ARMY POWER REACTORS

Objectives.—Develop reliable nuclear power plants which will largely eliminate the logistic burden required in support of military operations.

Program elements include—

1. Develop and test improved systems and components for portable medium-powered, water-cooled, nuclear power plants.
2. Investigate economical, reliable, semi-automated advanced technology plants for various applications.

In the desire to save time, I will read the program objectives only. These are:

Develop reliable nuclear power plants which will largely eliminate the logistic burden required in support of military operations.

REFERENCE 80—FEBRUARY 1966

ARMY POWER REACTORS

Summary—Operating costs

[In millions]

	Actual, fiscal year 1965	Estimate, fiscal year 1966	Estimate, fiscal year 1967
Water cooled reactors	$0.2	$0.7	$0.7
Gas cooled reactors	4.1	2.0	0
Military compact reactor program	4.0	(1)	0
General research and evelopment	.2	0	.2
Total	8.5	2.7	.9

[1] Estimate, $25,000.

This next chart shows the breakdown of the Army Power Reactors Program.

Representative PRICE. It certainly shows the breakdown in it.

Mr. SHAW. Yes, sir. The chart shows a funding decrease from $2.7 million in fiscal year 1966 to $900,000 in fiscal year 1967. The most significant event in the program is, of course, the termination of the ML–1 program which we advised the committee of earlier this year. We have had a great deal of correspondence on this matter, which you may wish to include in the record, including the detailed information provided at your request, Mr. Holifield. As you recall, you requested that we provide you more information than may be customary to explain the alternatives we considered as well as to support the actions we took.

We will be glad to provide that for the record, sir.

Chairman HOLIFIELD. All right.

(The document referred to follows:)

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., October 21, 1965.

Hon. CHET HOLIFIELD,
Chairman, Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. HOLIFIELD: In response to your telephone request of October 19, 1965, enclosed is the additional information related to the recent AEC decision to terminate the ML–1 program in fiscal year 1966. The background, alternatives which were considered, and other personal observations, together with the other

information provided by separate correspondence on the close-out of the ML–1 program, covers those points raised in your telephone call.

I would be pleased to discuss this matter further with you at your convenience, if you so desire.

Sincerely yours,

MILTON SHAW,
Director, Division of Reactor Development and Technology.

ML–1 PROGRAM

BACKGROUND

The ML–1 program, as such, began in 1955 when both feasibility studies and a preliminary design were performed. A letter from the Department of Defense (DOD) dated July 13, 1956 encouraged the Commission to pursue a gas-cooled reactor development program and formally initiated the Army Gas-Cooled Reactor Systems program, under which the ML–1 effort has been carried out. What is generally considered the normal hardware development cycle for an ML–1 type system was altered as a result of further correspondence with the DOD, on August 8, 1958, in which the DOD requested an expansion of the development effort and stated a desire for operation of a field prototype not later than June 1962. The DOD also defined the output of the plant to be 300–500 KWe and defined certain transportability and operational characteristics. The Commission, in an attempt to meet the June 1962 schedule, omitted the "breadboard" stage and proceeded directly into design and construction of the prototype, later named ML–1. Construction of the ML–1 was authorized in June 1959; military characteritsics of the system were prepared in September 1961 and established the following as objectives:

Electrical output: 300–500 KW.

Weight: 15 ton/package, 40 tons total.

Radiation: 5 mrem/hr at control cab (operating); 15 mrem/hr at 25 ft forward direction (shut down).

Cost: No objectives were stated.

Limited representative system operation of the ML–1 was initiated in early 1963. However, the system was not a true prototype, primarily in plant layout and auxiliary equipment and their effect on mobility. The DOD programed procurement of the ML–1A, which was to be the true field prototype, starting in 1963 but successively delayed this procurement. Concern regarding the ML–1 program was raised during the FY 1965 Authorization Hearings in February 1964, at which time the AEC requested $3.8 million for the ML–1 program. Discussion of a joint AEC/DOD report focused attention on the ML–1 problem areas and raised major questions regarding continuation of the program. This report concluded that the ML–1 program should be brought to an orderly conclusion. The bases for these conclusions were first, that there were few potential users of an ML–1 type system and, secondly, that an ML–1 type system was much more expensive to buy and operate than conventional generating systems. Noting that the Commission's proposed program was aimed at the completion of development work on the ML–1, the JCAE recommended that experimental work on the ML–1 project be completed including demonstration testing. This recommendation appears in House Report #1332, AEC authorization appropriations for FY 1965.

