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(App. B)

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Aerojet-General[®] CORPORATION

A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

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PROGRAM COST REDUCTION
FOR
HIGH RISK DEVELOPMENT

APPENDIX B
TO

AGC REPORT NO. 2224

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NERVA Recommended Program Contract Years 1963 & 1964

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Report No. 2224

APPENDIX B

I. PROGRAM CHANGES

Possible cost reductions are mainly characterized by eliminating major development areas which in themselves do not prohibit the main effort of providing engine hardware from proceeding but which do contribute significantly to the confidence level that such hardware will perform satisfactorily, or that adequate back up approaches will be available should major difficulties develop.

Neither Aerojet nor Westinghouse subscribe to such a high risk approach to a major program of the importance of NERVA. However, should such a course be followed a significant cost reduction could be achieved by adjusting the recommended program in the following manner.

A. SUMMARY OF CHANGES

Task Item 1.1

1. Reduced general level of engineering effort by approximately one-third.
2. Deleted test stand adapters for REF-SIE program.
3. Deleted tooling for item 2.
4. Pared development spares by about one-half.
5. Deleted four tests from Gen II, Mod I Simulator test program.
6. Deleted six tests from Gen II, Mod II test program.

7. Deleted seven tests from Development Test System test program.

8. Deleted the Acceptance Test System assuming that acceptance test will be performed at the component and/or subassembly level and is included in the test costs for these tests, and under any circumstances do not have E-series acceptance tests during C. Y. 1963.

9. Delete the LRP hard mock-up, and training mock-ups for E-MAD mock-up.

Task Item 1.2

1. Reduce general level of engineering effort about one-third.

2. Reduce hardware fabricated by about one-third.

3. Reduce testing effort and number of tests by about one-third.

4. Level of effort reductions in the various complexes, were higher than the nominal one-third in the areas of the propellant-feed system assembly, and lines and disconnects, and were less than one-third in the turbopump assembly and valves.

Task Item 1.3

1. Delete the NRX-B program.

2. Reduce scope of NRX-B program.

3. Delete REF-SIE non-nuclear reactor hardware and engineering.

4. Eliminate the incorporation of a shield for Kiwi B-5B.

Task Item 1.4

1. Reduced level of effort on engineering, fabrication and test by about one-third.
2. Deleted radiation cooled nozzle skirt effort and limited all effort on this sub-task to only the heated-bleed cycle engine.
3. Deleted studies and all associated effort on secondary gas injection thrust vector control.
4. Reduced nozzle coating effort by one-half effectively limiting study and effort to sprayed coatings.
5. Deleted one Titanium pressure vessel from development program.

Task Item 1.5

1. Reduced general level of effort on engineering, fabrication and test by about 40%.
2. Deleted all engineering, fabrication and test associated with backup actuator development.
3. Reduced effort on harness program to a single harness concept rather than three.

Task Item 1.6

1. Eliminate all effort on the destruct system in Contract Year 1963.

Task Item 1.7

1. Reduced general level of effort by about 40% by eliminating secondary or backup considerations for components in this system.

Task Item 1.8

1. Reduced general level of effort by about 40% by utilizing, where possible, similar development effort in task sub-item 1.7 and eliminating backup considerations from this sub-task.

Task Item 1.9

1. Deleted entire REF-SIE program.

Task Item 2.1

1. Reduced general level of effort by about one-eighth.
2. Deleted delivery of support items for SIE and NRX-B.
3. Delete support items necessary for E-MAD mockup at LRP.
4. Since engineering and fabrication of SIE support items have been deleted, level of effort during C. Y. 1963 for support of the E-series engines has been increased.
5. Transfer procurement and installation of wall mounted manipulators for E-MAD to the NRDS facilities budget.

Task Item 2.2

1. Same as action for sub-task 2.1.

Task Item 2.3

1. Same as action for sub-task 2.1.

Task Item 2.4

1. Reduced level of engineering effort by one-half.
2. Reduced level of fabrication and test by about 70%.
3. These reductions are accomplished by leaning upon LASL effort already accomplished on diagnostic instrumentation since requirements for NERVA E-series and Kiwi-B series engines are very similar.
4. Retained all effort associated with low NPSP temperature measurements.

Task Item 2.6

1. Considering that general level of effort in the C. Y. 1963 program has been reduced, reduce level of effort by 20% - removed data center.

Task Item 2.8

1. Remove all background information from courses.
2. Delete Design and Development Engineer Courses.
3. Increase class size and reduce number of instructors.
4. Level of effort has been reduced by about one-fourth as a result of the above.

