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NAA-SR-MEMO-6652
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SERIES A

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FISCAL YEAR 1962–63

SNAP 10A PROGRAM PROPOSAL

(Revised August 15, 1961)

[redacted] RESTRICTED DATA

[redacted]

ATOMICS INTERNATIONAL
A DIVISION OF NORTH AMERICAN AVIATION, INC.

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DISCLAIMER

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[redacted]-MEMO-6652

FISCAL YEAR 1962–63

SNAP 10A PROGRAM PROPOSAL

(Revised August 15, 1961)

COMPACT SYSTEMS DIVISION

[redacted]

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN AVIATION, INC.
P.O. BOX 309 CANOGA PARK, CALIFORNIA

CONTRACT: AT(11–1)–GEN–8
ISSUED: AUGUST 15, 1961

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CONTENTS

NOTE

The purpose of this document is to present information regarding the need for additional funds in FY 1962 for the SNAP 10A Program. NAA-SR-MEMO-6423, FY 1962-1963 SNAP Program Proposal, includes a detailed budgetary summary of the $5,525,000 SNAP 10A Program originally proposed for FY 1962. This document presents the same budgetary information contained in NAA-SR-MEMO-6423, and adds budgetary information covering the specific areas of work which will require additional funds during FY 1962.

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SUMMARY OF PROGRAM OBJECTIVES
SNAP 10A PROGRAM
AEC ACTIVITY 04-10-04-10

PROGRAM OBJECTIVES

The SNAP 10A program has as its objective the development of a nuclear power system for space application. This development effort will lead to flight tests under the SNAPSHOT program in conjunction with the Air Force. The system is being developed to the following specifications:

A. An electrical output of at least 500 watts over the system lifetime of 1 year.

B. A system weight of 875 lb including the special components and diagnostic instrumentation necessary to complete the SNAPSHOT objectives. The operational SNAP 10A system design objective is 775 lb with present day thermocouple materials. The shield in this system will be designed to provide protection for the electronic payloads in the flight vehicle in the present configuration which provides 17-1/2 ft separation between reactor and payload.

C. The SNAP 10A system shall utilize the SNAP 2 reactor with minimum modifications.

D. The system will be essentially static in its operation. Power conversion will be accomplished by a thermoelectric generator coupled to the reactor heat source by means of an electromagnetically pumped liquid metal heat transfer loop.

E. The system shall be designed to eliminate the need for active control, following orbital startup.

F. The system will be qualified to withstand the environment imposed by the vehicle ascent and space environments.

G. The unit must be designed to facilitate safe ground handling and launching and must be developed to contribute a minimal radiological hazard at launch to the launch facilities, personnel, and surrounding inhabitants.

H. The power conversion subsystem shall be of a design to accommodate future growth.

The SNAPSHOT program is a joint AEC-USAF effort to flight test SNAP units. SNAPSHOT flights are intended to establish the capabilities of nuclear auxiliary power so that its future use in space systems can be programmed with confidence overcoming both technical and psychological barriers. (See WDLPR-345). A set of flight tests for the SNAP 10A system form a part of this effort. These

flight tests are currently scheduled for April 1963, and August 1963, based on current launch site availability information. A detailed schedule is now being established for the completion of the flight test system as well as certain other interim systems necessary for vehicle integration work. The first SNAP 10A flight system is scheduled for delivery in January 1963.

The development objectives of the SNAP 10A system have been established to meet the requirements of the MIDAS weapon system under development by the Air Force. The SNAP 10A system has a unique capability in this regard as it would be unaffected by the Van Allen radiation existing at the operational altitude now proposed for the MIDAS system.

DEVELOPMENT PLAN

In order to meet the objectives of the SNAP 10A program a carefully scheduled set of development tasks and system tests must be performed. The nature of these are outlined in the following paragraphs:

A. Preliminary Design: The system performance objectives are analyzed and the requirements for the various subsystem components are established. The development necessary to meet the objectives is specified. The system package design is initiated.

B. Component Development: The development of the subsystem is carried out to meet the performance objectives established under the preliminary design. These components are tested under simulated vehicle launch as well as performance conditions. The major subsystems are as follows:

1) Reactor: The SNAP 2 reactor will be used in this system. The SNAP 2 program will carry out the major development of the reactor with only minor modifications being required for the SNAP 10A program.

2) Power Conversion System: A thermoelectric converter with an integral radiator will be used in this system. The converter development will be based on the utilization of current thermoelectric materials, such as lead telluride together with an intensive effort on low resistance mechanically sound electrical contacts and encapsulation to suppress sublimation of couples. In addition module development to meet the weight reliability and life objectives will be accomplished.

3) Heat Transfer System: NaK will be used to transfer the heat from the reactor to the converter. A d-c electromagnetic pump as well as other system components such as an expansion compensator will be developed.

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4) Shield: A lithium hydride radiation shield will be developed and tested to meet the nuclear as well as the environmental specifications.

5) Structure: A structural package will be designed to provide the support for all of the components and attachment to the vehicle structure.

C. Environmental Test System (S-10-PSM-1): The S-10-PSM-1 system will be used in performing mechanical tests on the package. It will consist of the basic structure together with the subsystems either mocked up as to mass and shape or as developmental prototype being subjected to the localized shock and vibrational environment. The package will be subjected to the specified shock, vibration, and stress environment and will provide structural information for the flight system design.

D. Performance Test (S-10-PSM-3): The performance of a converter and associated heat transfer components will be studied in the S-10-PSM-3 system. The system will be operated with electrical heat in simulated space environment. Data on efficiencies, heat losses, startup characteristics, and long term performance will be obtained.

E. Flight System Design: The design of the flight system will be executed on the basis of the results of the component development and environmental and performance system tests.

F. Non-nuclear Qualification Tests (S-10-FSM-1): The first system built from the flight design will be used for non-nuclear qualification tests. After going through the acceptance test procedures it will be subject to the qualification tests which will equal or exceed the expected mechanical environments of launch conditions.

G. Nuclear Qualification Tests (S-10-FS-1): The nuclear qualification test system will be used to provide a final check of the flight system before delivery. S-10-FS-1 will be identical to the subsequent flight test systems. It will incorporate any modifications found to be necessary as a result of the non-nuclear qualification tests. After going through the acceptance test procedure the system will be operated under nuclear heat as a performance demonstration.

H. Flight Test (S-10-FS-2 and S-10-FS-3): There will be two flight test systems. They will be identical to S-10-FS-1. Acceptance test procedures will be carried out and the system delivered for flight test.

