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ADDRESS

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DELIVERED BEFORE

THE AIR WAR COLLEGE  
MONTGOMERY, ALABAMA

MONDAY, 19 NOVEMBER 1956

11-13-46

21	OUTSIDE CONTROL
Copy No.	R1
Case No.	94-F-2370
T.S. No.	94-N-297
Document No.	1

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CURRENT U. S. NUCLEAR ENERGY PROGRAMS

1956 - 1959

The purpose of this lecture and the subsequent discussion period is to provide you with information on current developments in the nuclear energy field and the programs that will be effected during the next three years. The lecture outline suggests six questions, the answers to which should contribute to our general purpose. My task is somewhat more specialized than that which I undertook when I spoke to the class here last year. At that time I dealt with the broader aspects of impact of nuclear energy on national security policy and the translation of that policy into the roles and missions of the Armed Forces. I feel more at home in dealing with the more specialized field of nuclear energy development, but because in so doing it is necessary to describe developmental programs in some detail, it has been necessary to limit attendance to U. S. nationals.

Since we are to deal with developments, it would be well to start with a few words on the means by which military influences are exercised. I will not bore you, however, with any organizational charts showing the inter-relation of the various agencies of the Department of Defense and the Atomic Energy Commission.

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It is a most unusual situation in which the responsibility for research and development and, to a considerable extent, for production of military end items rests with an independent executive agency.

Although the situation is unique it has not proved unworkable. While there are many ardent dissenters, I would give it as my opinion that the system has operated to the general advantage of the Department as a whole.

In a formal way the process of development encompasses four separable stages, i. e.: concept, feasibility, material development, and production. In practice the first three are frequently overlapping and occasionally indistinguishable. Concepts may begin anywhere at any level within the Department or the Atomic Energy Commission. When the idea has been developed sufficiently to be put into words, the Service of primary interest usually submits a request for a feasibility study. Such a request is submitted to the Assistant Secretary of Defense (Research and Development) where it is considered by the Coordinating Committee on Atomic Energy and, if approved, is transmitted to the Atomic Energy Commission through the Military Liaison Committee. I may add here that such Service requests are invariably approved by the Coordinating Committee and by the Military Liaison Committee because we both believe that the utmost freedom should be allowed in the pursuit of new ideas. The feasibility study is made by a joint DOD-AEC committee, and if the report is favorable, a request for the development is transmitted to the Joint Chiefs of Staff who may or may not establish a development requirement.

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Once the Atomic Energy Commission has been formally advised a development requirement exists, the job is assigned to one or both of the nuclear development laboratories. Two other things happen about this time. First, the Armed Forces Special Weapons Project drafts a set of military characteristics for approval of the Military Liaison Committee and transmission to the Commission. Second, the Military Liaison Committee indicates to the Atomic Energy Commission the priority to be assigned to the development with respect to other projects and indicates desired date of stockpile entry of the new item.

While the Atomic Energy Commission has the broad responsibility for the development, there is constant cross-fertilization and coordination among the laboratories, the Service of interest, and the Armed Forces Special Weapons Project throughout the course of the developmental program. Also, by agreement, one of the Services may be assigned direct responsibility for some part of the development. For example: By a general DOD-AEC agreement the appropriate Service is responsible for the development and production of adaption kits and fuzing components for all guided missiles and, in the case of gun-type weapons, for all of the non-nuclear components. Obviously, research and development to be truly effective cannot be confined to formally adopted programs or directed from the Department of Defense by formal communications. Constant direct liaison based on mutual understanding of the status of the art and the ambitions of the several services provide the foundation for new applications and improvements of old uses.

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The broad fields of military application of nuclear energy may be defined for convenience and discussion in the following:

- (1) Nuclear weaponry;
- (2) Nuclear power for propulsion or for the production of electricity and heat;
- (3) Medical and biological uses;
- (4) Application as a preservative; and, finally, as a research and development tool.

Because our time is limited I will confine my discussion to the first two areas: nuclear weaponry and nuclear energy as a source of power.

Nuclear weaponry has advanced somewhat beyond the embryonic stage and may be compared by analogy to the development of gun powder at about the time of the American war between the States. By comparison the development of nuclear power is much less advanced. Before we look at the present status as evidenced by current programs, we should review some of the fundamentals of nuclear explosives at least to the extent that they are understood today. First, as to the quantity of nuclear materials required to create an explosion. As you know, the explosive power of a mass of fissionable material is governed by the number of fissions which occur in a given time. This number of fissions is, in turn, dependent upon the shape and density of the materials when the action begins.

