The Database of Cost References by Group—PDF#6

Prepared by Heuston Consulting, Inc., July 2009
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ENGINES (both Aircraft and Rocket)

E1 – RB-211-56, Rolls Royce Engine
Cost – Development Costs are estimated at $72 million
Discussion –
Source – Aviation Week, June 29, 1970, p 11
Recorded – August 11, 1970.

E2 – RB-202-31, Rolls Royce Lift Fan Engine
Cost – will cost $16 for every pound of thrust, or $288,000 for a 13,000 lb thrust power plant.
Discussion – which is planned for use in the proposed Hawker Siddeley HS-141 V/STOL jet transport.
Total of 16 engines would be mounted in 2 sponsons on either side of the fuselage.
Source – Aviation Week, July 27, 1970, p 48.
Recorded – September 29, 1970.

E3 – P & W Engine, Pratt & Whitney engine program for the F-15 and F-14B fighters.
Cost -- $448.2 million for development
Discussion – target price of$448.2 million
Initial purchase block of 90 engines.
Source – Aviation Week, April 27, p 15.
Recorded – June 23, 1970.

E4 – RB.211, Rolls Royce RB.211 Engine
Cost -- $168 million, total R&D cost is estimated at.
Discussion – of which $113 million is provided by the British government.
Source – Aviation Week, May 25, 1970, p 22.
Recorded – July 2, 1970.

E5 – Exp. Turbine Engine, Teledyne CAE small inexpensive and advance gas turbine.
Cost – expendable turbine engine probably could be sold for $5/lb of thrust – 15 minutes.
Discussion – extended life versions – say 5 hours – would sell somewhere between the $5lb of thrust for the ETE and the $10-$13/lb of thrust of the present 18 hour drone engines such as the J69-T-29.
Source – Aviation Week, November 2, 1970, p 41.
Recorded – November 30, 1970.

E6 – RB.199, Rolls Royce RB.199 engine for the multi-role engine contract
Cost -- $450,000, unit cost
Discussion – on the basis of a production run of 3,000 engines.
Source – Aviation Week, September 8, 1969, p 19.
Recorded – September 23, 1969.

E7 – JTF-16, Pratt and Whitney, engine for MRCA.
Cost -- $750,000, unit cost
Discussion – on the basis of a production run of 3,000 engines.
Source – Aviation Week, September 8, 1969, p 19.
Recorded – September 23, 1969.

E8 – Miniature floated inertial platform
Cost -- $5,000 to $10,000 each.
Discussion – could find application as a midcourse guidance sensor for tactical missiles or a relatively low cost altitude heading a reference system for aircraft is being developed by Northrop Corp. for the Air Force.
Northrop is hopeful it can refine the design & mechanization of the platform so it can be produced at $5,000 to $10,000 each, to be competitive with strap-down techniques for midcourse guidance applications.
Source – Aviation Week, April 13, 1970, p 48.
Recorded – April 13, 1970.

E9 – Turbojet, Air Force and Navy Turbojet Engines
Cost – as follows in 1964 dollars
Discussion – as follows in 1964 dollars

Engine	Cum Av Cost	Cum Av Cost	Cum Av Cost	Eng Cost/lb	Eng Cost/lb	Eng Cost/lb	Milit Thrust	Eng Dry Wgt (lbs)
	200 units	1000 units	5000 units	200 units	1000 units	2000 units		
J-1	259	222	190	64.8	55.5	47.5	11200	4000
J-2	23	23	23	12.8	12.8	12.8	4600	1790
J-3	137	108	86	119.1	93.9	74.8	3200	1150
J-4	54	45	38	23.9	19.9	16.8	5450	2264
J-5	115	100	88	42.5	36.9	32.5	5670	2707
J-6	65	61.5	57	145	137.3	127.2	3000	448
J-7	285	245	205	62	51.5	43.1	16100	4760
J-8	181	170	120	64.6	60.7	42.9	7220	2800
J-9	450	375	215	155.7	133.1	76.3	1000	28.7
J-10	80	59	36	235,3	173,5	105,9	1700	340
J-11	192	120	76	496.3	307.7	190.9	2720	390
J-12	145	142	140	67.4	66	65.1	1500	2150
J-13	103	99	95	49	47.1	45.2	7250	2100
J-14	250	230	215	147.1	135	126	4500	1750

Source – Cost Estimating Relationships for Turbojet Engines, Res. Paper, GSM/SM/65-3, AF Institute of Technology, School of Engineering, Wright Patterson AFB, December 1965.
Recorded – October 6, 1969.

