Forecasting Future Military Missions and Their Technological Demands

Dr. Donald M. MacArthur

The day-to-day management of Defense Department research and development, which is the current work of many of us, is in a sense nothing but forecasts. We must try to forecast potential threats. We try to forecast the potential of various fields and scientists that compete for our resources. We try to forecast the costs and payoffs of various development plans. As a regular part of management, we compare our past forecasts and plans with our current performance.

But the single most important job of defense research and development is to think—and think hard—about the options and the capabilities which the President and the Secretary of Defense may need in the future. We try to do this. Usually when we finish, we have a long list of projects designed to guard against a range of contingencies and to prepare for a range of sometimes relatively improbable needs. At this point, of course, the list is cut based upon the national priorities and the budgetary constraints. The crucial point, however, is that research and development is in the *option-creating* business, leading to ways of fulfilling national commitments with *alternative* methods, building *new* understanding of the interactions between policies, missions and technologies.

Overall, even though much of our business could be regarded as forecasts, we usually do not think of it that way. Too often there are unexpected problems, new solutions, unforeseen issues, unpredictable events. The Defense Department may be asked to carry out a mission on short notice which no one anticipated and this perhaps distinguishes defense research and development from the research and development supporting other national goals. In fact, the interaction of national policies, missions and technologies is clearly a "chicken-egg" phenomenon. New technology has forced decisions on new national policies and major missions—this happened with ICBMs. And a major policy decision can create a new mission and stimulate new technological requirements—this happened with our space program.

Once we understand that any mission-oriented research and development activity is inevitably in the forecasting business and in the business of influencing the future, we then see it is *both* the choice of long-term policies and missions, and the future technologies, which lie at the *heart of the forecasting problem.* Before going further, there are two obviously serious problems in developing this discussion. First, some of the detailed information central to an understanding of DOD's possible future missions is classified. Second, our crystal ball is neither panoramic enough nor blessed with high enough resolution to allow us to feel comfortable.

With these limitations in mind, this article will cover three areas:

- Interactions between choices of national goals and choices of military missions.
- Framework for thinking about the emphasis among possible future missions.
- Range of forecasting techniques and activities which DOD has employed and an indication of what they suggest about technological growth areas.

National Goals

To begin, we must understand our national objectives. Many experienced in national security affairs are today concerned with a reappraisal of past commitments in the light of our experience in Vietnam and the prospect of strategic arms talks with the Soviet Union. In Congress and on many university campuses, questions such as these are being raised: What is required to deter nuclear war? What kinds of arms control treaties are in the national interest, and how can they be enforced and how can we best handle our defense needs under the changed circumstances? What forms of defense alliances are needed, and how can they be made even more effective, in the future? What levels of standing forces do we need and how should they be deployed in association with our allies? Have the roles of air, land and sea power changed—and if so, what will we need in the future? Given that national security

Dr. Donald M. MacArthur is Deputy Director (Research and Technology), Office of Director of Defense Research and Engineering. The programs he directs cover rocket and missile propulsion, materials technology, medical, life, social behavioral and environmental sciences, and chemical technology. He also oversees the 76 DOD in-house laboratories for development of policy. Dr. MacArthur holds a B.S. degree from St. Andrew University, Scotland, and a Ph. D. in X-ray crystallography from Edinburgh University, Scotland.

must be assigned a top priority in our Federal budget, taking account of our many pressing domestic needs, how much do we need to spend on defense?

Essentially, these questions and many other ones are continually under review. President Nixon has a series of studies underway now to reassess our national security policies.

The choices posed by the questions are so complex, and have such broad political and military significance, that the follow-up work on details of alternative military missions is comparatively straightforward. There are scores of branch-points in terms of differences in the relations among major powers and minor powers, in the likelihood of military action, and in the kinds of contingencies in which our forces might become involved. To discuss all of the possible outcomes and their implications would require much more space than is available here.

Thus, let us make a few assumptions, while recognizing the hazards involved in trying to state hypothetical national objectives.

Let us consider, first, that the guiding national policy will be to continue to work for a peaceful world in which nations settle their differences without resort to violence. It seems clear that to do this, the United States will continue to require a strategic nuclear deterrent sufficient in *both* size and technological quality to represent a clear *and* credible capability. This objective would be consistent, of course, with a range of possible arms control agreements. It also seems clear that general purpose forces will be needed to complement the strategic deterrent through a capability for deterring—and defending, if necessary—against lower levels of violence. The likely future size and basing of our general purpose forces are difficult to estimate because costs and the structure of alliances are key variables, on which judgments must be made at the highest level of our Government.