A spherical shape is most favorable because it offers the minimum

\* You have had these fundamentals presented to you recently by Colonel Sabcock so I shall do no more than summarize them very briefly

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neutron escape area in relation to mass and, of course, the denser the mass the greater the probability of collisions resulting in fission. Theoretically, then, a critical mass may be any quantity down to two atoms; although obviously the fission of two atoms could hardly be called an explosion in the sense of military weaponry. This mass/surface relationship leads at once to the conclusion that for a given explosive effect the greater the compression of the fuel, the smaller the amount of fissionable material required. Since a degree of compression is dictated by the amount and arrangement of the high explosive which does the compressing, it is rather fundamental -- on the basis of present knowledge at least -- that the smaller the weapon, the greater the amount of fissionable material required to produce a given explosive effect.

A second fundamental is that the thermonuclear reaction is also governed as to occurrence and violence by the mass/surface ratio. Inasmuch as temperature rises with pressure, it would seem theoretically possible to apply sufficient pressure to a fusile material to cause it to ignite. In practice, a combination of pressure and temperature has been found necessary. Here, again, the efficiency of the fusion reaction is favored by large size because large size permits an increase in both temperature and pressure.

A third fundamental has to do with the theoretical and practical efficiencies of the fission and fusion reactions. The total energy contained; that is, the energy theoretically available from complete

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fission of 1 Kg of Uranium is 17 KT's and from 1 Kg of plutonium is 19 KT's. On the other hand, the energy theoretically available from 1 Kg of Lithium-6 deuteride is 66 KT's or almost four times that of Uranium. To date, obtainable efficiencies from the burning of Uranium and Plutonium range from 1 to 50% depending on the configuration and degree of compression; and from 15 to 40% for thermonuclear weapons. Thus, in seeking the maximum yield/weight ratios, which are of great military interest, we have some distance to go.

*In brief,*  
~~To repeat,~~ then, there are three fundamentals of nuclear science which have a marked effect on Service capabilities, plans and programs for the execution of their missions.

- (1) The weight/yield ratio of fission weapons strongly favors large weapons whether the yield desired is small or large.
- (2) The same is true of weapons employing fusion but the cost differential is markedly less because thermonuclear fuels are cheap.
- (3) Currently obtainable efficiencies in weapons of all types and sizes are subject to considerable improvement with increased research and development. However, it is not possible to fix exact time scales when such improvements may become effective.

These three factors have a marked effect on military plans and programs for the reason, among others, that up-to-date developmental effort has favored those delivery systems providing the greater

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destructive effect per unit of critical material. It has generally been possible to forecast the availability of bombs and warheads for these larger systems as well as the expected yields and quantities of materials required for such systems.

Had nuclear efficiencies favored those systems requiring warheads or bombs of small size, the whole concept of U.S. military strategy might well have been reversed and the balance of military effort vastly changed from where it stands today. You men in the light blue who make up the majority of my audience may be thankful that the facts of life are as they are. However, as I shall indicate later, you are not yet entirely out of the woods as regards certain other aspects of nuclear development.

At this point may I introduce the first of the questions of the lecture outline:

(1) How do you interpret current Service attitudes toward the adaptation of new developments to military use?

Service attitudes toward new developments in this field bring to mind a well-known Churchill comment about Clement Atlee sometime after the latter had succeeded Sir Winston as Prime Minister. ~~There is~~ There is no question of the enthusiasm of the Services toward the adaptation of nuclear energy to military purposes. They want to use it for everything. The Department of Defense has constantly encouraged the investigation of military application on a broad front, and I know of no important area or project in which the Services have been handicapped by lack of support

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either by the Atomic Energy Commission or the Department of Defense. In the nuclear weapon and nuclear power fields a constantly increasing research and development load has been imposed on the Atomic Energy Commission. In the fields of medicine, biology, and food and material preservation -- which the individual Services support more directly with their own facilities and funds -- business is extremely brisk. In general, it is an under-statement to say that the Service attitude is enthusiastic. In the heat of competition for what they feel to be a fair share of the development and production effort, all the Services have been decidedly over-enthusiastic both for their own good and for the good of the country as a whole. This is evidenced in three ways. Let us take a concrete example: In 1954 Service "A" conceives the idea of having a nuclear warhead for Missile "X" which is already under development. It requests a joint feasibility study of a compatible warhead indicating the desired characteristics as to size, weight, yield, etc., and the appropriate date on which the warhead will be needed -- say -- early in 1957. The request is granted; feasibility is determined; a development requirement is stated; funds are allocated for the development; and the AEC laboratories go to work on the job. As 1957 approaches and the warhead design nears completion, it is discovered that a number of things have happened:

- (1) The missile development has slipped and now looks like mid-1958;
- (2) The art of warhead design has progressed to the point where the model about to go into production has become obsolescent; and

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(3) A new design based on latest developments cannot be ready for production until early 1959.