Concern regarding the direction of the ML–1 program increased during the formulation of the fiscal year 1966 budget. The AEC budget included $4.1 million for the ML–1 development program on the basis that the Army had included an ML–1A field plant in their fiscal year 1966 procurement. It was emphasized that these funds were to support an ML–1A, not an advanced ML–2 or 3 type model.

To justify the slight increase in fiscal year 1966 ($4.1 million) over the fiscal year 1965 ($3.8 million) level on the ML–1 program, the AEC noted that an endurance test of the ML–1 plant, which ended in May 1964 after 664 hours of operation (at a self-sustaining power level) uncovered a number of deficiencies which had to be corrected prior to further test of the assembled power plant. During this endurance test period, on-stream time was 63 percent. The operation of the plant was resumed in early September 1964 and the plant was on the line 77 percent of the time in September, 79 percent in October and 90 percent in November. During this period, an additional 1,774 operational hours were accumulated. This test was followed by 318 hours at full thermal power. However, during test period, the maximum shaft output of the plant was 100 KW as compared to the design objective of 370 KW. Low power output was identified as a major deficiency with regard to intended use of this type of plant by the Army. Although the plant

operated at relatively high on-stream factor for a short period, it was recognized that better and more predictable plant reliability was required. Additional R&D was identified to resolve these major problems.

In order to pursue in a more deliberate manner the necessary plant improvements, continuation of a system testing was deferred in favor of a test program emphasizing component and subsystem development. The plant was disassembled in early 1965 and development was initiated on the most deficient of the power conversion components—the turbine compressor set. Meanwhile, the reactor skid was removed to the Gas Cooled Reactor Facility (GCRF).

Just prior to system disassembly, a leak between the shield water and primary system was discovered. This leak was repaired and testing of the reactor skid was resumed in the GCRF in May 1965. Low power tests continued until June 29 at which time ⅔ reactor thermal power (maximum power that could be absorbed by the GCRF) was achieved. Intermittent power operation continued until another leak (or leaks) developed between the reactor moderator water and coolant gas systems on August 9. Reference is made to our letter to you of September 20, 1965. The cause of the leak cannot be determined until an examination of the failed pressure vessel has been completed. It is recognized that continued operation with the present reactor pressure vessel is not advisable and a new vessel would be required. At this time, the determination as to the extent of design changes necessary prior to fabrication of the new reactor internals has not been made. After determination of the cause of the failure, a redesign of the deficient areas would be required, followed by necessary proof testing. Beyond this, the cost and time to procure a new pressure vessel of the ML–1 type is estimated presently in the order of $0.5 million and 12 to 18 months.

In the meanwhile, the Army had reviewed its position with respect to procurement of follow-on ML–1 type plants. By letter of April 19, 1965, Willis M. Hawkins, Assistant Secretary of the Army (R&D) advised the JCAE that the Army had taken action to delete the ML–1A procurement funds from the fiscal year 1966 program because several higher priority programs required additional fiscal year 1966 funding which could not otherwise be provided within the budget ceiling. Mr. Hawkins stated that the deletion did not imply a lessening of Army interest in the gas-cooled mobile reactor system and felt that the ML–1 technology should be continued. We were advised that as a direct result of the ML–1A deletion, the House Appropriations Committee reduced the ML–fiscal year 1966 program from $4.1 million to $2.0 million. The AEC asked for restitution of the funds based on the Army's continuing interest and the fact that ML–1 was a unique technology.