Military Mission Trends

With just this general framework of national objectives, we can begin to consider the trends in possible military missions.

Let us then consider the general categories of operational capabilities that appear to be what we have already decided we want in the foreseeable future. Assuming that strategic nuclear deterrence will remain the primary objective and that supporting military forces will be designed to deter lower-level conflict and to prevent escalation should conflict nevertheless occur, we will need continuing improvements in at least the following seven areas:

- First, and most important, continued emphasis on all of the equipment required for a sufficient and credible strategic nuclear deterrent in the face of what we can expect to be considerable uncertainties about growing Soviet and Chinese capabilities.

- Second, we will need to continue to improve our *all-weather, all-climate* fighting, capability, including our ability to hit targets *much more accurately* than we can today and at a cost commensurate with the *value of the target*. Another revolutionary concept first tested recently in Vietnam is the ability to provide around-the-clock, real-time battlefield surveillance.

- Third, high reliability and greater flexibility so that overall costs, and particularly logistic and maintenance requirements, can be minimized.

- Fourth, mobile and flexible deployment systems in small units, capable of rapid integration into larger units, sufficient to stop trouble before it breaks into major conflict.

- Fifth, much better understanding of the relationship among the military, political, economic, technical, and psychological factors influencing successful deterrence along both the strategic and tactical dimensions of the use, or the threat of the use, of force.

- Sixth, strategic and tactical intelligence and surveillance data collection and processing systems.

- Seventh, strategic and tactical real-time, comprehensive command-control communications systems that allow detailed handling of dispersed units in crisis situations.

The third and fourth areas in this short but demanding list are especially critical if only because we too easily take them for granted and, thus, tend to dismiss them.

The costs for new defense systems must be reduced, wherever possible, consistent with our goals and commitments, even if we revise our goals and commitments. One way to do some of this is to seize all of the revolutionary opportunities emerging for very high reliability equipment. On the other hand, high reliability can also be achieved through extremely simple and durable designs, *e.g.*, in ground combat and communications equipment, which may be relatively inexpensive both to purchase and to maintain.

The tasks are to examine precisely what performance is required, and then to carry out an explicit analysis of the purchase costs and the long-range costs required to achieve the *necessary* reliable performance. Many new systems must, of course, have new, complex and costly components. In general, however, our trend in the future will be toward using long-term cost as an even more decisive criterion in selecting the level of sophistication of subsystems to incorporate into new systems. In some cases, this will mean a sacrifice in our performance goals to make sure that we achieve higher reliability objectives and reduce costs. Much broader test and evaluation programs will be required to ensure that we meet these reliability objectives.

The fifth area mentioned is a reminder that we must deepen and broaden our interdisciplinary studies of deterrence and defense, of the steps needed for successful arms control, and of the tactics required for successful deterrence of local low-level violence. This is complex, often controversial work drawing on the social sciences.

Future Technology

We have now looked briefly at the problem of national policy choices and military missions. Next, we should look at the trends in potentially useful technologies. In starting this task, we are again confronted with great complexity. How do you forecast the directions of growth of technology to satisy likely missions? Are there analytical tools available to help with such a job?

The answer is mixed. While there has been a considerable amount of successful work in forecasting and in the development of useful forecasting aids, it is fair to say that the field is still evolving. We can be more systematic and mathematical than the ancient prophets. Planning, forecasting, or prognosticating may seem formally easier now, but they still seem little better than the insight of those who practice this difficult profession.

It is basically *long-term* forecasting that is difficult—15 to 20 years or more ahead. When we try to look 5 to 10 years ahead, the military needs are rather clear and the research and development paths are rather obvious even if the technology is not immediately available. In part, this is because of long development times. Farther into the future, few can make accurate predictions because scientific advances will create new options for *both* missions and the technologies in fulfilling old and new missions. Because of the long-term forecasting problem, we believe we must support a broad research program that "covers all bets." However, we do try to identify certain areas for emphasis which seem to possess "high-leverage" in solving national security problems.