These tasks are coupled through the system design efforts. The preliminary design will constitute the reference system through the environmental and performance tests (S-10-PSM-1 and S-10-PSM-3)

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after which the flight design will be the reference system. As a result of the non-nuclear qualification tests certain modifications may be necessary to the flight design. These modifications will be incorporated in the nuclear qualification and flight systems prior to their checkout.

In addition to the development program two pre-flight mockups are required by the Air Force. The first is an electrical simulator mockup S-10-PSM-2. S-10-PSM-2 will be developed to meet the vehicle contractor's requirements for an electrical test system. It will be used in the development and testing of the vehicle electrical system.

A second system S-10-FSM-2 will be used in the checkout of the flight vehicle. It will be integrated into the vehicle during final checkout and will go through the hot firing test of the vehicle. This test will provide a final qualification of the system for all of the vibration and shock conditions to be experienced in flight.

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ADDITIONAL FUNDING REQUIREMENTS
FOR NEW WORK - SNAP 10A PROGRAM

VOID-FREE CONVERTER SYSTEM

As a result of the many development problems and resulting performance and schedule uncertainties associated with thermoelectric conversion, it was decided in March of this year to pursue an alternate or backup converter approach. Because of its apparently inherent solution to the sublimation problem, and because of its potential mechanical ruggedness, the void-free design, exemplified by the developments at Westinghouse, was chosen as the alternate converter. This type of converter operates as a heat exchanger between a primary and a secondary coolant loop with the system waste heat rejected from a radiator which is separate from the converter. The temperature difference between the primary and secondary loop, which is imposed across the converter, causes the thermoelectric output.

The SNAP 10A program and our ability to meet the current SNAP 10A schedule is based on the successful development of the "encapsulated" converter. All system analysis and design, and all system structural (PSM-1) and performance (PSM-3) tests are based on the encapsulated converter. There is only a small analytical effort in support of the "void-free" 2-loop system. Therefore, even though the converter development for these two systems is proceeding in parallel, the system analysis and design are not proceeding in parallel.

Under the current development plan and funding, a change to the "void-free" converter beyond August 1961 would involve a schedule slippage. This delay in schedule would be caused by the amount of time necessary to bring the 2- loop system analysis and design up to that of the hardware development of the "encapsulated" design at the time of the change. If additional funding for the 2-loop system analysis and design can be made available, it will be possible to carry the two systems in parallel on the system hardware design as well as the converter development. The specific objective of the parallel void-free system design effort is to have a complete void-free system flight design available in December 1961. If this is done, final converter selection can be made as late as December 1961 without delaying the flight schedule. December 1961 is considered the latest date for this decision. In order to meet the flight schedule (FSM-1, scheduled for operation in April 1962), the flight system converter must be incorporated because environmental testing of FSM-1 is the first step in the environmental qualification of the flight design. The system configuration, structure, and startup details are significantly different for the two systems. The four months between December and April is the minimum time necessary to fabricate the first flight design system, FSM-1, and the nine months between April 1962 and January 1963 is the minimum time necessary to fabricate, qualify, acceptance test, and deliver the first flight system, FS-2.

ADDITIONAL SNAPSHOT DELIVERIES

The FY 1962 and 1963 funding requirements for delivering the additional prototype (S-10-FSM-3) and additional flight system (S-10-FS-4) requested by the Air Force are presented in this document.

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BREAKDOWN OF ESTIMATED COSTS BY
AEC BUDGET ACTIVITY NUMBERS
SNAP 10A

		Current Program ($000)	Additional Funding ($000)	Revised Total ($000)	FY 1963* ($000)
04-10-02-03					
.1	Research and Development	2,405	1,508	3,913	2,074
.2	Fuel Fabrication	447	-	447	860
.3	Test Operations	24	-	24	725
.4	Reactor Experiment Fabrication	2,224	1,054	3,278	3,487
.6	Irradiation Unit Charges	-	-	-	-
.7	In-Pile Tests	-	-	-	-
	Sub-Total Operating Funds	5,100	2,562	7,662	7,146
.9	Test Equipment	425	-	425	225
	Total 04-10-02-03	5,525	2,562	8,087	7,371

*Except for additional SNAPSHOT system deliveries, the FY 1963 funding has not been reviewed.

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BREAKDOWN OF ESTIMATED COSTS BY
AEC BUDGET ACTIVITY NUMBERS
SNAP 10A

		FY 1962 ($000)	FY 1963 ($000)
04-10-02-03			
.1	Research and Development	2,405	2,074
.2	Fuel Fabrication	447	860
.3	Test Operations	24	725
.4	Reactor Experiment Fabrication	2,224	2,141
.6	Irradiation Unit Charges	-	-
.7	In-Pile Tests	-	-
	Sub-Total Operating Funds	5,100	5,800
.9	Test Equipment	425	225
	Total 04-10-02-03	5,525	6,025

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SUMMARY OF PROJECTS
SNAP 10A
($000)

Project	FY 1962					FY 1963		
	Operating		Equipment	Total		Operating	Equipment	Total
	Current	Proposed		Current	Proposed			
04-10-02-03.1 R&D								
2100 Project Engineering	98	106	-	98	106	197	-	197
2101 System Safety Analysis	83	83	-	83	83	93	-	93
2104 System Analysis	96	243	-	96	243	153	-	153
2105 Design Integration	89	284	-	89	284	81	-	81
2106 SNAPSHOT Coordination	35	46	-	35	46	158	-	158
2133 Shield Experiments	66	66	-	66	66	-	-	-
2137 Safety Investigations	145	145	-	145	145	143	-	143
2141 Package and Structure	86	111	21	107	132	-	-	-
2143 Component Environmental Test	67	117	6	73	123	42	73	115
2145 Aerospace Ground Equipment	257	201	68	325	269	213	55	268
2146 Heat Transfer Subsystem Development	98	124	7	105	131	84	-	84
2148 Shield Development	52	139	-	52	139	80	-	80
2149 Startup, Control, Telemetry and Safety	76	140	18	94	158	167	11	178
2190 Thermoelectric Converter Development	641	1,323	52	693	1,375	395	11	406
2191 Thermoelectric Generator Materials and Procurement	75	103	2	77	105	42	-	42
2192 Thermoelectric Materials Development	100	265	-	100	265	59	-	59
2193 Process Development for Thermoelectric Converter	170	221	-	170	221	72	-	72
2194 Thermoelectric Generator Development Quality Test	118	118	6	124	124	59	-	59
2195 Thermoelectric Generator Development	53	78	-	53	78	36	-	36
Total	2,405	3,913	180	2,585	4,093	2,074	150	2,224
04-10-02-03.2 Fuel Fabrication								
2120 Fuel Forming	150	150	-	150	150	270	-	270
2121 Fuel Conversion	64	64	5	69	69	128	-	128
2122 Fuel Element Cladding	105	105	4	109	109	209	-	209
2123 Quality Testing	128	128	21	149	149	253	-	253
Total	447	447	30	477	477	860	-	860