On September 2, 1965 in a letter to Chairman Seaborg responding to an AEC letter of July 9, 1965, Major General A. W. Betts, Deputy Chief of Research and Development, stated that "logistic advantages of an ML–1 type system are not sufficiently great when compared to the high initial cost to recommend production of even a few units at this time". The Army recognized a need, however, for mobile nuclear plants of this same general size and power, provided the cost can be reduced, and recommended that the ML–1 program be brought to an orderly conclusion to include field testing.

DISCUSSION OF ALTERNATIVES

During the preparation of the fiscal year 1967 budget, the AEC was faced with three alternatives for the future ML–1 R&D program:

1. To continue full support of the ML–1 to meet the Army's original (1961) objectives.
2. To phase out the program through field testing, using the ML–1.
3. To terminate in fiscal year 1966.

With respect to the first alternative, the unique design of the ML–1, the test results to date, and the economic projections of this design led to the conclusion that an R&D effort significantly higher than what was authorized would be required. Our conclusion was that an R&D program in the order of $2.0–$4.0 million a year would not be adequate to achieve the program objectives. In terms of what may be required to achieve both the technical and economic goals, it is estimated that a minimum of $6.0–$8.0 million a year would be required for at least the next several years, in addition to the $50.0 million already invested by the AEC.

Alternative two was based on the Army's expressed willingness to supplement the ML–1 program with up to $1.0 million in fiscal year 1966, $2.0 million in fiscal year 1967, and to fund the cost of actual field testing in fiscal year 1968

and fiscal year 1969. The major considerations were: (1) when would the plant be satisfactory to start field testing and what would be the cost of obtaining the desired performance and (2) should this effort be undertaken in view of the Army's position on follow-on procurement? Independent of the recent reactor leak problem, at least two years of intense effort would be required before the plant could be considered ready for field test. These years would require comparable funding levels to those of alternate one, depending primarily on the level of performance (power rating, reliability, etc.) of the plant deemed acceptable. Furthermore, we were in agreement with the Army's recognition, as stated, that there are still significant technical problems in the ML–1 program which would result in termination of the program prior to field testing. The major problems with the ML–1, particularly with the reactor vessel and the power conversion equipment require solution. After these component problems are satisfactorily resolved and proven by test, the plant would have to be reassembled and satisfactorily tested as a system prior to field testing.

It was recognized that if the system performed satisfactorily prior to and during a field test, the Army could gain significant experience. Operating in the field could provide experience with respect to logistics and other factors which could not be learned on the test stand. The pre-requisites for performance and logistics to adequately support field testing were not yet developed. Until these pre-requisites were developed and met, introduction of such a unit into the field testing phase would have entailed large risks. Unsuccessful field tests could have had extremely adverse effects on the potential of mobile nuclear power for subsequent Army use. Previous experience with other reactors which have been prematurely introduced into their operational environments raised many cautions in this regard. Thus, it appeared to be extremely important to assure that the ML–1 was completely satisfactory for field testing before supporting this position.

In summary, the rejection of alternates 1 and 2 was primarily on the basis of: (1) inadequate funds to support the near-term R&D and testing to establish component and system capabilities, and to permit the assembled package to be introduced into field testing; (2) the serious technical problems with the reactor and power conversion equipment; (3) the position that the Army had taken with reference to future procurement of the ML–1 design. This position was reinforced as the result of the decision by the Congress to appropriate $2.0 million in fiscal year 1966.

GENERAL CONSIDERATIONS

In response to your questions on user agencies support as it affects R&D, the following comments are offered. It is difficult to continue to support projects which have been authorized to meet specific criteria of a user agency when the continued interest of the user agency is in doubt. In spite of the technical difficulties with the ML–1, continued interest by the Army in terms of procurement of an ML–1A had been sufficient for the Commission to continue to support the R&D program. The consequences of its deletion by the Army were severe with respect to AEC support of the ML–1 R&D program. The extent to which the Army's action was influenced by the technical status of the ML–1 program is not certain. The relative influence of the Army's priorities, the ML–1 technical problems, and the economic potential of the system cannot be determined from the information which we have at hand.

