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SANDIA CORPORATION
ALBUQUERQUE, NEW MEXICO 87115

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SANDIA SYSTEMATIC DECLASSIFICATION REVIEW
1st Review Date 10/22/97
Authority ADC ADD
Name W.H. LAWRENCE
2nd Review Date 10/23/97
Authority ADD
Name W Layne
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NO 4 OF 8 COPIES, SERIES A

Mr. Robert T. Carpenter, Chief
Isotope Power Systems Branch
Space Electric Power Office
Space Nuclear Systens Division
U. S. Atomic Energy Commission
Washington, D. C. 20545 M01163

Recd 9500 7-31-70

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Dear Bob:

Re: System Impact of Fuel Form Trade-offs

Ref: TWX, Carpenter to Hildebrandt, dtd 7/21/70 attached

As requested in the above reference, within the time available Sandia has undertaken an evaluation of the system trade-offs associated with the alternate fuel forms presently being considered. The Sandia evaluation is based on the presently-available fuels information and would be subject to change as fuel development progresses and more data become available.

The specific questions asked in the referenced TWX have been addressed and in addition, charts have been prepared for the Transit and Pioneer programs summarizing the items considered in the Sandia evaluation, Enclosures 1 and 2.

Question 1 - "Schedular Flexibility related to Pioneer and Transit Programs."

Pioneer

Very little flexibility exists. We understand that C. Baxter has determined that the February 5 date for delivery of prototype RTG's and August 1 date for delivery of flight RTG's must be met. In order to meet these schedules capsules are needed as follows:

Prototype	Flight
Nov. 5, 1970	March 11, 1971
Nov. 14, 1970	March 25, 1971
Nov. 26, 1970	April 8, 1971
Dec. 3, 1970	April 22, 1971
	May 31, 1971 (Backup)

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The above schedule on the prototypes requires that assembly and test operations proceed on a seven day a week basis in order to meet the February 5 date for delivery at NASA.

Transit

The present Transit RTG program requires an October 20, 1970 delivery of a fueled heat source for the ground test of the RTG qualification unit. The first flight RTG delivery is March 31, 1971; the second flight RTG delivery is June 15, 1971. These RTG deliveries require fueled heat source deliveries of February 28, 1971 and May 1, 1971.

Recent discussions (mid July 1970) with J. Dassoulous, APL, revealed that the Improved Transit Program had received sufficient funding from the Navy, and that APL was pursuing a three-satellite program (one solar cell powered and two nuclear powered). The solar cell powered satellite launch time is estimated in the July-October 1971 time period. No nuclear-powered systems will be launched in CY 71.

Although APL would not commit to a nuclear powered system launch date, Sandia/TRW estimates a March 1972 date. Three-four month minimum lead times have been required by APL; therefore, December 1971 is a logical RTG delivery date to APL for the first flight RTG. March 1972 is a reasonable delivery date for the second flight RTG.

The TRW RTG program has required a one-month lead time for the fueled heat source delivery prior to RTG delivery. The resulting fueled heat source deliveries are November 1971 and February 1972.

In reviewing the Transit RTG program plan, it appears that the fueled heat source for the ground test of the RTG qualification could be delivered as late as January 15, 1971 without seriously perturbing program activities or costs.

In summary, the present and the estimated slipped heat source delivery dates are:

Present Dates

gd test	10/20/70
flt 1	2/28/71
flt 2	5/01/71

Estimated Slipped Dates

gd test	1/15/71
flt 1	11/71
flt 2	2/72

Question 2 - "Appraisal of Heat Source Production interface problems."

Pioneer

The use of SSC, cermet or ceramic fuel forms with a power density of 3.2 watts/cc should cause no change to the heat source. A change to microspheres or to a power density lower than 3.2 watts/cc will require a capsule longer by approximately 0.5 inches. The effect on the heat source of a longer capsule is negligible. However, a longer heat source fueled with lower power density SSC, cermet or ceramic would be heavier and would have an effect on overall RTG weight. A detailed summary is given in Enclosure 1.

Transit

There are four fuel forms being considered: solution solution cermet (SSC), solid solution (SS), cermet, and microspheres. Assuming that SS and the cermet fuel forms can be produced to a 3.2 w/cc power density, only the microsphere fuel form would require a design change in the Transit program. The change would be a lengthening only of the three fuel capsule members (clad, strength member and liner) by approximately 0.70 inch. Preliminary analyses indicate that minor interior alterations would be required to the graphite insulation and reentry protection materials. The outside dimensions of the reentry shield and the Inconel can would not be changed. The overall heat source weight would decrease by approximately one pound. Please refer to Enclosure 2 for a summary of these details.