E10 – JT-8D, Pratt & Whitney's JT8D

Cost – Development – will run about $175 million to ready engine for airline service.
Began in 1960
Has cost more than $100 million
$37 million of which was spent to make the engine ready for initial airline service
Source – Aviation Week, April 14, 1969.
Recorded – October 15, 1969.

E11 –MRCA, European Multi-role Combat Aircraft Engine

Cost –
Discussion –

	Pratt & Whitney JTF-16	Rolls-Royce RB-199
Development Cost	$424 mil	$300 mil
Unit Price	$835,000	$452,000
Price (3000 units)	$2.5 billion	$1.36 billion
Total Program	$2.9 billion	$1.66 billion

The estimates for a single line capable of producing 77 engines monthly plus as many as 23 spares was $182.4 million for plan, machine tools and tools. Support tooling for a single line would cost about $5 million annually.
For dual production lines, the total cost would be $220.8 million, with support tooling costs of $5-5.5 million annually.
It was agreed that, with a single production line, the development costs would total $125 million and unit production engine cost would be $144 million for development and $380,000 per engine. These were revised upwards in the formal submissions.
Source – Aviation Week, November 10, 1969, p 23.
Recorded – February 3, 1970.

E12 – Turbofan Modification

Cost – Existing commercial turbofan engines can be made significantly quieter
Discussion – modification alone would be from $655,000 to $1 million per 4 engine aircraft.
Source – Aviation Week, October 27, 1969, p 31.
Recorded – February 3, 1970.

E13 – Turbo-Jet

Cost – Cost Estimating Relationship for Turbo-Jet
Cost per Pound of Engine at Unit 200
Y = 399.42 – 885.59 X (1)
Y = cost per lb. of engine at unit 200
X(1) = Specific Weight
Coefficient of correlation = -.7101
Standard error of estimate = 83.9206 (uncorrected)
Source – Research Paper, BSM/SM/65-3, Air University, December 1965. p 47.
Recorded – March 6, 1970.

E14 – JT9D, Pratt & Whitney Aircraft Division of United Aircraft Eng. Corp., JT9D
Cost – Initial development cost for the JT8D was $37 million
Bruse N. Torell, ex-vice pres., of P&W told a meeting of the Society of Financial Analysts here recently that the cost of developing the JT9D would be appropriately $175 million. Another $175 million will be required to refine the engine and enlarge it after certification.
Source – Aviation Week, April 7, 1969, p 27.
Recorded – June 6, 1969.

E15 – Aircraft Engine
Cost -- $23,000, price per engine
Discussion – Modified Cessna)-2 forward air controller (FAC) a/c.
Source – Aviation week, December 1968, p 21.
Recorded – March 3, 1969.

E16 – JT9D
Cost – Pratt & Whitney JT9D high-bypass ratio turbofan
Cost – Development cost will total $350 million
Discussion – for the Boeing 747 and McDonnell Douglas DC-10
Source – Aviation Week, November 18, 1968, p 49
Recorded – January 7, 1969.

E17 – L-1011
Cost -- $17 million, including spares
Discussion – in Eastern & TWA order
Base price $15 million, covered a range of $14.7 million with a 15% spares allowance to $15.4 million with a 10% spares allowance.
Included is $2.5 million per aircraft for engine, nacelle & reverser package.
Source – Aviation Week, April 8, 1968, p 36.
Recorded – May 19, 1968.

E18 – JT15D
Cost -- $60,000
Discussion – designed especially for fast business and touring aircraft
A prototype began test runs last October.
Source – Interavia, June 1968, p 717

Recorded – August 30, 1968.