The Service insists it must have a capability of using the missile in 1958 although it may be necessary to use an obsolescent warhead. So, the 1957 design is completed and produced for stockpile. By late 1957 Missile "X" has slipped again and it now looks like 1959 -- and so on. We have cases on the books where three different warheads have been developed for specific missile applications while the missile itself was and is still in the developmental stage.

Now, the Services are no novices in the development of missiles so it seems clear that in some such cases deliberate over-confidence (I will not go so far as to call it deception or dishonesty) has been practiced. Let us see what has happened.

~~(A)~~ At the technical level the missile developers have set-up a projected state of availability applying many optimistic "if's" and scratching most of the pessimistic "if's". They then subtracted a few months -- just in case. The project reaches higher level where it is scanned with great enthusiasm. "This is good," says the top brass, "we will really put the heat on this and get it out six months ahead of schedule." Besides, the top-side knows that Service "B" is doing something along this line. Most certainly when Service "B" finds out that Service "A" plans to have Missile "X" ready by a given time, it moves its own schedule forward. And, of course, there are several repetitions of this cycle.

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Now, had both services been realistic or even mildly optimistic about their original schedules, a tremendous amount of wasted development effort would have been avoided and, in addition, they would have been assured of the best warhead which the state of the art could produce.

A second area in which over-enthusiasm manifests itself is in the realm of public relations. There is in existence a national policy statement which reads as follows:

" . . . . . oral or written statements to be made public by Government officials regarding nuclear weapons, which contain information not previously made public officially, must be checked in advance with the Chairman, Atomic Energy Commission, who will coordinate the intelligence aspects with the Director of Central Intelligence and the foreign climate of opinion aspects with the Operations Coordinating Board."

The purpose of this policy is two-fold:

- (1) To determine whether an existing or prospective nuclear weapon capability will be of intelligence value to an enemy; and
- (2) Whether such an official statement may have an undesirable effect upon some delicate international negotiation which may be in progress.

The policy is extremely unpopular with the Services. One may debate whether the policy is a good one, but I see no excuse for a

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deliberate violation simply for the purpose of getting a bit of publicity. I could give you specific examples of violations by high-ranking officers and civilians of each of the three Services but will not waste your time on this subject other than to say that the matter has reached a point where some disciplinary measures are to be applied in the future.

The third area in which Service enthusiasm for military applications seems to over-reach itself is in the numbers racket.

- (1) As to damage or destructive potential required; and
- (2) As to the pieces of equipment needed to deliver nuclear bombs or warheads.

**E** To me it does not make good sense to provide at least three ways of destroying every military and industrial target; every individual in the Armed Forces of an enemy; every enemy aircraft that flies, and every ship or submarine that roams the seas, plus 100% for contingencies. Yet, if we add up Service claims for nuclear ammunition this is about what they amount to. As to delivery vehicles, it is readily understandable that despite the enormously increased fire power deliverable by each vehicle, there is little enthusiasm for decreasing the total number of such vehicles in the regular Armed Forces, because:

- (1) Heavy losses from the enemy's offensive use of nuclear explosives must be expected;

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(2) Time for the replacement of losses from new production seems improbable. However, it does not seem logical for each of the three Services to produce by a given time enough missiles; for example to deliver all of the stockpile warheads adaptable to all of the different systems.

I appear to have registered three basic complaints as to Service over-enthusiasm. You may inquire properly why doesn't the Department of Defense do something about it. Something is being done about it, but I assure you it is not easy and certainly what is done must be done very carefully and competently because arbitrary decisions based on inadequate information which would diminish the over-enthusiasm would be more harmful than beneficial.

It is now appropriate to try to answer the remaining specific questions of the lecture outline.

To what extent have the Services placed requirements for and caused effort to be expended toward the development of specialized weapons?