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SUMMARY OF PROJECTS
SNAP 10A
($000)

Project	FY 1962			FY 1963		
04-10-02-03.1 R&D	Operating	Equipment	Total	Operating	Equipment	Total
2100 Project Engineering	98	-	98	197	-	197
2101 System Safety Analysis	83	-	83	93	-	93
2104 System Analysis	96	-	96	153	-	153
2105 Design Integration	89	-	89	81	-	81
2106 SNAPSHOT Coordination	35	-	35	158	-	158
2133 Shield Experiments	66	-	66	-	-	-
2137 Safety Investigations	145	-	145	143	-	143
2141 Package and Structure	86	21	107	-	-	-
2143 Component Environmental Test	67	6	73	42	73	115
2145 Aerospace Ground Equipment	257	68	325	213	55	268
2146 Heat Transfer Subsystem Development	98	7	105	84	-	84
2148 Shield Development	52	-	52	80	-	80
2149 Startup, Control, Telemetry and Safety	76	18	94	167	11	178
2190 Thermoelectric Converter Development	641	52	693	395	11	406
2191 Thermoelectric Generator Materials and Procurement	75	2	77	42	-	42
2192 Thermoelectric Materials Development	100	-	100	59	-	59
2193 Process Development for Thermoelectric Converter	170	-	170	72	-	72
2194 Thermoelectric Generator Development Quality Test	118	6	124	59	-	59
2195 Thermoelectric Generator Development	53	-	53	36	-	36
Total	2,405	180	2,585	2,074	150	2,224
04-10-02-03.2 Fuel Fabrication						
2120 Fuel Forming	150	-	150	270	-	270
2121 Fuel Conversion	64	5	69	128	-	128
2122 Fuel Element Cladding	105	4	109	209	-	209
2123 Quality Testing	128	21	149	253	-	253
Total	447	30	477	860	-	860

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SUMMARY OF PROJECTS (Continued)
SNAP 10A

Project	FY 1962					FY 1963		
	Operating		Equipment	Total		Operating	Equipment	Total
	Current	Proposed		Current	Proposed			
04-10-02-03.3 Test Operations								
2152 Reactor Operations	24	24	-	24	24	481	7	488
2153 Test Facility Operations and Maintenance	-	-	-	-	-	94	-	94
2156 Remote Handling and Viewing	-	-	-	-	-	150	-	150
Total	24	24	-	24	24	725	7	732
04-10-02-03.4 Reactor Experiment Fabrication								
2161 Packages and Structures	191	224	-	191	224	110	-	110
2162 Reflector and Drive Assembly Fabrication	346	346	21	367	367	297	44	341
2166 Heat Transfer Design and Fabrication	47	70	1	48	71	28	-	28
2167 Core Design and Fabrication	87	87	-	87	87	41	-	41
2168 Design and Fabrication	85	92	-	85	92	60	-	60
2169 Startup, Controls, Safety and Telemetry	200	247	13	213	260	332	13	345
2170 S-10-FS System Engineering	66	201 •	-	66	201	56	-	56
2171 S-10-FS-1 Installation and Preoperation	27	27	-	27	27	112	-	112
2172 S-10-FS-2 System Assembly and Acceptance	32	74	-	32	74	92	-	92
2173 S-10-FS-3 System Assembly and Acceptance	-	-	-	-	-	142	11	153
2174 Launch Operations	58	56	-	58	56	262	-	262
2181 S-10-PSM-1 System Engineering	34	35	-	34	35	-	-	-
2182 S-10-PSM-2 & 3 System Engineering	33	63	-	33	63	30	-	30
2183 S-10-FSM-1 & 2 System Engineering	54	53	-	54	53	-	-	-
2184 S-10-PSM-1 Environmental Development	145	156	-	145	156	-	-	-
2186 S-10-PSM-3 Assembly and Installation Test	111	151	-	111	151	27	-	27
2188 S-10-FSM-1 Installation and Test	72	147	10	82	157	66	-	66
2189 S-10-FSM-2 Installation and Test	72	123	-	72	123	23	-	23
2199 Power Conversion System Design and Fabrication	564	564	170	734	734	463	-	463
21xx S-10-FSM-3	-	465 •	-	-	465	368	-	368
21xy S-10-FS-4	-	97 •	-	-	97	978	-	978
Total	2,224	3,278	215	2,439	3,493	3,487	68	3,555
04-10-02-03 Grand Total	5,100	7,662	425	5,525	8,087	7,146	225	7,371

SUMMARY OF PROJECTS (Continued)

SNAP 10A

Project	FY 1962			FY 1963		
04-10-02-03.3 Test Operations	Operating	Equipment	Total	Operating	Equipment	Total
2152 Reactor Operations	24	-	24	481	7	488
2153 Test Facility Operations and Maintenance	-	-	-	94	-	94
2156 Remote Handling and Viewing	-	-	-	150	-	150
Total	24	-	24	725	7	732
04-10-02-03.4 Reactor Experiment Fabrication						
2161 Packages and Structures	191	-	191	110	-	110
2162 Reflector and Drive Assembly Fabrication	346	21	367	297	44	341
2166 Heat Transfer Design and Fabrication	47	1	48	28	-	28
2167 Core Design and Fabrication	87	-	87	41	-	41
2168 Design and Fabrication	85	-	85	60	-	60
2169 Startup, Controls, Safety and Telemetry	200	13	213	332	13	345
2170 S-10-FS System Engineering	66	-	66	56	-	56
2171 S-10-FS-1 Installation and Preoperation	27	-	27	112	-	112
2172 S-10-FS-2 System Assembly and Acceptance	32	-	32	92	-	92
2173 S-10-FS-3 System Assembly and Acceptance	-	-	-	142	11	153
2174 Launch Operations	58	-	58	262	-	262
2181 S-10-PSM-1 System Engineering	34	-	34	-	-	-
2182 S-10-PSM-2 & 3 System Engineering	33	-	33	30	-	30
2183 S-10-FSM-1 & 2 System Engineering	54	-	54	-	-	-
2184 S-10-PSM-1 Environmental Development	145	-	145	-	-	-
2186 S-10-PSM-3 Assembly and Installation Test	111	-	111	27	-	27
2188 S-10-FSM-1 Installation and Test	72	10	82	66	-	66
2189 S-10-FSM-2 Installation and Test	72	-	72	23	-	23
2199 Power Conversion System Design and Fabrication	564	170	734	463	-	463
Total	2,224	215	2,439	2,141	68	2,209
04-10-02-03 Grand Total	5,100	425	5,525	5,800	225	6,025