E19 – J-2 Engine

Cost -- $75.8 million for 48 more engines = $1.6 each.
Discussion – NASA has increased the value of North American Aviation, Inc., Rocketdyne Div., contract for the J-2 engine by %75.8 million for a new total of $206 million.
The add-on provides for 48 more engines to be produced, raising the total purchase to 103 engines = $2.0 million each.
The amendment also calls for the firm to provide such support services as field engineering, documentation, and ground test support equipment.
Source – Missiles & Rockets, December 6, 1965, p 13.
Recorded – January 26, 1966.

E20 – Aircraft Engine for the US Airbus Competition

Cost – as follows
Discussion – Pratt & Whitney – JT18D, 35,000 lbs of thrust and 5:1 bypass ratio = $710,000
General Electric CF6, 34,000 lbs and 6:1 bypass ratio = $635,000
Rolls-Royce RB.211, 33,260 lbs, & 5:1 bypass ratio = $485,450
Source – Aviation Week, February 26, 1968, p 28.
Recorded – June 2, 1968.

E21 – TF30, Pratt & Whitney, Turbojet Engine

Cost -- $750,000 billing price.
Discussion – Navy refuses to pay
Declares it will pay no more than $625,000 each for the TF30-P-3 engine for 1968 delivery.
For 1969 deliveries it will pay $552,000; 1970 will pay $504,000.
Source – Aviation Week, June 10, 1968, p 16.
Recorded – June 29, 1968.\

E22 – JT9D. for 747

Cost -- $106 million to Pratt & Whitney
Discussion – Pratt's part of the $531 million deal for 25 747's
Weight 7,800 lbs including the spinner but no the nozzle.
Development costs of the JT9D-1 engines are expected to amount to approximately $100 million in company funding, according to P&W. These costs calculated from the time P&W lost the C-5A engine competition and decided to move ahead with development of the commercial JT9D on its own.
Source – Aviation Week, April 18, 1966, p 42.
Recorded – April 9, 1966.

E23 – GE 4/45, General Electric 445 supersonic transport engine

Cost – preliminary unit price = $1.1 million
Source – Aviation Week, April 18, 1966, p 51.

Recorded – April 9, 1966.

E24 – JT17A-20, supersonic transport engine.
Cost – preliminary unit price = $1.45 million
Discussion – Pratt & Whitney
Source – Aviation Week, April 18, 1966, p 51
Recorded – April 9, 1966.

E25 – JT18D, Pratt & Whitney
Cost -- $710,000
Discussion – for potential US three-engine airbus application
Rate at 35,000 lb. take-off thrust
Which is $75,000 higher than the price being quoted by G.E. for its 34,000 lb thrust CF6/34 airbus engine entry, and almost $150,000 more than Rolls-Royce is reportedly asking for its 35,000 lb thrust RB-211 engine.
Source – Aviation Week, October9, 1967, p 43.
Recorded – October 30, 1967.

E26 – Airbus Engine
Cost – $635,000, G.E.'s turbo fan for medium to long range airbus
Discussion – new, two-spool, high-bypass turbo fan
CF6/34
Bypass ration of 6:1.
Take off thrust of 34,000 lbs
6,975 lbs, including standard engine equipment and noise suppression materials, but excluding cowling, thrust resources, and aircraft accessories.
Source – Aviation Week, September 25, 1967, p 28.
Recorded – Aviation Week, September 25, 1967, p 28.
Recorded – October 17, 1967.

E27 – Small Jet Engines
Cost -- $5 per pound
Discussion – Design of a small, inexpensive jet engine for general aviation under way at NASA's Lewis Research Center is aimed at development of 1000 lb of thrust at a $5/lb sales price, compared with $15-$20/lb cost for today's small jet engines.
Source – Aviation Week, August 14, 1967, p 23.
Recorded – September 6, 1967.

E28 – P&W STF284-A-1 Engine for Airbus
Cost -- $675,000 per engine, price may be…
Discussion – P&W is using its basic JT9D engine technology
Twin spool, high by-pass ratio fan
Weight 5,870 lbs.
Source – Aviation Week, July 10, 1967, p 45
Recorded – August 27, 1967.

E29 – GE CF6 Engine for Airbus

Cost -- $575,000 expected cost
Discussion – 30,000 lb – 35,000 lb thrust category
Utilizing the core portion of the TF 39 turbo fan for the USAF/Lockheed C-5A.
Bypass ratio will be about 6
Weight 6,500 lbs and specific fuel consumption about 0.63.
Source – Aviation Week, July 10, 1967, p 45.
Recorded – August 27, 1967.