The additional tests needed to qualify the heat source for the SS, cermet or microsphere fuel forms are summarized in Enclosure 2.

The additional capsule and heat source hardware required for these tests and the additional POV and walk-thru efforts are summarized in Enclosure 2.

Question 3 - "Impact and Technical Considerations for the Following Fuel Production Alternatives."

A summary of detailed information for each fuel form is given in Enclosures 1 and 2. Only general comments will be given in answer to the specific questions A through F.

A. "Continuing present effort to produce solid solution cermet for ground test and flight systems."

Pioneer & Transit

If capsules are delivered later than the dates shown under question one, the delivery dates to NASA and DOD will be

delayed. Since Sandia is not deeply involved in the fuels program, it is difficult to judge just how realistic are the capsule delivery dates. However, it is apparent that with the problems encountered in producing the SSC fuel, the capsule delivery dates must be considered somewhat nebulous.

Our information indicates that fuel will be produced by 3 sources. Every effort should be made to assure either that the fuel from each source has radiation characteristics similar to that from the other sources or that the fuels are mixed so that the capsules have similar characteristics.

B. "Producing Plutonium Molybdenum for ground test systems and solid solution cermet for flight systems."

Pioneer

Capsule delivery dates must be maintained. The radiation characteristics of the qualified PMC fuel form should not differ significantly from the characteristics of the SSC. NASA plans to use the prototype generator to check out radiation measuring instruments on the spacecraft. NASA has consistently indicated that radiation from the RTG should be as low as possible and should not vary significantly from RTG to RTG. NASA may be very reluctant to accept qualification of one fuel form in ground testing and using another fuel form for flight. Since three of the four prototypes are used as flight back up units, the RTG's would, using this concept, have to be refueled after ground testing with the flight-qualified fuel form.

Transit

It is not apparent that using this option on Transit would materially affect the program. This conclusion assumes that the power density of the fuel is maintained at the level required by the SSC specification such that no change is required to capsule or heat source. Additional walk-thru hardware may be required at MRC.

C. "Producing solid solution for ground test systems and solid solution cermet for flight systems."

Pioneer

Same as 3.B.

Transit

Same as 3.B.

D. "Producing Plutonium Molybdenum for ground test and flight systems."

Pioneer and Transit

Delivery dates for capsules should meet that presented in question one. If this fuel form can be sufficiently characterized in the near term to allow performance of safety analyses, the use of this fuel form should not materially affect the program. However, long term characterization data such as aging and swelling are not abundantly available and could result in major program perturbation at a later date.

E. "Producing Solid Solution for ground tests and flight systems."

Pioneer & Transit

The comments given in 3.D. pertaining to schedule and fuel characterization also apply to this question. The reentry and operational temperature analyses for both systems would have to be repeated in part because of the different thermal properties of this fuel form. In addition, the impact response of the fuel and the effect of the fuel on the capsule may be appreciably different from that of SSC or PMC and may require additional testing.

F. "Producing microspheres for ground test and flight test."

Pioneer & Transit

Use of microspheres requires a longer capsule but results in lower weight. There is some evidence that impact resistance of the capsule is improved. However, the evidence is controversial on the basis that the fuel simulant used may not actually simulate the impact response of microspheres. The response of microspheres to the center fireball environment is judged to be considerably less favorable than the response of the disc-type fuel forms.

In order to meet the capsule delivery schedules under question one, we judge that a production yield of 2.3 Kilograms per month is required starting in August, 1970. In order to meet such a schedule microsphere production capability must be established immediately.

The various effects to the Transit heat source program in using the microsphere fuel form is detailed in Enclosures 1 and 2. In summary, those effects are:

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		Pioneer	Transit
1.	Centerline temperature increase, operation.	450°F	450°F
2.	Centerline temperature increase, reentry.	550°F	550°F
3.	Capsule length increase.	.50 inch	.69 inch
4.	Heat Source weight, decrease.	.70 pound	1.0 pound
5.	Additional Safety Test	5	5
6.	Additional sets of capsule piece parts.	40	32
7.	Additional heat source hardware.	5 partial, 5 whole	5 whole
8.	Design and Safety Analysis Effort.	Increase	Increase

Original Signed By
G. J. HILDEBRANDT

G. J. Hildebrandt, Manager
Space Isotope Power Department

JJ:9522:mck

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Encs. 1 - Pioneer Data Tabulations (U)
2 - Transit Data Tabulations (U)

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