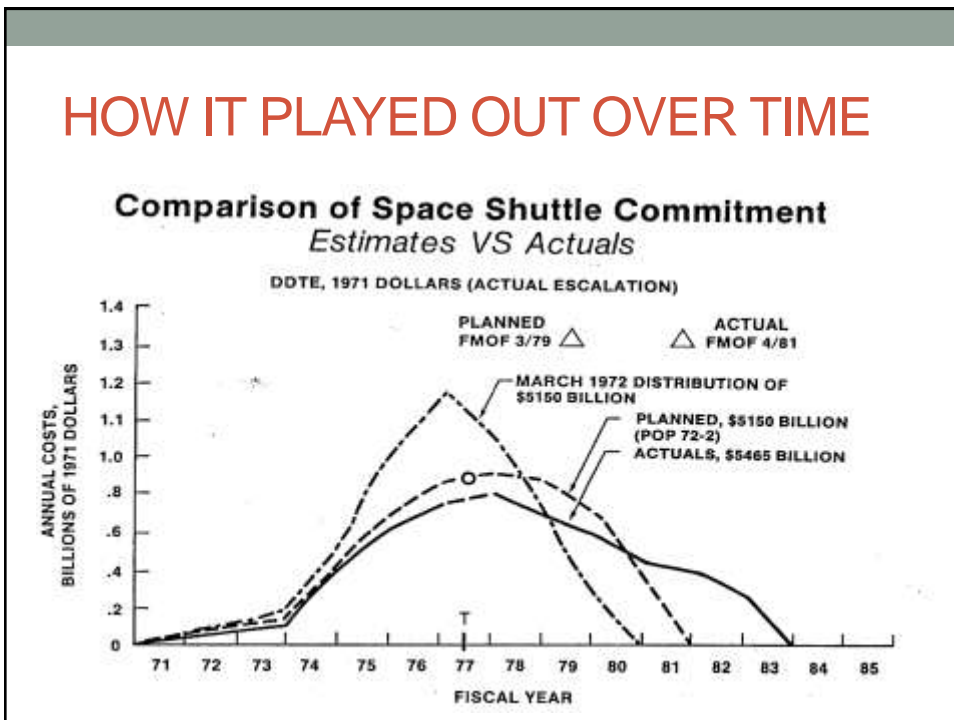
Space Shuttle DDT&E Cost Actuals (1971 Dollars, Millions)

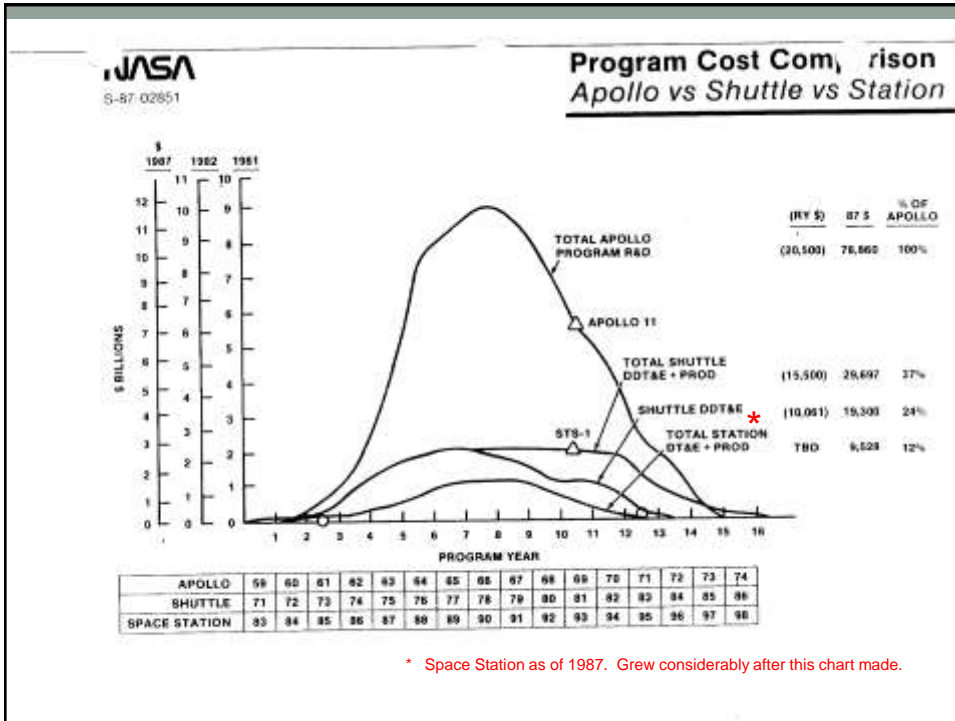
	1971 ESTIMATE	ACTUAL DDT&E COSTS NASA HQ/OMB ESCALATION	ACTUAL ESCALATION
ORBITER	3750.0	3288.3	2846.1
JSC (PROGRAM) SUPPORT	470.0 (NOTE 1)	877.7	687.9
SPACE SHUTTLE MAIN ENGINE (SSME)	580.0	964.8	751.4
SOLID ROCKET BOOSTER (SRB)	350.0	391.2	332.8
EXTERNAL TANK (ET)	(NOTE 2)	412.0	342.0
MSFC SUPPORT	(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