E30 – Pratt & Whitney Aircraft Div. of United Aircraft proposed engine

Cost -- $690,000 per power plant with development cost of $200 million
Discussion – for use in any three-engine design for a 250-300 passenger airbus.
P&W proposal STF284 A-1 would provide power plant in the 32,000 lb thrust.
Source – Aviation Week, July 3, 1967, p 28.
Recorded – July 26, 1967.

E31 – Hybrid Hover Motor

Cost -- $3,944,000 for production (per unit of $39,400)
Discussion – production 100 motors
Production of 50 motors = $2,222,000 (unit cost $44,440)
Units loaded with fuel and without any oxidizer
Source – Final Report – Design Study of a Hybrid Hover Motor, Lockheed Propulsion Co., 17 January 1964, Vol. II, Development Plan and cost Estimates.
Recorded – December 21, 1964.

E32 – Hybrid Hover Motor

Cost -- $4,000,000 for 3 phase development program.
Discussion – Phase I – Critical Concept & Component Eval.Tasks = $564,000

(1) Prove aft-end make-up concept =	$192,000
(2) Prove fuel grain regression rate laws	$119,000
(3) Prove nozzle heat transfer analysis	$ 89,000
(4) Develop variable area injector	$ 74,000
(5) Demonstrate hypergolic ignition	$ 50,000
(6) Fuel grain costing study	$ 50,000
(7) Hybrid motor design	$ 10,000
Phase II – Motor Component Development Task	= $1,515,000
(1) Develop helium pressure system	$191,000
(2) Develop oxidizer supply system	$245,000
(3) Develop combustion chamber with injector & nozzle	$847,000
(4) Test integrated prop. Unit	$232,000
Phase III – Motor Development Qualification PERT Task	= $1,878,000
(1) Basic Motor develop	$620,000
(2) Motor qualification	$726,000
(3) Motor preflight rating test	$532,000

Source – Final Report – Design Study of a Hybrid Hover Motor, Lockheed

Propulsion Co., Redlands, 17 January 1964, Prepared for NASA Cont. No. NAS 7-143, Vol II, Dev. Plan & Cost Estimate.
Recorded – December 21, 1964.

E33 – Turboprop Engines, Installation of Allison 501-D13.
Cost -- $320,000
Discussion – on 4 of Frontier Airlines Convair 340 transports
Increase speed by 100 mph
Raise allowable gross weight from 47,000 to 53,200 lbs.
Passenger capacity will be increased from 44 to 52 seats.
Shaft horsepower is 3,750 compared with 2,400 hp for Pratt & Whitney CB 16 piston engines now on aircraft.
Source – Aviation Week, November 25, 1963, p 39.
Recorded – February 16, 1964.

E34 – R-985 Engine
Cost – 985 Aircraft Engine, US Navy
Discussion – about $6,898
Mr. BeLieu – transfer
89 R-985 aircraft engines, with a value of $623,000 went from the Navy to the Army.
Source – Senate Subc. of Appropriations Committee Hearing, 88th Congress, 1st Session, HR 7179, p 1100.
Recorded – November 13, 1963.

E35 – Spey Engine, Military Version of the Spey Bypass Turbofan Engine
Cost -- $520,000 per
Discussion – rolls-Royce, Ltd.
For McDonnell F-4 Phantom 2 strike fighter
The Spey 36 for the F-111 A will cost about $525,000
The ministry of Aviation cost section, probably in reflection on past project increases, has insisted on funding the unit cost at about $75,000 higher than the Rolls quote.
Source – Aviation Week, October 4, 1965, p 64.
Recorded – November 23, 1965.

E36 – Olympus 593B Jet Engine
Cost -- $825,000 unit cost
Discussion – Bristol Siddeley Engines
For Concorde
593B will be on the test bed in November
Run in the 35,000 lb thrust range.
Source – Aviation Week, October 25, 1965, p 131.
November 26, 1965.

