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STATEMENT ON THE TECHNOLOGY BASE, BY DEPUTY DIRECTOR OF DEFENSE--ETC(U)
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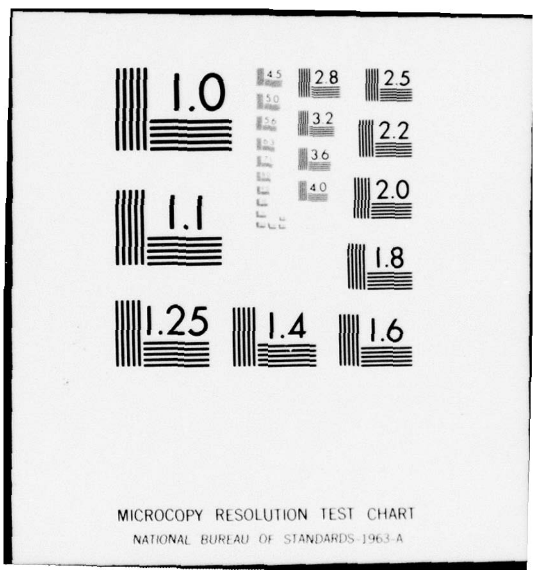
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STATEMENT ON THE TECHNOLOGY BASE

BY

DR. JOHN L. ALLEN
DEPUTY DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
(RESEARCH AND ADVANCED TECHNOLOGY)

BEFORE THE

RESEARCH AND DEVELOPMENT SUBCOMMITTEE

OF THE

ARMED SERVICES COMMITTEE

OF THE

UNITED STATES SENATE
95TH CONGRESS, FIRST SESSION

29 MARCH 1977

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TESTIMONY ON THE TECHNOLOGY BASE

Mr. Chairman, and Members of the Committee:

My name is John Allen, and I am the Deputy Director for Research and Advanced Technology in the Office of the Director of Defense Research and Engineering. I appreciate the opportunity to appear before this Committee in support of the Technology Base portion of the Department of Defense's (DoD's) Research, Development, Test and Evaluation Program. I am pleased with the interest of this distinguished Committee on a matter of such great importance to the DoD and the Nation.

I am accompanied by Dr. David Charvonia, a member of my staff, who assists me in the formulation and management of the Technology Base. In addition, other members of the Office of the Director of Defense Research and Engineering and representatives of the Services who participate in Technology Base activity are available for questions, if required.

I. Rationale for a DoD Technology Base Program

A cornerstone of U.S. defense policy is the achievement of a credible deterrent posture by technological superiority rather than just numerical superiority. Our equipment and personnel must be capable of out-performing those of potential adversaries both now and in the future. To insure our future advantage, the U.S. must have a strong Technology Base in those disciplines that are fundamental to military R&D; disciplines such as the physical and engineering sciences, mathematics, environmental science and some aspects of the biological and "people related" sciences.

The DoD draws on the entire U.S. technology base--military, industrial and academic--to meet our needs to the extent that it is possible. However, many of our needs are distinctive. Fighter aircraft cannot use quite the same technology employed in 747s. There are no civilian counterparts to most of our weapons. Consequently, the DoD must conduct its own R&D program in areas of special needs. Furthermore, since second best in defense will not suffice, the DoD must work at the frontiers of technology to insure our military capability. Not surprisingly, we find the DoD program pioneers in many technologies. Thus, although the DoD's Technology Base represents only about 20% of the total Federally funded basic and applied research in the U.S., it is--and must continue to be--a vital, distinctive and productive 20%.

Let me give you some evidence of its value to DoD. In the late 1960's, a major DoD study called Project HINDSIGHT examined the origins of the technical advances that made several of the weapons systems under development at that time possible. We were gratified to find that 95% of those advances came directly or indirectly out of the DoD-sponsored Technology Base.

DoD's emphasis on working at the frontiers of technology has also led to major contributions to the economic strength of our country. Because our needs are vital, we are usually willing to pay more in money and in development effort for our technical products than is the consumer market. In many cases, however, after we have paid the price, the end result has been profitably converted into civilian use. Jet aircraft, large and small digital computers, integrated circuits, and most of our advanced structural materials either came from or were substantially aided by Defense R&D. The economic impact of these advances is substantial: the aircraft and electronic industries represent a $50B/year gross business, providing over two million jobs. In summary, the DoD Technology Base is a national necessity and a national asset.

In my testimony, I will cover the topics indicated in Figure 1, beginning with some facts and figures to give you a feel for the scope of the Technology Base and then a few examples to give you an appreciation for the nature of the program. I'll then outline how we manage and coordinate it, discuss some problems and what we are doing about them and compare how we are doing with respect to the Soviet Union.