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.

PRIMARY REFERENCES

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- Letter From NASA Deputy Comptroller Mack Steel To AA General Abrahamson, Dated 3/20/84
- Schomburg, R., "Reconciliation of POP 74-2 Mark to the Agency Commitment." NASA JSC, Program Resources Office, Sept. 20, 1974.
- 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

	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	TOTAL		
ORBITER																									
REAL YEAR \$	0.0	0.0	70.7	327.9	587.0	734.0	106.5	146.7	605.9	462.2	363.9	244.7	178.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,440.0	
INFLATION %	0.0	0.0	7.3	6.5	7.1	13.3	14.0	2.2	4.2	13.2	11.3	11.5	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	
CONSTANT Y18	0.0	0.0	60.7	242.9	437.4	483.1	124.0	137.4	313.4	215.1	151.3	86.4	59.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,146.1
(1750.8)																									
ORBITER PROGRAM																									
REAL YEAR \$	0.0	0.1	0.1	52.9	48.3	91.3	26.9	127.3	161.9	220.3	240.3	214.5	201.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,413.1	
INFLATION %	0.0	0.0	0.0	9.2	1.8	13.2	18.0	2.1	9.0	12.1	10.3	11.5	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	0.0	0.1	0.1	47.1	49.0	57.8	17.1	74.3	89.4	103.8	121.0	89.3	69.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,187.9
(1,955.3)																									
ORBITER																									
REAL YEAR \$	0.0	0.1	81.8	85.7	122.8	138.0	16.5	182.2	197.7	170.9	177.9	137.6	144.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,413.1	
INFLATION %	0.0	0.0	8.2	10.2	5.0	11.9	11.1	2.5	9.2	12.1	10.3	11.3	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	0.0	0.1	74.7	75.0	78.0	87.5	24.9	103.8	100.3	78.3	56.7	50.8	44.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,251.4
(1,437.1)																									
ORBITER																									
REAL YEAR \$	0.0	0.0	0.0	3.4	21.5	62.2	10.3	107.3	189.2	113.8	47.1	52.1	52.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	609.4	
INFLATION %	0.0	0.0	0.0	4.1	7.8	9.9	9.9	2.6	11.3	9.2	6.3	11.5	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	0.0	0.0	0.0	0.0	14.5	43.4	13.7	45.8	41.1	49.8	31.7	21.8	19.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	332.8
(1,437.1)																									
EXTERNAL TASK																									
REAL YEAR \$	0.0	0.4	0.0	15.5	29.3	88.4	16.0	84.4	88.2	123.3	48.3	72.9	57.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	626.0
INFLATION %	0.0	0.0	0.0	8.4	10.5	9.4	9.3	2.8	6.6	6.3	10.2	11.5	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	0.0	0.4	0.0	12.3	25.6	57.5	16.8	51.4	49.5	53.4	31.8	29.6	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	347.8
(1,122.7)																									
SPC SEE MGMT																									
REAL YEAR \$	0.0	0.0	0.0	0.0	2.0	7.0	3.0	25.0	44.1	32.0	28.1	24.9	21.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	188.8
INFLATION %	0.0	0.0	0.0	0.0	7.4	11.2	6.2	9.0	12.1	12.4	12.5	12.3	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	0.0	0.0	0.0	0.0	1.4	5.3	2.0	14.4	22.9	15.3	11.9	9.4	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	89.6
(1,406.8)																									
LAUNCH & SERVICES																									
REAL YEAR \$	0.0	0.0	0.2	3.5	10.2	40.1	14.5	83.4	105.5	146.3	146.6	239.2	249.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,459.4
INFLATION %	0.0	0.0	9.2	9.8	11.2	10.0	0.3	9.0	12.1	10.3	11.5	12.3	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	0.0	0.0	0.2	3.0	7.2	26.1	6.2	48.7	57.8	48.0	49.5	93.1	84.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	463.5
(1,717.7)																									
RESEARCHERS																									
REAL YEAR \$	43.1	53.4	13.9	4.7	7.2	11.9	3.1	12.4	13.7	9.4	7.3	12.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	198.6
INFLATION %	0.0	4.4	9.2	7.4	11.2	10.0	2.2	9.0	12.1	10.3	11.5	12.3	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	43.1	50.1	11.9	3.7	5.9	7.7	2.1	7.2	6.1	4.9	3.1	4.5	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	152.3
(1,006.1)																									
RESEARCHERS																									
REAL YEAR \$	43.1	54.5	144.5	167.1	244.7	148.9	214.2	1384.1	1327.8	1238.0	1028.1	1018.1	903.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10,061.3
INFLATION %	43.1	45.8	294.2	402.6	421.3	381.1	232.1	886.3	684.8	598.4	433.8	385.1	303.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	43.1	50.1	119.5	111.9	141.7	111.9	111.9	111.9	111.9	111.9	111.9	111.9	111.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,664.7
(1,042.0)																									
GRAND TOTAL																									
REAL YEAR \$	43.1	59.5	144.5	167.1	244.7	148.9	214.2	1384.1	1327.8	1238.0	1028.1	1018.1	903.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10,061.3
INFLATION %	43.1	45.8	294.2	402.6	421.3	381.1	232.1	886.3	684.8	598.4	433.8	385.1	303.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
CONSTANT Y18	43.1	50.1	119.5	111.9	141.7	111.9	111.9	111.9	111.9	111.9	111.9	111.9	111.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,664.7