E37 – 60,000 lb. Thrust Engine

Cost – GE's GE/J5 Turbojet = $1.15 million
Discussion – up $1 million when the engine was at the 50,000 lb thrust design level.
P&W entered the competition with its JTF 17-21 duct-burning turbofan at a relatively high price, dropped it in 2 steps to $1.48 million, and most recently to $1.25 million, as the power plant increased in thrust from 57,000 lbs.
Source – Aviation Week, August 22, 1965, p 34.
Recorded – September 24, 1966.

E38 – M-1 Engine
Cost – as follows
Discussion –

	1962	1963	1964
Engine Development	4,100,000	23,100,000	33,300,000
Test Equipment	7,100,000	9,200,000	5,700,000
Facilities	5,494,000	1,200,000	--
Propellants	11,000	1,500,000	6,000,000
Subtotal, Dir. R&D	16,705,000	35,000,000	45,000,000
Personnel Costs	202,000	884,000	1,930,000
Operations of Instal.	134,000	345,000	772,000
Total	17,041,000	36,229,000	47,702,000
Total Personnel	23	126	202

The M-1 engine was conceived as a state of the art engine intended for use in upper stages of possible large vehicles of the NOVA class. It will provide 1,200,000 lbs of thrust using the high energy combination of LOX and LH2.
Development began in April 1962 by Aerojet and is under technical direction of Lewis Research.
Six fold increase over largest liquid hydrogen engine mover under development, the J-2.
Major component testing will start in late 1963 and continue until 1965 when actual engine testing will start. The preliminary flight rating test is scheduled for 1967 and the qualification test for 1969.
M-1 consumes approp. 280,000 gals of LOX in a single duration run of 260 seconds.
Source – House Appropriations Committee, Hearings. 88th Congress, Part 3, p 304.
Recorded – October 30, 1963.

E39 – J-2 Engine
Cost – as follows
Discussion –

	1962	1963	1964
Engine Development	31,597,000	35,542,000	38550,000

Test Equipment	--	--	1,400,000
Facilities	--	--	--
Propellants	2,038,000	9,000,000	8,250,000
Subtotal, Dir. R&D	33,635,000	44,542,000	48,250,000
Personnel Costs	536,000	773,000	896,000
Operations of Instal.	353,000	433,000	587,000
Total	34,524,000	45,748,000	49,683,000
Total Personnel	61	73	82

In 1960 – needed high performance LH2/LOX propellant system in upper stages of Saturn class vehicle to increase payload carrying capabilities.
Contract let to Rocketdyne in September 1960 to developed J-2
200,000 lb thrust rocket engine will have 13 times the thrust of the RL-10, the first operational engine using LH2.
A single J-2 will power the second stage of the Saturn V3 and the 3rd stage of the Advanced Saturn, and a cluster of 5 will supply the propulsion for the second stage of the Advanced Saturn.
Source – House Appropriations Committee, Hearings, 88th Congress, Part 3, p 347.
Recorded – October 31, 1963.

E40 – Development Cost for J2 Engine

Cost – R&D $44 million and requires 3 years
Discussion – North American's Rocketdyne Div., Bell Aerojet -- General, and Pratt & Whitney Div. of United Aircraft for the coveted contract to develop a 200,000 lb thrust liquid-hydrogen rocket engine for the second stage of the C-2 version of Saturn. NASA said it expects the work to cost $44 million and require three years. The C-2 stage, a new second stage propelled by a pair of the "200 K" Rocketdyne engines, a third stage propelled by four P&W LOX-hydrogen engines totaling 80,000 lbs., and a fourth stage consisting of the Centaur vehicle. C-2 should be available in the late 1960's, NASA said.
Source – Astronautics, July 1960, p 8.
Recorded – October 22, 1964.

E41 – Nuclear Rocket Stage, Flyable

Cost -- $2.6 billion through 1978 to develop
Discussion – including work on the vehicle itself.
Estimate from Harold Finger, Manager of the Joint NASA/Atomic Energy Commission Space Nuclear Propulsion Office.
He told a Congressional committee last week that $800 million already has been spent on the Rover system.
Cost of the large NERVA program is seen as $1 billion from 1967 through the flight program in 1978.
Source – Missiles and Rockets, March 14, 1966.
Recorded – March 18, 1966.