The initial motivation for specialized weapons came from the development laboratories rather than from the Services. Until quite recently the Services have not been greatly concerned about specialization. As long as their specific requirements could be met they felt that interchangeability of nuclear materials among several systems was a good thing. Certainly in the days of so-called "atomic scarcity" the

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possibility of using the same warheads, and particularly the same nuclear materials for several applications, provided a flexibility not otherwise attainable. As soon as the nuclear designers learned and pointed out that higher efficiencies would be obtained if weapons were tailored to specific systems, the Services accepted the idea gladly. Complete specialization is, of course, unnecessary and undoubtedly would prove wasteful in the long run. With the exception of a few cases, complete warhead interchangeability is being provided among several systems. However, by 1960 there will be no independent interchangeability of nuclear materials since by that time, unless there is a definite change in present policy, all nuclears will be built in. This blessing of higher efficiency is not purchased without a price. [The built-in nuclear has a bothersome feature in the probability of detonation in handling, transporting, and maintaining; and is of particular concern in those systems such as the air-to-air rocket where the probability of accident is relatively high.] \* It seems certain that specialization will impose some compromises between safety and maximum operational readiness.

You now asked: "How much of the progress in weapon development has been the result of stated requirements by the Services?" And: "How much has come as a result of independent action on the part of scientists and engineers?"

No categorical answer to these questions is possible. Our liaison and working relations with the development laboratories have been very

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very good, particularly on a person-to-person basis over the past ten years. In general, in both official and unofficial contacts the Services have always held out objectives considerably beyond the existing state of know-how and thus have stimulated the laboratories to constantly increasing endeavor. This has been particularly true in the small weapons field and in weight reduction in all areas -- large, medium and small. Some years ago the Los Alamos Laboratory was quite reluctant to extend its effort into the small weapons field because the scientists felt that it was fundamentally and economically unsound to use precious materials in low efficiency nuclear systems. In recognition of that attitude, among other things, the Department of Defense insisted that the AEC set up a second laboratory to provide competition and, in particular, to emphasize research on more advanced applications. This has been proved eminently successful.

Your next question is: "What major effect has the development of nuclear weapons had on the Service plans and programs since World War II?"

This is a subject which merits a full lecture period by itself. In the time at my disposal I will do no more than brush rapidly by it. With respect to Service plans and programs as thus far converted into new organizations, equipment, strategy and tactics, I should say that no marked change has taken place except with regard to emphasis placed on continental defense. As you well know, the recognized possession

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of nuclear weapons by the enemy has directed vastly increased attention to warning systems, to improvement of intelligence, to counter-measures and to active anti-aircraft and anti-submarine defenses at great cost of funds and manpower. There are many plans, studies, and programs in various stages of development which have been brought about by the advent of nuclear weapons and nuclear power, but which have not as yet been reflected in marked changes in strategy, tactics or organization.

As examples I have in mind the Army's plans for fast-moving, widely dispersed units employing maximum fire-power from minimum weight equipment; the Navy's plans for nuclearized task forces to include propulsion as well as weaponry; and Air Force's concepts of nuclear powered aircraft, missiles and satellites. Under study also are concepts of nuclear interception of an enemy's long range missiles. From these plans, studies and programs there will emerge many new systems for offense and defense, but as far as I can see no revolutionary changes in warfare which would drastically affect the future roles of the armed forces.

As I have indicated, the acceptance of a nuclear offensive power in the hands of the USSR has made it necessary that we turn with greater emphasis to continental defense. This fact has made it clear also that the existence of a powerful deterrent force is not enough because a deterrent force can accomplish its purpose only as long as the aggressor knows he cannot destroy it before it can become effective. I think it likely also that the day of massive mobilization of manpower and materiel,

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such as we saw in World War II, has passed and that in due course we must turn to greater dependence upon forces and materiel in being. While such a course is highly unpopular in many circles, I believe it to be inevitable that Service plans and programs must eventually be based on that concept.

Your next question is: "In what ways will industrial development of nuclear energy affect Service programs?"

I will make only two general comments:

(1) Anything that improves our industrial capacity and stature improves military capability, and vice versa -- much as Secretary Wilson is alleged to have said with respect to the United States and General Motors.

(2) The development of the art of applying nuclear energy to power production will assure the Services of an industrial competence to meet their increasing demands for greater performance and freedom from the tentacles of a cumbersome logistic system. It is interesting to note, however, that by and large to date Service programs for the development and use of nuclear power have been more useful to industry than industrial developments have been to the Services.