REVISED

PROGRAM SUMMARY

SNAP 10A

COST BREAKDOWN ($000)	Present Program	Additional Funds to Present Program	Additional Funds for Void Free Study	Additional Funds for Extra SNAPSHOT Deliveries	Revised Total	FY 1963*
1. System Analysis	546	64	297	-	907	825
a. Project Engineering	98	8	-	-	106	197
b. System Analysis	96	47	100	-	243	153
c. Reactor Analysis	-	-	-	-	-	-
d. Safety and Flight Analysis	352	9	197	-	558	475
2. Component Development	1589	652	551	-	2792	1028
a. Fuel Element Development	-	-	-	-	-	-
b. Reactor Subsystem Development	86	25	-	-	111	-
c. Heat Transfer Subsystem Development	101	28	240	-	369	87
d. Power Conversion Subsystem Development	1200	443	311	-	1954	685
e. Shield Development	123	90	-	-	213	83
f. Heat Rejection Development	-	-	-	-	-	-
g. Control, Safety, and Flight Component Development	79	66	-	-	145	173
3. System Development	1850	369	-	-	2219	1453
a. Non-Nuclear Test System						
1. S-10-PSM-1	247	37	-	-	284	-
2. S-10-PSM-3	350	80	-	-	430	57
3. S-10-FSM-1	897	104	-	-	1001	66
b. Nuclear Test Systems						
1. S-10-FS-1	356	148	-	-	504	1330
4. Flight Test Systems	787	125	-	562	1474	3357
a. Pre-Flight Mockups						
1. S-10-FSM-2	711	83	-	-	794	23
2. S-10-FSM-3	-	-	-	465	465	368
b. Flight Test Systems						
1. S-10-FS-2	76	42	-	-	118	991
2. S-10-FS-3	-	-	-	-	-	997
3. S-10-FS-4	-	-	-	97	97	978
5. Flight System Support	328	<58>	-	-	270	483
a. Aero-space Ground Equipment	270	<56>	-	-	214	221
b. Launch Base Operations	58	<2>	-	-	56	262
Total Operating Funds	5100	1152	848	562	7662	7146
Test Equipment	425	-	-	-	425	225
Grand Total	5525	1152	848	562	8087	7371

*Except for additional SNAPSHOT system deliveries, the FY 1963 funding has not been reviewed.

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PROGRAM SUMMARY
SNAP 10A

COST BREAKDOWN ($000)		FY 1962	FY 1963
1. System Analysis	Subtotal	546	825
a. Project Engineering		98	197
b. System Engineering		96	153
c. Reactor Analysis		-	-
d. Safety and Flight Analysis		352	475
2. Component Development	Subtotal	1589	1028
a. Fuel Element Development		-	-
b. Reactor Subsystem Development		86	-
c. Heat Transfer Subsystem Development		101	87
d. Power Conversion Subsystem Development		1200	685
e. Shield Development		123	83
f. Heat Rejection Development		-	-
g. Control, Safety, and Flight Component Development		79	173
3. System Development	Subtotal	1850	1453
a. Non-Nuclear Test System			
1. S-10-PSM-1		247	-
2. S-10-PSM-3		350	57
3. S-10-FSM-1		897	66
b. Nuclear Test Systems			
1. S-10-FS-1		356	1330
4. Flight Test Systems	Subtotal	787	2011
a. Pre-Flight Mockups			
1. S-10-FSM-2		711	23
b. Flight Test Systems			
1. S-10-FS-2		76	991
2. S-10-FS-3		-	997
5. Flight System Support	Subtotal	328	483
a. Aero-Space Ground Equipment		270	221
b. Launch Base Operations		58	262
Total Operating Funds		5100	5800
Test Equipment		425	225
Grand Total		5525	6025

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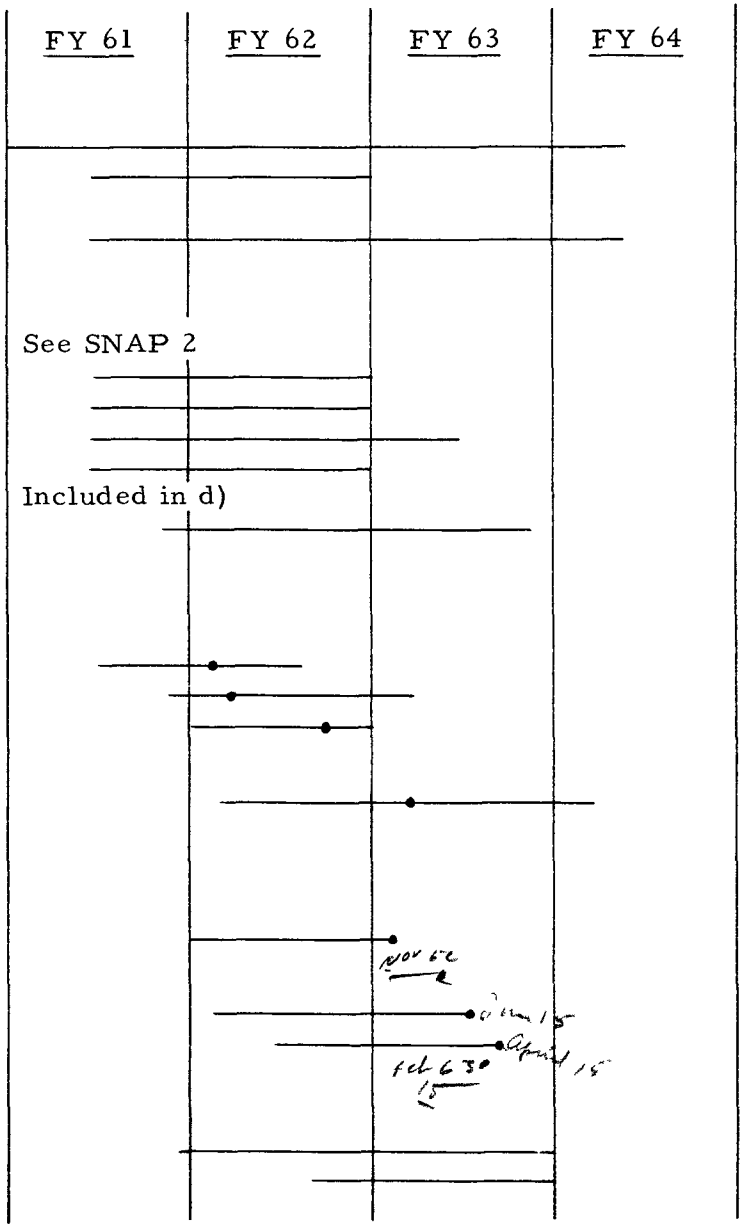
DEVELOPMENT SCHEDULE
SNAP 10A