E42 – 260 inch diameter, 6,000 lb thrust solid propulsion rocket motor
Cost -- $1,534/lb total motor weight.
Discussion – Production cost
Average cost of the first 24 production motors
95% learning curve
6-14% contingency factor

Breakdown	Total Cost	$/lb Total Motor Weight
Case	1,351,525	0.377
Nozzle	1,761,038	0.490
Motor Processing	2,290,188	0.639
Other Costs	100,000	0.028

Source – Production Cost Study for 260-in Dia. Solid Prop. Rocket Motor, NASA, Technical Memo., X-53228, April 16, 1965, p 1.
Recorded – May 2, 1966.

E43 – Nuclear Rocket Stage
Cost -- $1 billion for development
Discussion – including $75 million in new facilities at Jackass Flats, Nevada, Nuclear Development Center.
Source – Missiles & Rockets, May 23, 1966, p 36.
Recorded – June 20, 1966.

E44 – F-1s,
Cost -- $141 million for 30
Discussion – NASA has ordered 30 F-1 rocket engines and varied support services from Rocketdyne at a cost of $141 million.
The order completes the number of engines needed for use on the 15 schedules Saturn V rockets, plus spares.
Source – Technology Week, November 28, 1966, p 14.
Recorded – December 21, 1966.

E45 – 260 inch Diameter Solid Propulsion
Cost – Average cost of 1st 24 production motors is est. to be $1.534/lb total motor weight
Discussion – 6,000,000 lb thrust
FOB Cape
Includes provisions for thrust vector control system, but do not provide for thrust termination or destruct systems or for vehicle system staging components.
Cost is based on a 95% learning curve and is estimated to have a 6-14% contingency factor.

Case	Total Cost = $1,351,525	$/lb total Motor We = 0.377
Nozzle	= $1,761,038	= 0.490
Motor Processing	= $2,290,188	= 0.639

Other Costs	= $100,000	= 0.028
Total	= $5,502,751	= 1.534

Source – Production Cost Study for 260 in Dia. Solid Prop. Rocket Motor, MSFC, NASA, NASA-TMS, April 16, 1965. p 1.
Recorded – August 2, 1966.

E46 – High Pressure, Storable/Hypergolic Liquid Fueled Rocket Engine
Cost -- $20 million, 3 year development
Discussion – Air Force last week awarded a #3 million, one year contract to Aerojet General Corp. for development
May become the propulsion system of a third generation intercontinental ballistic missile and an advanced space booster.
Called Ares (Advanced Rocket Engine/Storable)
Cluster of 24 modular combustors, each with a thrust of 125,000 lbs. Total thrust 3 million lbs.
Burn nitrogen tetroxide and a 50-50 USMH and hydrazine at a chamber pressure of 2,000 to 4,000 psi.
Pump fed combustors
Source – Aviation Week, July 5, 1968, p 19.
Recorded – August 30, 1965.

E47 – SNAP-50/SPUR Nuclear-Electric Space Powerplant
Cost -- $500 million
Discussion – total cost through ground testing of a prototype SNAP-50 powerplant.
Double that for a flight-qualified unit
Present SNAP-50 funding is about $20 million per year.
Electric propulsion, which depends on a primary power source in the SNAP-50 range – 300 to 1,000 kw – is currently being funded at about $14.7 million annually by the AF and NASA.
Source – Aviation Week, November 2, 1964, p 59.
Recorded – December 1, 1964.

E48 – M-1 Engine
Cost -- $190 million through development
Discussion – M-1 engine is an advanced engine using liquid hydrogen and liquid oxygen fuels. It has a million and a half pounds of thrust. It is an engine to serve in our advanced space programs for the future.
It is going to take 7 or 8 years to develop this engine for operational use.
Thomas – already spent about $90 million on it.
Source – House Appropriations Committee Hearings, 88th Congress, Part 3, p 340
Recorded – October 30, 1963.

E49 -- 156 inch Motor
Cost -- $5.5 million contract
Discussion – Lockheed Propulsion will build and test five

Construction of one segmented motor 75 ft long to develop 3 million lb thrust
Motor will contain 700,000 lb of propellant
The second motor will have a monolithic case 33 ft long and will be designed to develop 1 million lb. of thrust.
Source – Aviation Week, September 6, 1965, p 30.
Recorded – November 23, 1965.