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

Actuals Through FY 82; DDTE Ends FY 82

INFLATION %	(\$MILLIONS)																TOTAL
	FY71	FY72	FY73	FY74	FY75	FY76	FY77	FY78	FY79	FY80	FY81	FY82	FY83	FY84	FY85		
ORBITER	(\$757.88)																
REAL YEAR \$	0.0	0.0	70.7	37.8	497.8	734.0	184.5	744.7	449.9	462.2	763.9	744.7	778.6	0.0	0.0	0.0	4560.0
CONSTANT 71\$	0.0	0.0	36.7	106.4	673.8	881.1	155.1	341.7	410.8	746.2	722.1	710.9	79.6	0.0	0.0	0.0	3285.3
OMB OTH-PROCESSEDP	(\$754.97)																
REAL YEAR \$	0.0	0.0	8.1	52.8	66.7	92.1	24.9	127.1	141.5	228.2	240.3	214.5	261.4	0.0	0.0	0.0	1412.1
CONSTANT 71\$	0.0	0.0	8.1	49.3	58.5	72.1	21.2	92.2	108.5	174.4	133.4	188.1	89.7	0.0	0.0	0.0	877.7
SOME	(\$55.79)																
REAL YEAR \$	0.0	5.5	51.6	95.7	112.8	128.8	46.5	182.7	197.7	178.8	132.9	127.8	149.4	0.0	0.0	0.0	1411.8
CONSTANT 71\$	0.0	5.5	51.6	95.4	97.3	109.6	32.0	132.7	124.0	105.8	76.4	68.1	82.5	0.0	0.0	0.0	944.8
SRB	(\$432.13)																
REAL YEAR \$	0.0	0.0	0.0	7.4	21.5	62.2	28.5	102.7	109.7	113.6	87.1	52.1	52.1	0.0	0.0	0.0	602.4
CONSTANT 71\$	0.0	0.0	0.0	7.2	18.4	68.1	14.2	78.5	74.0	78.3	37.9	35.8	23.2	0.0	0.0	0.0	351.2
EXTERNAL TANK	(\$233.51)																
REAL YEAR \$	0.0	0.0	0.0	15.5	35.3	88.8	24.0	84.6	84.2	103.2	84.9	72.9	57.7	0.0	0.0	0.0	828.0
CONSTANT 71\$	0.0	0.0	0.0	14.5	30.5	63.8	20.3	81.4	59.8	64.0	38.3	38.6	23.5	0.0	0.0	0.0	412.0
WPC EYE MOUNT	(\$132.71)																
REAL YEAR \$	0.0	0.0	6.8	4.7	2.0	5.0	3.1	25.0	44.3	37.8	38.1	34.8	21.1	0.0	0.0	0.0	188.8
CONSTANT 71\$	0.0	0.0	6.8	4.7	1.7	3.9	2.8	28.1	28.9	29.3	19.8	12.3	9.4	0.0	0.0	0.0	114.8
LAUNCH & LANDING	(\$404.61)																
REAL YEAR \$	0.0	0.0	6.2	2.5	18.1	68.3	44.5	83.4	109.5	144.3	184.6	239.2	249.0	0.0	0.0	0.0	1658.4
CONSTANT 71\$	0.0	0.0	6.2	2.3	8.7	31.7	31.4	80.5	74.2	94.4	91.4	118.1	119.9	0.0	0.0	0.0	600.2
HEADQUARTERS	(\$171.77)																
REAL YEAR \$	43.1	53.4	13.9	4.7	7.7	11.9	3.3	32.4	31.7	9.6	7.3	12.0	7.8	0.0	0.0	0.0	288.8
CONSTANT 71\$	43.1	53.4	13.9	4.4	4.4	8.4	2.6	9.8	7.9	4.1	5.9	3.5	0.0	0.0	0.0	0.0	169.8
SUPPORT ACTS	(\$7662.0)																
REAL YEAR \$	43.1	59.5	144.5	502.1	844.7	1165.9	331.3	1364.1	1329.8	1254.0	1078.1	1818.1	903.1	0.0	0.0	0.0	10061.3
CONSTANT 71\$	43.1	59.5	144.5	455.1	746.2	928.5	261.6	889.6	868.3	779.6	596.7	503.5	402.3	0.0	0.0	0.0	4818.3
SPA-SHALL LOCATED	(\$0.0)																
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	(\$7662.0)																
REAL YEAR \$	43.1	59.5	144.5	502.1	844.7	1165.9	331.3	1364.1	1329.8	1254.0	1078.1	1818.1	903.1	0.0	0.0	0.0	10061.3
CONSTANT 71\$	43.1	59.5	144.5	489.3	746.2	928.5	261.6	889.6	868.3	779.6	596.7	503.5	402.3	0.0	0.0	0.0	4818.3