1. System Analysis
   - a) Project Engineering
   - b) System Engineering
   - c) Reactor Analysis
   - d) Safety and Flight Analysis

2. Component Development
   - a) Fuel Element Development
   - b) Reactor Subsystem Development
   - c) Heat Transfer Subsystem Development
   - d) Power Conversion Subsystem Development
   - e) Shield Development
   - f) Heat Rejection Subsystem Development
   - g) Control, Safety, and Flight Component Development

3. System Development (Points indicate test start)
   - a) Non-nuclear Test System
     - S-10-PSM-1
     - S-10-PSM-3
     - S-10-FSM-1
   - b) Nuclear Test System (Points indicate delivery)
     - S-10-FS-1

4. Flight Test Systems
   - a) Pre-flight Mockups
     - S-10-FSM-2
     - FSM-3
   - b) Flight Test Systems
     - S-10-FS-2
     - S-10-FS-3
     - FS-4

5. Flight Test Support
   - a) Aerospace Ground Equipment
   - b) Launch Base Operations

[redacted]

ADDITIONAL FUNDING REQUIREMENTS
SNAP 10A FY-1962
($000)

PROPOSED COST BREAKDOWN	INCREASE Current Program	INCREASE Void-free Study
1. System Analysis		
a. Project Engineering		
(Current Program)		
2100 — Project Engineering The increase is due to a higher level of coordination activities as a result of the increased scope of Atomics International activities and additional reports and similar activities.	8,000	
b. System Analysis		
(Current Program)		
2104 — System Analysis The increase is due to a rescoping of effort with increased emphasis on flight-induced problems, e.g., NaK freezing and operating torques.	47,000	
(Void-free Study)		
2104 — System Engineering Provision is made for system analysis to investigate and determine requirement and performance of SNAP 10A using the void-free converter design.		100,000
c. Reactor Analysis	-	-

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PROGRAM COST DISTRIBUTION
SNAP 10A
($000)

COST BREAKDOWN	FY 62	FY 63
1. System Analysis		
a. Project Engineering	98	197
Objective: Project Engineering will provide the overall program coordination to assure adherence to the technical schedule, and budgeting objectives of the programs. System tests and their facility requirements will be defined and liaison with the AEC will be conducted		
FY 62: The FY 62 tasks include coordinating a number of system tests and establishing the flight design.		
FY 63: The flight tests program will be initiated during FY 63. Extensive coordination between AEC and USAF contractors will be required.		
2100 Project Engineering	98	197
b. System Analysis	96	153
Objective: The system performance will be established through analysis. The design operating points will be established and the kinetic properties will be studied. The reliability goals will be analyzed, apportioned to the subsystems and test results monitored.		
FY 62: The design point for the flight system will be established and the test program monitored for performance and reliability.		
FY 63: The flight test program will be monitored to provide the design point of the final system.		
2104 System Analysis	96	153
c. Reactor Analysis		
Objective: The analysis of the reactor for the SNAP 10A system will be derived from the SNAP 2 program in that the two reactors are essentially identical.	No Cost	

[redacted]

PROPOSED COST BREAKDOWN (Continued)

	INCREASE Current Program	INCREASE Void-free Study
d. Safety and Flight Analysis		
(Current Program)		
2101 – System Safety Analysis	-	-
2105 – Design Integration	<2,000>	-
2106 – SNAPSHOT Coordination	11,000	-
The increase is due to a higher level of coordination activities as a result of increased activities with LMSD.		
(Void-free Study)		
2105 – Design Integration	-	197,000
Provision is made here for system design and layout efforts on systems using the Westinghouse void-free converter.		
2. Component Development		
a. Fuel Element Development	-	-
b. Reactor Subsystem Development		
(Current Program)		
2141 – Package and Structure Development	25,000	-
Provision is made here for development and test of the assembly destruct mechanism.		

[redacted]

COST BREAKDOWN (Continued)	FY 62	FY 63
d. Safety and Flight Analysis	352	475
Objective: The flight test program requires a complete analysis of the safety problem, a design consistent with the vehicle integration requirements, and planning support to establish the flight test objectives and schedule.		
FY 62: The flight system design will be established in conjunction with the USAF contractor. The safety aspects of the flight will receive detailed analysis.		
FY 63: The flight test program will be carried out. Support will be provided in the areas of scheduling, test coordination and safety.		
2101 System Safety Analysis	83	93
2105 Design Integration	89	81
2106 SNAPSHOT Coordination	35	158
2137 Safety Investigations	145	143
2. Component Development		
a. Fuel Element Development		
Objective: The fuel element development task will be carried out under the SNAP 2 program.	No Cost	
b. Reactor Subsystem Development	86	-
Objective: The basic reactor development will be provided under the SNAP 2 program. Those features requiring special development will be carried out under this task.		
FY 62: The reflector and drive assembly will be modified to meet the SNAP 10A system objectives.		
2141 Package and Structure Development	86	-

[redacted]

PROPOSED COST BREAKDOWN (Continued)