Your last question invites me to look well into the blue yonder. What future trends in nuclear developments appear to be most important to the military Services? We will look first into the power and propulsion fields because here lie the least experience, the most exacting requirements as well as the severest competition from the chemical industry. In the

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weapons field it has been conceded that the chemical explosive does not belong in the same ball park as the nuclear explosive. In the power field this is not the case. For application to stationary plants and for the propulsion of many types of ships it appears most certain that nuclear energy will gain the inside track in the long run. For the propulsion of aircraft, rockets, missiles, etc., it will be a long and expensive fight, and the showdown between advanced chemical and nuclear power plants is not just around the corner. The trend, of course, is more power per unit weight to insure maximum operational freedom with minimum logistical support. This is of greatest importance to all of the military services. In the beginning I said that in some fields the facts of the nuclear phenomenon were not so favorable to the Air Force. In nuclear power, the Navy in particular, and the Army to a lesser degree, are favored by the fact that they are much less sensitive to the weight vs. horsepower factor and to the accident hazard than is the Air Force. It is a thousand times easier to develop a 300-megawatt power source for a ship than for an aircraft. I venture to say that despite the great advances being made in these developments, even the most optimistic are beginning to discount the probability of the operational nuclear powered aircraft in inventory by the mid '60's. And the less optimistic are wondering whether it would be a battle-worthy machine even when it eventually arrives. This is not intended to depreciate the effort expended in that direction but merely to point out that by the time the concept of unlimited <sup>manned</sup> flight is achieved, it may find itself obsolescent and supplanted by other concepts.

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In the nuclear power field, therefore, I find that over the next ten years the Navy will derive greater satisfaction from the development of this application to its major mission. The Army will find some considerable use for stationary plants in remote areas, and to a limited extent to the propulsion of land vehicles in high fuel cost areas. The Air Force, I fear, is due to some frustrations in its attempts to apply nuclear power to combat aircraft as we conceive them today. However, if we may look further into the blue skies to such things as satellite vehicles and interplanetary travel, nuclear propulsion or even thermonuclear propulsion may come into its own.

In the weapons field there are three trends of greatest importance to the Services:

- (1) The trend toward increased yield/weight ratios;
- (2) Increased nuclear efficiency in smaller weapons; and
- (3) Longer shelf life with minimum maintenance.

Improved yield/weight ratios are important to all systems; particularly to long range systems where pin-point accuracy is difficult and where a specified degree of damage is essential to the success of the system. It is most clear that the current ICBM-IRBM concept of a five-mile c. e. p. and a 1-MT payload affords a poor weapon for use against hard targets. Unless there is a vast improvement in both c. e. p. and yield, hard targets will have to remain in the target folders of the manned bomber and the long-range missile systems will be useful against soft targets only.

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The same argument for improved yield/weight ratios holds for all delivery systems. As I have indicated, the theory permits us to envision great strides in the direction. Casting about for ideas as to where improvements may lead us over the next ten years, I find some nuclear physicists who are willing to predict the following by 1965:

<u>Weight</u> (lbs)	<u>Yield</u>	<u>Weight/Yield Ratio</u> (KT/lb)
25	10 KT	0.4
100	200 KT	2
300	750 KT	2.5
600	2 MT	3
1000	4 MT	4

As I have said, the Services are enthusiastic about using nuclear energy for everything. This is commendable and encouraging but ambition should be tempered with patience. Like the proud papa who buys his son a football or a bicycle on his first birthday, we are trying to force the pace faster than natural laws will permit. It is a good idea to hold out objectives which force the pace of development, but we should not trap ourselves into believing that these objectives will always be met simply because we want them. We reached our first plateau in the early '50's with the successful development of a family of bombs and warheads adaptable to a wide variety of vehicles and purposes. We levelled off

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briefly; then moved ahead with the high yield family and a whole new group of specialized weapons embodying entirely new principles of design.

Perhaps we are reaching a second plateau where we should pause for a short breathing spell looking toward the next sharp rise ahead while basic nuclear science catches up. I do not advocate complacency, but we must concede that as of this date nuclear energy has afforded us a military potential far greater than we thought possible five years ago. I firmly believe that it would be folly to rest on that potential, but I also believe that we ~~could~~<sup>can</sup> afford to be more deliberate and discriminating in fostering new adaptations and applications. I consider it particularly appropriate that in our enthusiasm to get the most out of this new tool we give careful consideration to the homely problem of logistics which we impose upon ourselves by the care and feeding of a large family with enormous appetites; delicate constitutions; and explosive emotions. If we do consider these things carefully, I believe we will find it profitable to have the big papa hold a protective umbrella over the brood while some of the little fellows are growing up toward man's stature.

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