E50 – M-1 Engine Development
Cost -- $200 – 250 million
Discussion – Thomas – what will be a pretty good wrap-up figure?
Seamans – Three or four more years, through proof test.
Source – House Appropriations Committee Hearings, 88th Congress, Part 3, p 372
Recorded – October 31, 1963.

E51 – RL-10 Engine
Cost – as follows
Discussion –

	1962	1963	1964
Engine Develop.	$11,157,000	$22,330,000	$25,300,000
Test Equipment	3,125,000	1,427,000	--
Facilities	--	238,000	--
Propellants	2,050,000	8,650,000	7,300,000
Subtotal, Dir R&D	16,332,000	32,645,000	32,600,000
Personnel	387,000	593,000	688,000
Oper. Of Installation	253,000	336,000	488,000
Total	16,972,000	33,574,000	33,736,000
Total Personnel	44	56	63

The RL-10 engine is used in clusters of six in the S-IV stage of the Saturn vehicle and in pairs in the second stage of the Centaur vehicle. The engine produces 15,000 lbs of thrust for 450 sec. duration, burning the high energy combination of LOX and LH2.
It is under development and production by Pratt & Whitney Aircraft Div of united Aircraft, West Palm Beach, Fla. and East Hartford, Conn.
The RL-10 A-3 passed its preliminary flight rating test (PFRT) in July 1962 and has been cleared for flight use.
Source – House Appropriations Committee Hearings, 88th Congress, Part 3, p 346
Recorded – October 31, 1963.

E52 -- H-1 Engine
Cost – as follows
Discussion –

	1962	1963	1964
Engine Develop.	$4,950,000	$4,510,000	$4,500,000
Test Equipment	--	--	--
Facilities	--	100,000	--

Propellants	712,000	650,000	700,000
Subtotal, Dir. R&D	5,662,000	5,260,000	5,200,000
Personnel	350,000	370,000	295,000
Oper. Of Installation	230,000	208,000	193,000
Total	6,204,000	5,838,000	5,688,000
Total Personnel	40	35	27

H-1 as first stage of the Saturn & Saturn B launch vehicles
It produces 188,000lbs of thrust, burning a mixture of LOX and hydrosene for 150 seconds duration.
Produced by Rocketdyne Div. of NAA.
Engine development started by the Army in September 1958 in a 165,000lb thrust version.
H-1 engine has been used successfully in the first 3 Saturn launches.
The 188,000 lb version will be used in the remaining 6 Saturn & Saturn B vehicles.
Source – House Appropriations Committee Hearings, 88th Congress, Part 3, p 345
Recorded October 31, 1963.

E53 – F-1 Engine
Cost – as follows
Discussion –

	1962	1963	1964
Engine Develop.	$44,284,000	$42,500,000	$43,500,000
Test Equipment	--	--	3,000,000
Facilities	1,000,000	--	--
Propellants	3,036,000	8,300,000	7,600,000
Subtotal, Dir. R&D	48,320,000	50,800,000	54,100,000
Personnel	465,000	815,000	830,000
Oper. Of Installation	308,000	465,000	546,000
Total	49,093,000	52,080,000	55,476,000
Total Personnel	53	77	76

The 1,500,000 lb thrust F-1 engine will be used in clusters of 5 to power the Advanced Saturn vehicles with manned payloads for lunar explorations.
The F-1 is the largest single rocket engine under development by the free world
By Rocketdyne Div. of NAA. Engineering and fabrication testing at Edwards AFB
Source – House Appropriations Committee Hearings, 88th Congress, part 3, p 346
Recorded – October 31, 1963.

E54 – Gaseous Core Reactor Basic Research
Cost -- $1 million per year.
Discussion – is being supported at approximately the same relatively low level as work on Orion.
Among the groups reported to be working on the concepts are united Aircraft Research Laboratories, NASA's Lewis Research Center, General Electric % Westinghouse.

The work at United Aircraft, which started out basically as a fluid flow research problem, is believed to be funded at somewhat under $1 million per year.
Source – Aviation Week, November 25, 1963, p 32.
Recorded – March 16, 1964.