II. What It Is

The Technology Base is that part of the DoD RDT&E program devoted to advances in concepts, components and subsystems. In short, it is that part of our program directed at providing options for future systems. (cont on p 37)

PRESENTATION OUTLINE

- THE MAKE-UP OF THE TECHNOLOGY BASE
- EXAMPLES OF TECH BASE PROJECTS
- MANAGEMENT AND COORDINATION OF THE PROGRAM
- SOME PROBLEMS AND WHAT WE ARE DOING ABOUT THEM
- THE U.S. TECH BASE VS. THE SOVIET TECH BASE

Figure 1

The major categories of the program and their proposed FY 78 budget levels are shown in Figure 2. The categories "electronics," "weapons," etc., refer to the development of the underlying technology, devices and subsystems for electronic systems and weapons, etc., and not to the actual development of the systems for production; that type of development is not part of the Technology Base. Note also that we have substantial programs in environmental sciences, biomedical and personnel sciences. These technologies do not usually lead to hardware per se but contribute indirectly to the effectiveness with which we use it.

Technology Base projects are mostly concerned with early pursuits of ideas, concepts and new facts. They are generally small in keeping with their exploratory nature. Consequently, the FY 78 program of about $2.3B is composed of about 20,000 separate efforts submitted to you in about 175 Program Elements. About 18% of the program is Research--the search for new knowledge, new principles and innovative ideas. Sixty-four percent of the work is Exploratory Development--the application of the new knowledge and principles to the development of techniques, devices or subsystems. The remaining 18% is a part of the DoD Advanced Development Program--that part mostly devoted to Advanced Technology Demonstration projects. These projects focus on the development and testing of demonstration models built to assess the operational utility of new techniques, devices and subsystems. These projects provide the "final exams" of the Technology Base.

TECHNOLOGY BASE MANAGEMENT AREAS
(MILITARY DEPARTMENTS)
(FY 78 PRESIDENT'S BUDGET)

TECHNOLOGY	SCOPE ($ MILLION)
ELECTRONICS	500
VEHICLES AND PROPULSION	380
WEAPONS	260
MATERIALS AND STRUCTURES	240
BIOMEDICAL AND PERSONNEL SCIENCES	240
ENVIRONMENTAL AND OTHER SCIENCES	180

Figure 2

The Technology Base program is executed by the three Military Departments and two of the Defense Agencies, DARPA and the Defense Nuclear Agency. The proposed FY 78 levels for the Research and Exploratory Development portions of the program are shown in Figure 3. Generally speaking, DARPA's program is focused on a few, intensive, short-term projects that are aimed at high risk, highly leveraged projects. The other programs contain some projects of this nature, but also provide the broad based, long-term efforts required for the orderly advance of technology across a broad front.

It is my understanding that you will receive a separate briefing from DARPA and DNA on their activities so I will concentrate on the Service program.

The responsibilities for Technology Base management are shared by OSD and the Services. The responsibility for setting broad management policy on what will be pursued and how resources are to be allocated resides with the Secretary of Defense and the Director of Defense Research and Engineering (DDR&E), specifically with my office for the Service programs and with the Director, DARPA, for theirs. My office is responsible for technical and financial review and approval of the Services' portion of the program. The implementation of the program and its day-to-day management is by the Service and Defense Agency staffs. My office (17 professionals) is in turn responsible to the DDR&E for assuring the overall quality of the Services' program.

TECHNOLOGY BASE PROGRAM
(FY 78 RESEARCH AND EXPLORATORY DEVELOPMENT BUDGET SUBMIT)

SERVICES	• ARMY	$425M
	• NAVY	$550M
	• AIR FORCE	$475M
DEFENSE AGENCIES	• DARPA	$280M
	• DEFENSE NUCLEAR AGENCY	$150M

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III. Some Examples of Technology Base Projects

The Technology Base program is both diverse and exciting. In the past, it has produced such revolutionary advances as smart weapons, thermal and night vision devices and precision time standards that make navigation systems like GPS possible. It is too diverse to make a comprehensive description feasible, so instead I will describe a few representative, on-going projects that are indicative of its scope and vitality. The examples I have chosen are the directed energy weapon program, an autonomous homing projectile project, some work in simulators for training our soldiers and our turbine engine technology program. These are predominantly demonstration projects. However, each one is built on an extensive foundation of research and exploratory development, some of which I will describe.

a. Directed Energy Weapons

Science fiction writers have been fascinated with the concept of a directed energy weapon that "beams" energy directly to a target, obviating the need for bombs, missiles or projectiles. A weapon of this type now appears not only to be possible, but we may even have a choice of the beams that can be used--photons, electrons or other fundamental particles. These beams travel at or near the speed of light so that the delivery time is negligible, an attractive attribute for a weapon. The beams can also be moved rapidly from one target to the next. Thus, for defense against nearly simultaneous multiple attackers, directed energy weapons are appealing.

The high energy laser (HEL) is the most advanced of the directed energy devices. About 10 years ago it became apparent that the generation and propagation of damaging levels of energy might be feasible. However, the technical problems foreseen were formidable. High power is needed for useful lethal ranges. The achievement of such high power requires a strong foundation of basic knowledge of the physics and chemistry of highly excited gases, coupled with, in some systems, sophisticated high volume, high velocity gas flow technology. The flow rates involved in gas dynamic HELs are like those from a jet engine. The physical size is also comparable to a jet engine.