	INCREASE	
	Current Program	Void-free Study
c. Heat Transfer Subsystem Development		
(Current Program)		
2146 – Heat Transfer Subsystem Development	26,000	-
The pump test program will be expanded to include additional tests, as well as extend those tests which were planned previously.		
2143 – Component Environmental Testing	2,000	-
(Void-free Study)		
2146 – Heat Transfer Subsystem Development	-	240,000
Provision is made here for radiator development for the void-free design study and minor additional pump work for this system.		
d. Power Conversion Subsystem Development		
(Current Program)		
2190 – Thermoelectric Converter Development	129,000	-
Additional funds are for design and evaluation of modules ($29,000), and additional work at General Instruments ($100,000) on brazing and encapsulation.		
2191 – Thermoelectric Generator Materials and Process Engineering	28,000	-
Severe problems have developed in the stress and analytical design engineering of the thermoelectric generator, solutions for which are required to produce a reliable module.		
2192 – Thermoelectric Materials Development	165,000	-
The deeper understanding of the materials problems points out a need for a further understanding to proceed with confidence toward development of a reliable module. Increased emphasis is required in development of braze materials, sublimation barriers, studies of interdiffusion between barriers and PbTe, and studies of thermal gradient diffusion; post-mortem of test samples needs to be extended and intensified.		
2193 – Process Development for Thermoelectric Converters	51,000	-
Additional funding is required to increase production rate of modules, and for testing of process variables during contacting, brazing, and encapsulation, for full-size modules.		
2194 – Thermoelectric Generator Development Quality Control and Test	-	-
2195 – Thermoelectric Generator Development	25,000	
Additional surveillance and control are needed due to poor vendor supply material and control.		
2143 – Component Environmental Testing	39,000	-
The increase is to accommodate the accelerated module testing schedule.		
(Void-free Study)		
2190 – Thermoelectric Converter Development	-	311,000
Provision is made here for additional Westinghouse R&D ($130,000), additional Westinghouse module delivery ($103,000), and Westinghouse module evaluation ($78,000).		
2143 – Component Environmental Testing	-	4,000

[redacted]

COST BREAKDOWN (Continued)	FY 62	FY 63
c. Heat Transfer Subsystem Development	101	87
Objective: The SNAP 10A system will use a d-c electromagnetic pump to circulate the coolant. Other heat transfer system components will be adapted from the SNAP 2 program.		
FY 62: The heat transfer components development will be completed and they will be tested on the S-10-PSM-3 system.		
FY 63: The system and flight test data will be reviewed to establish a final design.		
2146 Heat Transfer Subsystem Development	98	84
2143* Component Environmental Testing	3	3
d. Power Conversion Subsystem Development	1200	685
Objective: The SNAP 10A thermoelectric converter will be developed to meet the system performance, life, and reliability objectives.		
FY 62: The converter modules will be placed on an extensive test program to separate the effects of the various environments to which they will be subjected. Materials studies will be conducted as necessary to ensure the life and reliability objectives.		
FY 63: The developmental and system test data will be reviewed to establish the final converter design.		
2190 Thermoelectric Converter Development	641	395
2191 Thermoelectric Generator Materials and Process Engineering	75	42
2192 Thermoelectric Materials Development	100	59
2193 Process Development for thermoelectric Convertors	170	72
2194 Thermoelectric Generator Development Quality Control & Test	118	59
2195 Thermoelectric Generator Development	53	36
2143* Component Environmental Testing	43	22

*Includes only a part of the overall project cost. Remaining costs for the project will be incurred in support of other areas of work.

[redacted]

PROPOSED COST BREAKDOWN (Continued)

	INCREASE Current Program	INCREASE Void-free Study
e. Shield Development		
(Current Program)		
2133 — Shield Experiments	-	-
2148 — Shield Development Additional small-sample thermal testing will include cycling, more extensive stress analysis, and measurement of gas evolution.	87,000	-
2143 — Component Environmental Testing	3,000	-
f. Heat Rejection Subsystem Development	-	-
g. Control, Safety, and Flight Component Development		
(Current Program)		
2149 — Startup, Control, Telemetry and Safety Development Provision is made for additional work in controls, and more extensive system diagnostic instrumentation. Additional reactor features, due to safety program requirements, are to be investigated.	64,000	-
2143 — Component Environmental Testing	2,000	-

[redacted]

COST BREAKDOWN (Continued)	FY 62	FY 63
e. Shield Development	123	83
Objective: The shield development program will provide a structurally sound radiation shield for the SNAP 10A system.		
FY 62: Shield components will be mechanically tested under the launch environment, and tested in the nuclear, thermal, and vacuum environments. Radiator transmission measurements will be made in standard configurations.		
FY 63: The performance of the shield in the flight test systems will be studied from telemetry data.		
2133 Shield Experiments	66	-
2148 Shield Development	52	80
2143* Component Environmental Testing	5	3
f. Heat Rejection Subsystem Development		
Objective: The radiator development is an integral part of the converter subsystem development (d). Emissive coatings will be developed on the SNAP 2 program.	No Cost	
g. Control, Safety, and Flight Component Development	79	173
Objective: The ground command and telemetry links will be developed together with the startup programmer associated with the ground command system and the special devices necessary to meet the safety criteria.		
FY 62: Standard telemetry transducers will be modified as required to meet the flight test requirements Other components will be developed and tested.		
FY 63: The flight hardware will be tested and integrated into the flight system. The flight test performance will be reviewed and final design established.		
2149 Startup Control Telemetry and Safety Development	76	167
2143* Component Environmental Testing	3	6

*Includes only a part of the overall project cost. Remaining costs for the project will be incurred in support of other areas of work.

[redacted]

PROPOSED COST BREAKDOWN (Continued) — INCREASE

3. System Development

a. Non-Nuclear Test Systems

1) S-10-PSM-1 Environmental Test System — 37,000

The system testing is to be accomplished with mass mockups in those instances where actual components of the system are not yet available. During the testing, and as the components become available, the mass mockups will be replaced. This continuous substitution, and an extension of the test program, will require additional funding.

2) S-10-PSM-3 Performance Test System — 80,000

The original test program has been extended to conform to that of the converter. The scope of the testing has been revised to include a portion of the converter assembly as soon as such becomes available. Multishift operation of the test is contemplated.

[redacted]

COST BREAKDOWN (Continued)	FY 62	FY 63
3. System Development (Detail by project is provided on pages 22 and 23.		
a. Non-Nuclear Test Systems		
1) S-10-PSM-1 Environmental Test System	247	-
Objective: The S-10-PSM-1 system will be used in performing environmental tests on the structural package.		
FY 62: The fabrication of system will be completed and tests will be conducted. Developmental subsystems will be integrated in the test program as they become available.		
System Engineering	34	-
Fuel Fabrication	-	-
System Fabrication	68	-
Power Conversion System Assembly, Checkout and Test Operations	145	-
2) S-10-PSM-3 Performance Test System	350	57
Objective: The S-10-PSM-3 will be used to study the performance of the converter and associated heat transfer components. System interactions and components degradations will be determined.		
FY 62: The system will be fabricated and placed on test in a vacuum environment. Startup tests will be conducted.		
FY 63: The testing will be continued to gather life and reliability data.		
System Engineering	33	30
Fuel Fabrication	-	-
System Fabrication	45	-
Power Conversion System	161	-
Assembly Checkout and Test Operations	111	27

[redacted]

PROPOSED COST BREAKDOWN (Continued)	INCREASE
3) S-10-FSM-1 Non-Nuclear Qualification Test	104,000
The test schedule is to be extended in order to define more accurately long-term system performance and degradation.	
b. Nuclear Test Systems	
1) S-10-FS-1 Nuclear Qualification Test	148,000
The increase provides for acceleration of the test program and hardware procurement.	