E55 – F-1 Engine
Cost -- $400 million – 4 years work
Discussion – started in 1959
900 tons of fuel a minute
Mr. Webb, NASA
Source – House Appropriations Committee Hearings, 88th Congress, Part 3, p 97.
Recorded – October 17, 1963.

E56 – H-1 Engine Procurement
Cost -- $19.7 million for manufacture of 114 engines.
Discussion – NASA Marshall Space Flight Center last week signed the contract. Engines will be used on Saturn S-1B boosters built by Chrysler at NASA's Michoud, LA., and will include spares.
Source – Aviation Week, November 25, 1963, p 30
Recorded – March 16, 1964.

E57 – Solid Propulsion Rocket for Control of Satellites & Space Vehicles
Cost -- $97,000 development
Discussion – rocket Research Corp., of Seattle
NASA/Goddard
Utilize a solid propellant which sublimes from solid to gas when thrust is needed to adjust the satellite.
Source – Space Age News, February 1964.
Recorded – May 15, 1964.

E58 – SNAP 8 System
Cost -- $48 million contract for 2
Discussion – Aerojet General Corp's Azusa for NASA, Lewis Research Center
2 35 kw Snap 8 systems will be delivered to Lewis for environmental test and possibly flight testing in 1968.
35 kw of power for a minimum of 10,000 hours.
Power source for NASA's large manned orbiting space station and for a permanent lunar base.
Source – Aviation Week, September 16, 1963, p 37.
Recorded – January 30, 1964.

E59 – SNAP 9
Cost -- $40,000, and $50,000
Discussion – according to AEC
Units can be modularized in series to double or triple power available
SNAP 9A is 9.5 inches high and 20 inches in diameter including fins.

Source – Aviation Week, October 7, 1963, p 37.
Recorded – January 29, 1964.

E60 – Gas Core Nuclear Rocket
Cost -- $10 to $20/lb on round trip to moon
Discussion – as opposed to current estimate of $1,000 to $10,000/lb for a chemical rocket
First flight in 1980
United Aircraft Corporation
Chemically boosting a gaseous core rocket into orbit for a start would cost an estimated $1,000/lb.
It would cost only $5 to $10/lb to chemically boost the nuclear vehicle to an altitude of200,000-30,000 ft but at zero velocity
UA estimates it will require 10-30 lbs of plutonium 239 fuel to achieve criticality, at roughly $7,000/lb.
Source – Aviation Week, February 3, 1964.
Recorded – May 14, 1964.

E61 – 120 inch Case
Cost -- $263,830
Discussion – A single …case segment will be fabricated through the roll extension method in a United technology Center development program under a $263,830 contract from the Air force materials laboratory
The development case section will be 129 inches long and made from Republic Steel Corps HP-9-4-25 steel plate. The program will conclude in December 1966 with a hydrostatic test
Source – Missiles & Rockets, December 20, 1965, p 25.
Recorded – January 26, 1966.

E62 – Rover Nuclear Propelled Rocket Program
Cost -- $2 billion
Discussion – is approaching a decision that must be made whether to move forward and prepare for early post-Apollo missions or let the technology dwindle.
Over $900 million has been committed to the program so far.
Whether to start a $50 million construction program in Nevada for testing in the Vicinity of the nuclear rocket development station near Las Vegas.
Source – Aviation Week, December 6, 1965, p 57
Recorded – December 28, 1965.

E63 – M-1 Engine
Cost -- $127 million
Discussion – Program has cost $127 million since its initiation in 1962.
Webb has approval from the Budget Bureau to use $2 million in reserve Fiscal 1966 funds to terminate Aerojet General corps M-1 hight energy upper stage for post Saturn launch vehicles.
Source – Aviation Week, December 13, 1965, p 35

Recorded – January 19, 1966

E64 – F-1 Engine
Cost – between $400 - $500 million for development
Discussion – which is the basic engine in the first stage of the Saturn V.
Source – NASA Auth. FY66 Hearings Committee on Aeronautics & Space, Senate, 89th Congress, 1st session, Part I, march 1965, p 37.
Recorded – March 22, 1966.