In addition to our in-house work, we ask independent ad hoc task forces of the Defense Science Board to think hard in rather specific ways about the future needs of DOD. For example, the Director of Defense Research and Engineering asked, "Just what might his successor in 5 to 10 years wish had been started?" The task force, chaired by Dr. Simon Ramo, considered topics within the context of major developments in the 1980s that could be relevant to national security. The topics included the following, which are mixed between our problems and our technologies—what you might call our sicknesses and our cures:

- **Search, Identify and Destroy Missions.** Improvement in the battlefield surveillance and command and control will permit the rapid deployment of land forces, to seek out and destroy the enemy while he is on the move at night or in bad weather. The capability to use laser-guided weapons, under all environments, will be routine for airborne attack. Self-contained night and all-weather interdiction aircraft systems will detect, identify and destroy both fixed and fleeting targets, using a computerized system of sensors, communications and weapons. This will require improved navigational and terrain avoidance systems expected to be available by the early 1980s.

- **The Interdependence of Social, Technological, Economic, Military and Political Factors.** By the early 1980s, we can expect to have moved substantially beyond the present haphazard way in which these different considerations are related to each other. Military planners and defense managers of that period will be supported by extensive banks of information, based on observations of importance to DOD, made over a period of time, and computerized models. They will use these to distinguish between those interaction effects which are likely and those which are unlikely. Seated at a console, they could suggest alternative courses of action, run through the model, and receive back analysis of the probable major consequences. Similar methods could also be used to train personnel in these complicated and interrelated areas.

- **Accelerated Learning Techniques.** The formal classroom, standard curriculum, the fixed schedule of instruction will all be things of the past. DOD will employ a small number of massive central processing computers which will support 5 to 10,000 consoles for military students at distant locations. Defense Department personnel will be engaged in a continuous learning process in their field of primary interest of responsibility, *e.g.*, vocational, scientific, managerial. Supported by new forms of educational technology, they will learn according to their own speed and style. The hours of instruction will be those they choose. The place of instruction will be wherever they are located.

- **Lasers.** Foreseen new devices are tunable lasers which will give us the ability to do in the optical region what we can do today in the microwave region, *i.e.*, heterodyning, mixing, etc; and parametric conversion devices which would enable us to utilize the best techniques for a given problem. The key here is the expected availability of non-linear materials which can operate in optical regions.

- **Materials Development.** Incidentally, materials will continue to be the foundation of our success, and often the reason for our failures, in new systems of all kinds. The use of composite materials in aircraft should yield a weight savings of up to 50 percent which will double the range, or double the payload, or increase loiter time. New materials for lift engines will allow for increased payload of between 25 to 50 percent and a doubling of the thrust/weight ratio. We can look forward to manned transparent glass submersibles, capable of exploring and patrolling at depths sufficient to examine most of the oceans' bottoms. In space satellite applications, materials will be developed which will last for periods up to 15 years without degradation.

- **Identification of Friend or Foe (IFF).** Development of stand-off weapon systems demand that there be commensurate improvements in IFF equipment. It is hoped that technology can provide airborne IFF equipment that will permit firing weapons at maximum weapon range with minimum chance of revealing our aircraft position.

- **Computer-Based Information Processing and Pattern-Recognition Systems.** While present practical applications of these techniques are evident in character recognition devices we are familiar with (such as optical and magnetic character recognition for bank check accounting and retail store receipt compilation and accounting), there has been little day-to-day use in the military. In the next few years, however, we will be using these technologies in reconnaissance, surveillance, and data transmission.

- **Ocean Sciences and Engineering.** In the 1980s, our capabilities should permit us to go anywhere in the world's oceans at any time and at most depths. Nuclear reactors will be operating as power generators on the ocean floor. Airports will be constructed offshore and living on the ocean bottom can be commonplace for recreation and scientific investigations.

- **Weather Prediction and Modification.** Because weather depends on known scientific phenomena, and data can be secured and computer processed, worldwide weather conditions will be forecasted with greater accuracy for 30 days longer. Ultimately, everyday forecasting will be quite accurate through computer prognoses and worldwide satellite coverage of many more meteorological parameters. Accurate measurements from satellite-based sensors, particularly above 10,000 feet, will replace individual soundings now taken at multiple points on the surface, and will be coupled with inputs from atmospheric, water surface and underwater sensors. Weather modification techniques will be available for almost any type weather condition and limited in its extent only by legal, political and social demands.

- **Cryogenics.** Superconducting materials and devices are expected to be routinely used for computers and a variety of electronic devices, enabling large savings in power consumption, smaller size and more efficient operation.