[redacted]

COST BREAKDOWN (Continued)	FY 62	FY 63
3) S-10-FSM-1 Non-Nuclear Qualification Test	897	66
Objective: The S-10-FSM-1 system will be used to qualify the flight system for launch and space environments. The interactions of environment on performance will be determined.		
FY 62: The system will be built from the flight design, checked out, and tested through simulated launch environment.		
FY 63: The system will be operated on electrical heat in a simulated space environment.		
System Engineering	27	-
Fuel Fabrication	283	-
System Fabrication	354	-
Power Conversion System	161	-
Assembly Checkout and Test Operations	72	66
b. Nuclear Test Systems		
1) S-10-FS-1 Nuclear Qualification Test	356	1330
Objective: The nuclear qualification system will provide an operational demonstration of the flight system in a radiation, thermal and vacuum environment.		
FY 62: Design, fabrication, and assembly will be initiated.		
FY 63: The system will be fabricated, assembled, and checked out and placed in operation in the SNAP Environmental Test Facility. Performance and reliability data will be obtained.		
System Engineering	22	-
Fuel Fabrication	11	280
System Fabrication	191	112
Power Conversion System	81	101
Assembly and Checkout	27	112
Test Operations	24	725

PROPOSED COST BREAKDOWN (Continued)	INCREASE
4. Flight Test System	
a. Preflight Mockup	
1) S-10-FSM-2 Mechanical Mockup	83,000
The increase reflects a more accurate pricing of test hardware, in addition to preparation for accelerated acceptance testing.	
b. Flight Test Systems	
1) S-10-FS-2 First Flight System	42,000
Increase reflects costs of accelerated hardware delivery and assembly preparation.	

COST BREAKDOWN (Continued)

	FY 62	FY 63
4. Flight Test System		
a. Pre-Flight Mockup		
1) S-10-FSM-2 Mechanical Mockup	711	23
Objective: This system will be integrated in the flight vehicle and used in checkout and the hot firing tests. It will contain all components including a few U-238 Fuel elements so that the effects of combined vibration, shock and acoustical environment can be determined.		
FY 62: The system will be fabricated, assembled, and checked out.		
FY 63: The system will be delivered to the vehicle contractor for test.		
System Engineering	27	-
Fuel Fabrication	153	-
System Fabrication	298	-
Power Conversion System	161	-
Assembly and Checkout	72	23
Test Operations	-	-
b. Flight Test Systems		
1) S-10-FS-2 First Flight System	76	991
Objective: This system will be delivered to the Air Force for flight test. Data on its performance will be obtained by telemetry, reduced, and analyzed to establish a final design.		
FY 62: The system will be desinged.		
FY 63: The fabrication will be completed, the system assembled, checked out, and delivered.		
System Engineering	44	56
Fuel Fabrication	-	290
System Fabrication	-	372
Power Conversion System	-	181
Assembly and Checkout	32	92
Test Operations	-	-

PROPOSED COST BREAKDOWN (Continued)	INCREASE
2) S-10-FS-3 Second Flight System	-
5. Flight System Support	
a. Aero-Space Ground Equipment	
2145 – Aero-space Ground Equipment	< 56,000>
Reduction of funds required is due to re-evaluation and deferment of some items to FY 1963.	
2143 – Component Environmental Testing	-

[redacted]

COST BREAKDOWN (Continued)	FY 62	FY 63
2) S-10-FS-3 Second Flight System	-	997
Objectives: This system will be used in a second flight test. The basic objectives of the first flight system will be retained, and the test will provide a backup in case of launch failure.		
FY 63: The system will be designed and fabrication initiated. Fabrication will be completed, then system assembled, checkout, and delivered.		
System Engineering	-	-
Fuel Fabrication	-	290
System Fabrication	-	384
Power Conversion System	-	181
Assembly and Checkout	-	142
Test Operations	-	-
5. Flight System Support		
a. Aero-Space Ground Equipment	270	221
Objectives: The handling and checkout equipment will be developed to support the flight test program.		
FY 62: Checkout equipment will be designed and tested. Standard handling equipment will be modified for the SNAP 10A system.		
FY 63: Support activities will be coordinated with the flight test program. Special equipment will be provided as required.		
2145 Aerospace Ground Equipment	257	213
2143* Component Environmental Testing	13	8

*Includes only a part of the overall project cost. Remaining costs for the project will be incurred in support of other areas of work.

[redacted]

PROPOSED COST BREAKDOWN (Continued)	INCREASE
b. Launch Base Operations	
2174 – Launch Operations	< 2,000>

[redacted]

COST BREAKDOWN (Continued)	FY 62	FY 63
b. Launch Base Operations	58	262
Objective: Overall direction and coordination of the SNAP 10A Program launch site facilities and activities will be provided. Provision will be made for the final assembly, fuel loading and pre-launch non-nuclear system checkouts of the flight systems.		
FY 62: Launch site facilities and activities will be coordinated with the customer agency. Detailed facility requirements will be determined and detailed launch site procedures established.		
2174 Launch Operations	58	262