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 ported 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 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



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

Date: 12-13-83

To: Distribution

From: (A) Manager, National SSB Program

Subject: Cost Control of Shuttle Development

We recently had the honor to review the cost status of the Space Shuttle program as presented against the original SSB Commission. The results are noteworthy and deserve wide-wide dissemination. In the Spring of 1982, a NASA JOINT-INDUSTRY WORKING GROUP began the development of a government cost estimate, which was completed in FY 82, and started in FY 83 to complete. As a result, as shown in the first column below, total cost is \$10,000 million, a final adjustment has been recommended to a recently completed study (Management of Space Shuttle Cost Estimating Methods, A. G. Hambley, August 1981). Comparing to FY 82 figures, actual costs for the program are shown in the second column, where actual inflation rates experienced by the program. The third column is the most based on the total SSB Commission indications rates which will be adjusted according to the actual cost of the program. The last column presents the actual costs in million dollars (billions of the year reported).

	Original Estimate	Actuals	1979 Actual	1980 Actual	1981 Actual	1982 Actual
Shuttle	1750	840	850	1000	1100	1200
Program Support	270	60	60	60	60	60
SSB	400	75	75	75	75	75
ST	50	10	10	10	10	10
SSB	**	15	15	15	15	15
SSB	***	80	80	80	80	80
SSB System Req.	**	80	80	80	80	80
SSB System Req.	110	10	10	10	10	10
SSB System Req.	50	5	5	5	5	5
TOTAL	2720	1120	1120	1280	1380	1480
Percent over SSB	56%	41%	41%	41%	41%	41%

**was part of SSB
 ***was included in program estimates and program support

Additionally, direct costs adjustment to the actual commission with conditions when included as the time the estimate was made (e.g., removal of support items not included in the original estimate) result in actuals of \$10.2 billion (10.2) or an increase of 0.2 billion (2%) relative to the original estimate, which, was a result of overlapping adjustments.

Original Estimate	Actuals
SSB	1000
Program Support	60
SSB	75
ST	10
SSB	15
SSB	80
SSB System Req.	10
SSB System Req.	5
SSB System Req.	5
TOTAL	1120
Percent over SSB	12%

Walter A. Luttrell