It is apparent that the Commission must exert stronger efforts to insure that the user does have a more realistic understanding of the potential problems and risks in these R&D programs aimed at meeting user requirements. We must take more positive steps to assure that user support will continue even though problems are being encountered in the R&D program, as long as those problems do not prohibit realization of the final product that the user has specified. We recognize that user support will be influenced by changing priorities.

It is also necessary to note that unique technologies and applications such as ML–1 will be significantly more difficult to develop than those projects which have a broader base from which to draw experience. In addition, the resources (funds, technical and management personnel, and facilities) available to the contractor for each of these unique projects must be considered. In regard to these points, the contributions to the ML–1 from the other gas programs, such as EGCR, Peach Bottom and EBOR, were practically non-existent.

In recognition of these factors, the AEC has been devoting considerable attention to on-going and new programs in identifying technical problems and establishing specific engineering and technology efforts prior to undertaking

major project commitments. In addition, we are taking the necessary steps to insure that those organizations performing the work do not underestimate the management, technical, engineering and funding resources necessary to meet commitments. A key element in this approach is the Commission's actions to strengthen the Division of Reactor Development and Technology.

AEC PROGRAMS AT AEROJET-GENERAL NUCLEONICS

The ML–1 contract was with the Aerojet-General Corporation (AGC), with the main effort being accomplished by Aerojet-General Nucleonics (AGN), a Division of AGC, at San Ramon, California. The ML–1 program represented a significant portion of the total AGN workload as evidenced by the following table:

AEC sponsored work at AGN in fiscal year 1966

Army Gas Cooled Reactor Program (direct to AGN)	$1,890,000
Alkali Metals Evaluation Program (Thermodynamic Properties Study)	380,000
Fissiochemical R&D	400,000
Total AGN	2,670,000

NOTE.—In addition to the AGN work the parent corporation, AGC, performs a portion of the Rover-Nerva work. The fiscal year 1966 cost estimate for this work is $2,929,000.

Aerojet-General Nucleonics is one of the prospective bidders for the National Reactor Testing Station operations contract. The bid due date for this is October 22.

Mr. SHAW. A significant item on the chart is the "general research and development" category where we are requesting $200,000. This is similar to what we are doing in a number of programs; requesting sufficient funds to assess the situation and determine our future course of action:

MC MURDO REACTOR

The $700,000 fiscal year 1967 request for water-cooled reactors will provide continued support for the SM–1, the PM–1, PM–3A, and other reactors currently operating. Knowing of the committee's interest, I can provide for the record detailed information of the performance of the PM–3A and the other reactors under the Army program.

(The information referred to follows:)

MAJOR EVENTS—MILITARY NUCLEAR POWER REACTORS, CY 1965

SM–1

(*a*) *September 2, 1965.*—Resumed operation for training following eleven months shutdown for plant modifications including the erection of a new building addition, installation of a new vapor container entrance, relocation of equipment, and installation of a new station service transformer.

(*b*) *December 17 to December 30, 1965.*—Modification of vapor containing manhole closing mechanism, turbine maintenance and relagging of cooling water lines in the vapor container was cause for plant shutdown during this period.

SM–1A

(*a*) *Availability.*—56.9% in 1965 vs 65.1% in 1964.

(*b*) *February 12 to April 25, 1965.*—Plant shutdown for repairs to primary coolant pumps #1 and 2, removal of canned rotor pump #1, and repair to canned rotor pump #2 mechanical seal.

(*c*) *October 13, 1965, to February 1, 1966.*—Plant shutdown for core change and annual maintenance. Shutdown lengthened by need to reduce containment leakage and to repair leakage of pressure vessel head gasket.

PM–1

(*a*) *Availability.*—84.3% in 1965 vs 57.3% in 1964.

(*b*) *March 26 to April 9, 1965.*—Plant shutdown for replacement of synchro drive motor for rod position indicator #6. Delayed delivery of replacement motor caused increased shutdown time.