REVISED

PROJECT COST ESTIMATE BY SYSTEMS
($000)
FY 1962

Project	Title (A = Present Program; B = Proposed Program)	Total		PSM-1		PSM-3		FSM-1		FSM-2		FS-1		FS-2		FS-3	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
2120	Fuel Forming	150	150	-	-	-	-	89	89	50	50	11	11	-	-	-	-
2121	Fuel Conversion	64	64	-	-	-	-	40	40	24	24	-	-	-	-	-	-
2122	Fuel Cladding	105	105	-	-	-	-	70	70	35	35	-	-	-	-	-	-
2123	Quality Testing	128	128	-	-	-	-	84	84	44	44	-	-	-	-	-	-
2152	Reactor Operation	24	24	-	-	-	-	-	-	-	-	24	24	-	-	-	-
2153	Test Facility, Op. & Maint.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2156	Remote Handling & Viewing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2161	Package & Structure Des. & Fab.	191	224	68	93	36	45	29	29	29	29	29	28	-	-	-	-
2162	Reflector & Drive Des. & Fab.	346	346	-	-	-	-	160	160	106	106	80	80	-	-	-	-
2166	Heat Transfer Design & Fab.	47	70	-	-	9	10	12	20	11	20	15	20	-	-	-	-
2167	Core Design & Fab.	87	87	-	-	-	-	29	29	29	29	29	29	-	-	-	-
2168	Shield Fabrication	85	92	-	-	-	-	29	31	28	31	28	30	-	-	-	-
2169	Startup - Design & Fab.	200	247	-	-	-	-	95	115	95	115	10	17	-	-	-	-
2170	S-10-FS System Eng.	66	201	-	-	-	-	-	-	-	-	22	157	44	44	-	-
2171	S-10-FS-1 Ass'y, Inst-Check	27	27	-	-	-	-	-	-	-	-	27	27	-	-	-	-
2172	S-10-FS-2 Ass'y, Inst-Check	32	74	-	-	-	-	-	-	-	-	-	-	32	74	-	-
2173	S-10-FS-3 Ass'y & Accept.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2181	S-10-PSM-1 Syst. Eng.	34	35	34	35	-	-	-	-	-	-	-	-	-	-	-	-
2182	S-10-PSM-2 & 3 Syst. Eng.	33	63	-	-	33	63	-	-	-	-	-	-	-	-	-	-
2183	S-10-FSM-1 & 2 Syst. Eng.	54	53	-	-	-	-	27	26	27	27	-	-	-	-	-	-
2184	S-10-PSM-1 Env. - Dev.	145	156	145	156	-	-	-	-	-	-	-	-	-	-	-	-
2186	S-10-PSM-3 Ass'y & Inst.	111	151	-	-	111	151	-	-	-	-	-	-	-	-	-	-
2188	S-10-FSM-1 Ass'y & Inst.	72	147	-	-	-	-	72	147	-	-	-	-	-	-	-	-
2189	S-10-FSM-2 Inst & Test	72	123	-	-	-	-	-	-	72	123	-	-	-	-	-	-
2199	T.E. Converter Des. & Fab.	564	564	-	-	161	161	161	161	161	161	81	81	-	-	-	-
	TOTAL	2637	3131	247	284	350	430	897	1001	711	794	356	504	76	118	-	-

[redacted]

BREAKDOWN OF PROJECT COST ESTIMATE BY SYSTEMS
($000)
FY 1962

	Project	System							
		Total	PSM-1	PSM-3	FSM-1	FSM-2	FS-1	FS-2	FS-3
2120	Fuel Forming	150	-	-	89	50	11	-	
2121	Fuel Conversion	64	-	-	40	24	-	-	
2122	Fuel Cladding	105	-	-	70	35	-	-	
2123	Quality Testing	128	-	-	84	44	-	-	
2152	Reactor Operation	24	-	-	-	-	24	-	
2153	Test Facility, Op. & Maint.	-	-	-	-	-	-	-	
2156	Remote Handling & View	-	-	-	-	-	-	-	
2161	Package & Structure Des. & Fab.	191	68	36	29	29	29	-	
2162	Reflector & Drive Des.& Fab.	346	-	-	160	106	80	-	
2166	Heat Transfer Design & Fab.	47	-	9	12	11	15	-	
2167	Core Design & Fab.	87	-	-	29	29	29	-	
2168	Shield Fabrication	85	-	-	29	28	28	-	
2169	Startup - Design & Fab.	200	-	-	95	95	10	-	
2170	S-10-FS System Eng.	66	-	-	-	-	22	44	
2171	S-10-FS-1 Ass'y, Inst-Check	27	-	-	-	-	27	-	
2172	S-10-FS-2 Ass'y, Inst-Check	32	-	-	-	-	-	32	
2173	S-10-FS-3 Ass'y & Accept.	-	-	-	-	-	-	-	
2182	S-10-PSM-2 & 3 Syst. Eng.	33	-	33	-	-	-	-	
2183	S-10-FSM-1 & 2 Syst. Eng.	54	-	-	27	27	-	-	
2184	S-10-PSM-1 Env. - Dev.	145	145	-	-	-	-	-	
2186	S-10-PSM-3 Ass'y & Inst.	111	-	111	-	-	-	-	
2188	S-10-FSM-1 Ass'y & Inst.	72	-	-	72	-	-	-	
2189	S-10-FSM-2	72	-	-	-	72	-	-	
2199	T.E. Converter Des. & Fab.	564	-	161	161	161	81	-	
2181	S-10-PSM-1 Syst. Eng.	34	34	-	-	-	-	-	
	TOTAL	2637	247	350	897	711	356	76	

[redacted]

[redacted]

BREAKDOWN OF PROJECT COST ESTIMATE BY SYSTEMS
($000)
FY 1963

Project		System							
		Total	PSM-1	PSM-3	FSM-1	FSM-2	FS-1	FS-2	FS-3
2120	Fuel Forming	270	-	-	-	-	88	91	91
2121	Fuel Conversion	128	-	-	-	-	42	43	43
2122	Fuel Cladding	209	-	-	-	-	67	71	71
2123	Quality Testing	253	-	-	-	-	83	85	85
2152	Reactor Operations	481	-	-	-	-	481	-	-
2153	Test Facility Oper. & Main.	94	-	-	-	-	94	-	-
2156	Remote Handling & Viewing	150	-	-	-	-	150	-	-
2161	Package & Structure Design	110	-	-	-	-	-	57	53
2162	Reflector & Drive Ass'y & Des.	297	-	-	-	-	-	149	148
2166	Heat Transfer Design & Fab.	28	-	-	-	-	-	10	18
2167	Core Design & Fab.	41	-	-	-	-	-	20	21
2168	Shield Fabrication	60	-	-	-	-	-	30	30
2169	Startup Design & Fab.	332	-	-	-	-	112	106	114
2170	S-10-FS System Eng.	56	-	-	-	-	-	56	-
2171	S-10-FS-1 Ass'y, Inst-Check	112	-	-	-	-	112	-	-
2172	S-10-FS-2 Ass'y Accept.Test	92	-	-	-	-	-	92	-
2173	S-10-FS-3 Ass'y Accept.Test	142	-	-	-	-	-	-	142
2182	S-10-PSM-2 & 3 Syst. Eng.	30	-	30	-	-	-	-	-
2186	S-10-PSM-3 Ass'y Inst.	27	-	27	-	-	-	-	-
2188	S-10-FSM-1 Ass'y Inst.Test	66	-	-	66	-	-	-	-
2189	S-10-FSM-2 Inst. & Test	23	-	-	-	23	-	-	-
2199	T.E. Converter Des. & Fab.	463	-	-	-	-	101	181	181
	TOTAL	3464	-	57	66	23	1330	991	997

[redacted]