Task Item 2.9

1. Eliminate all LASL support.

Task Item 4.0

1. Reduce general level of effort by about one-fourth.

Task Item 6.2

1. Delete harness, fatigue and tensile tester.

Task Item 6.5

1. Delete all items associated with E-MAD Mock-up.

Applicable Items

Eliminate portions of supplementary Contract Year 1962 requirements; i.e., those associated with the items such as REF, destruct system, etc., that have been eliminated in Contract Year 1963.

B. COST REDUCTIONS

The estimated savings resulting from the above are as shown in Table I.

C. DISCUSSION

1. The REF-SIE program was added originally to provide a means of obtaining a correct radiation environment capable of extended testing of any desired component or assembly. Elimination of this program would limit combined cryogenic and irradiation testing to materials testing and small components only except for side-by-side testing. The infrequency and relative inflexibility of such testing will produce only limited supporting confirmation of design suitability prior to engine testing.

2. Development of the destruct system and confirmation of its concept has been programmed early in the event its incorporation should seriously effect basic engine design. Eliminating effort in the present period as well as in contract year 1963 will require a later incorporation in the engine and would probably compromise its effectiveness. Complete elimination would require prior understanding that the lack of a destruct system will not prohibit the flight tests to take place.

3. Elimination of the NRX-B program presupposes that the Kiwi B and NRX-A programs will provide a suitable flight type reactor. Although the recommended NRX-B program timing is such that some reprogramming would be required in the event the basic program fails, it nevertheless provides a back up approach and could significantly minimize program slippage.

4. The NRX-A program could be reduced from three reactors to two and the test interval between the two tests extended from two months to three months.

5. Eliminating the B-5B shield reduces the amount of confirmation data available to only one test and would not permit testing of even minor modifications to the original design.

6. Engine support systems can be reduced in the area of remote handling, GSE and training if the REF-SIE program is eliminated, and effort on ETS-1 can be delayed.

7. The quantity of non-nuclear hardware to be built and tested can be reduced at the risk of less proven performance but is consistent with accepting a higher risk program. In general, engineering fabrication, and test effort has been reduced from 20% to 40%. All backup programs such as actuators and the hot bleed tests would be eliminated.

Also, the engine acceptance test system has been deleted assuming that acceptance tests performed at the component and/or subassembly level will suffice.

8. It now appears the SNPO policy would dictate that the wall mounted manipulators for the E-MAD building should not be funded under contract SNP-1 but included in the NRDS general facility budget.

9. Elimination of the E-MAD mockup and hard mockup for LRP introduces the possibility of an increased number of engineering changes in engine hardware at a time when such changes are more expensive both in terms of time and cost.

10. Elimination of LASL support would possibly adversely affect the basic Kiwi program progress. This program will assume even more importance if the NRX program is curtailed.

11. Portions of the supplementary contract year 1962 funding described in Appendix A can be eliminated as follows:

- a. Long lead hardware was only required for early component proofing before SIE testing.
- b. REF reactor manufacturing tooling is no longer required.
- c. The manned control car can be delayed since it is no longer required for SIE, likewise, the SIE handling system is not required.

Table I

ROUGH ORDER OF MAGNITUDE ESTIMATE OF PROGRAM COST REDUCTIONS
(EXPENDED BASIS)

Item	Total			
	Before 1 Oct 62*	1 Oct 62-30 June 63	1 July 63 - 30 Sept 63	1 Oct 62 - 30 Sept 63
REF-SIE	907,750	8,663,599	963,144	9,626,743
Destruct	175,000	2,899,887	434,790	3,334,667
NRX-B	--	3,219,736	3,439,211	6,658,947
NRX-A	--	2,551,933	1,085,161	3,637,094
Kiwi B-5B Shield	224,620	307,676	--	307,676
Support Systems	346,200	2,880,165	469,485	3,349,650
Reduced Effort Engr, Fab, Test	--	9,880,000	3,077,000	12,957,000
Wall Mounted Manipulators	--	1,000,000	760,000	1,760,000
Delete E-MAD & Hard Mockup	--	300,000	181,523	481,523
LASL Support	<u>294,400</u>	<u>449,876</u>	<u>204,072</u>	<u>853,948</u>
Total	1,947,970	32,352,872	10,614,376	42,967,248

Basic Contract Year Expended Cost	119,267,732
Less Above	<u>42,967,248</u>
Total	76,300,484

* Assuming 15 May decision.