Obviously, this is an enormously broad and challenging array of topics. One of the most refreshing and useful characteristics of Dr. Ramo's work was that the recommendations were brief, and depended on qualitative reasoning based upon a realistic analysis of the current military and scientific situation. There is simply no substitute, when trying to forecast, for an understanding of the current situation. Someone once said that all the really good ideas he ever had came to him while he was milking a cow. Few of us milk cows these days. However, those who make military or technical forecasts relative to military systems should really know military or technical operations. If they do not, their forecasts can be no better than skimmed milk.

Forecasting: Which Direction?

In the past there has been continuing work on forecasting. Much of the long-range forecasting has been frankly labelled intuitive or judgmental. An expert—military or scientific—would simply make an analysis of what he believed would evolve in the future. Sometimes experts have gotten together to compare and criticize projections, and then develop a consensus viewpoint.

Other forecasting has been and is done in a more detailed way. Past trends can be plotted numerically and then compared or extrapolated. Analogies can be made and tested. Curves can be drawn for characteristics of fields large and small, and then adjusted to suggest either goals or expectations.

The Defense Department, since World War II, has contributed to many of these pioneering activities in forecasting and related enterprises. Reports have been commissioned by distinguished scientists and managers. Organizations have been established to concentrate on thinking about long-range issues. Retrospective analyses have been performed to document those lessons of the past that might be relevant to "managing" the future. As most of you know, each of the Military Departments today has groups of analysts trying to develop and analyze long-range requirements. Special experiments are being run to explore new ways of meshing requirements with allocations of research and development resources.

This article has covered the range of forecasting activities and a list of assorted topics to underscore one fundamental point. It is simply not possible today, given the broad range of defense missions and the almost bewildering pace of technological development, to predict with great confidence what *specific* shifts will occur in either missions or technological demands. Forecasting efforts are worth our investment only in the sense that they define the broad boundaries of our choices a bit better. They rarely provide detailed answers about what we need in the long term. The reason they do not—or perhaps more accurately, the reason they cannot—is simply that much of the future will be governed by our decisions rather than dominated by some impersonal factors that can be plotted and calculated. The country must decide on its commitments, and research and development must provide practical alternatives for fulfilling them. What is quite clear, then, is that the Defense Department must and will sustain a strong commitment to all of the research fields related to national security.

Our broad missions and our overall research and development needs are clear. Certainly the war in Vietnam has revealed many of our strengths and a number of our weaknesses. In the next 10 to 20 years, there will be no decrease—in fact, there will probably be an increase—in the strong dependence of national security upon advanced technology. We will be relearning and re-applying all of the lessons learned in past conflicts to ensure that our future forces will be even better prepared for whatever they are asked to do.

We can take as a guideline the quite remarkable comment of the English scientist Michael Faraday who, when asked by a politician what good his discoveries in electricity were, answered: "I do not know yet; but some day you will tax it." So it is with national security and technology. Today's laboratory curiosity may be the basis for tomorrow's national defense. No statements of long-term "likely missions" and long-range technological developments will anticipate all of what probably will occur.

The challenge to all of us is to think through the basic requirements of national security for the last third of the 20th century and do what is necessary for our preparedness. This is quite a challenge. To meet this challenge, we need great skill and a sure sense of our responsibilities to the country.

Electronics Component Conference Calls for Papers

The 20th Electronics Components Conference, to be held May 13–15, 1970, at the Statler-Hilton Hotel in Washington, D.C., has called for papers of presentations. The conference, sponsored by the Electronic Industries Association and the Parts, Materials and Packaging Group of the Institute of Electrical and Electronic Engineers, will include sessions on materials, passive components, hybrid integrated circuits, interconnection and packaging, filters and networks, and new functional devices.

Abstracts, with a minimum length of 250 words, along with a list of papers, salient concepts and features, are due by November 15. Four copies of the abstracts should be sent to Darnell P. Burks, Technical Program Chairman, Electronic Components Conference, Sprague Electric Company, Marshall Street, North Adams, Mass. 01247. Authors will be notified of acceptance by January 1, and final manuscripts will be due March 1.

Improved Windshields Sought by Army

Detachable, shatterproof windshields for tracked combat vehicles have been proposed by the Army Combat Developments Command, Fort Belvoir, Va. In addition to providing protection for drivers and commanders in arctic and cold weather climates, the shields would also deflect gravel, dust, water and other substances from the faces of personnel.

The windshields would provide protection from winds from side angles of up to 45 degrees, and would be spring loaded for quick release and mounting. CDC sees the windshields applicable to personnel carriers, tanks and self-propelled artillery pieces.