The Services and DARPA are investigating different types and applications of HELs. Both the Army and the Navy are pursuing terrestrial applications. The Air Force is pursuing airborne applications, and DARPA is looking at the possible application of lasers in space defense with emphasis on chemical lasers. It is still too early to determine the potential cost effectiveness of HELs as weapons, but the next two or three years will yield a great deal of insight.

Particle beams--beams of electrons, for example--are not directly affected by the weather and may provide longer ranges than the HEL in adverse weather. However, they have other problems. Charged particle beams have a tendency to be unstable. They also are deflected by magnetic fields, so pointing and tracking uncertainties exist. If these problems can be solved, a viable weapon could result. We believe that charged particle weapons might, in some applications, represent a useful alternative or complement to the HEL for giving us a "zero time of flight" weapon. We are pursuing projects at an exploratory level.

b. Autonomous Homing Projectiles

I would now like to talk about a less radical, but also potentially revolutionary weapon concept, that of autonomous homing projectiles or "fire and forget" guided weapons.

The number of tanks, armored vehicles and support vehicles in the Warsaw Pact nations is formidable. We need a means to attack vehicles in their staging areas so we do not have to face them in direct combat. However, it is difficult to acquire, identify and accurately target individual vehicles in remote locations. Also, tanks are "hard targets" so that direct hits are necessary to disable them.

It is comparatively easy to determine the general area where vehicles are being marshalled. Thus, a weapon is needed that, if fired into the general vicinity of a known marshalling area, could seek out individual vehicles and make direct hits. Infrared (heat) seekers appear promising. An infrared seeker could, in principle, be used on a homing missile, on an artillery shell or in a glide bomb. The central problem is the fact that the infrared "signature" of a tank resembles that of supporting vehicles and, to a lesser degree, that of buildings, bonfires or even large, warm rocks in the marshalling area. We know of no way to guarantee that every projectile would strike a tank.

The issue then becomes a classic trade-off between cost and performance. It is clear that we can make a projectile that, if fired into a marshalling area, rather than just falling at random as is now the case with area artillery fire, would almost always hit some warm target. If the round were as costly as a tank, but could not distinguish tanks from rocks--as it probably would have 5-10 years ago--it would not be cost effective. On the other hand, if it had a cost comparable to even a low value target like a supply truck and could select and hit tanks most of the time, it would be a real bargain.

In the last few years, several things have happened in the Technology Base that can drastically increase the cost effectiveness of such a weapon.

We have learned a great deal more about the infrared signatures of vehicles and have developed techniques that will allow us to do a better job of extracting tank-like signatures from background clutter. This reduces the probability of hitting rocks and buildings. Integrated circuit technology, which has made inexpensive hand calculators and digital watches possible, offers a means to do this more cheaply than ever dreamed possible 5 years ago. Thus, we now may be able to make such a missile cheaply and effectively.

Captive flight models are now being built to find out if this can be done under a program called "Terminally Guided Submunitions (TGSM)." Success in this program may revolutionize indirect fire artillery.

c. Training Simulators

Simulation technology has made significant strides in recent years. Signs are clear that the impact of this technology on military training can be impressive. It can provide a high level of training for personnel in operational, maintenance and combat skills and do so economically. We will be able to realistically train for combat and emergency situations in peacetime with safety to personnel and equipment.

While flight simulators with their impressive mechanical, electronic and visual systems have received the most attention of these new devices, new advances in low cost electronic devices show promise of a substantial impact at the other end of the military spectrum--training of the individual soldier.

In close combat, concealment and cover are the keys to survival. Exposure to the lethality of modern weapons with their high accuracy and high fire power means high casualty rates. To impress this fact upon our soldiers and to teach them to instinctively do the right thing, we are evolving a system based upon low power lasers and microcomputers to teach battle skills in realistic two-sided combat training. Training units are furnished with rifles, machine guns, tank and anti-tank weapons that are equipped with an eye-safe laser. Sensors are mounted on each infantryman, vehicle and weapon and connected to a microcomputer carried by each man or weapon. On the infantryman the sensors and the computer are mounted on the belt harness and helmet as shown in Figure 4. When a weapon is "fired," a blank round is fired from the weapon and a light beam containing a distinctive code is emitted from the laser. Any sensor intercepting the beam records a "lethal" hit if the sensor is located in an area where a hit from that kind of weapon would normally disable the target. The infantryman's computer knows that a hit in a vital area from any weapon is likely to be a kill. The computer on a tank knows that a rifle cannot kill a tank regardless of where it is hit. The computer informs the bearer if he has been hit and automatically disables his weapon, removing him from the exercise. His status can also be remotely verified by the umpires.

The result of preliminary exercises with this type of system has been most impressive. It has generated real enthusiasm from recruits and experienced veterans alike. They say it puts new challenges and excitement into military field training and teaches skills that formerly could only be learned in battle.

M16A1 RIFLE SUBASSEMBLY (A17A60)

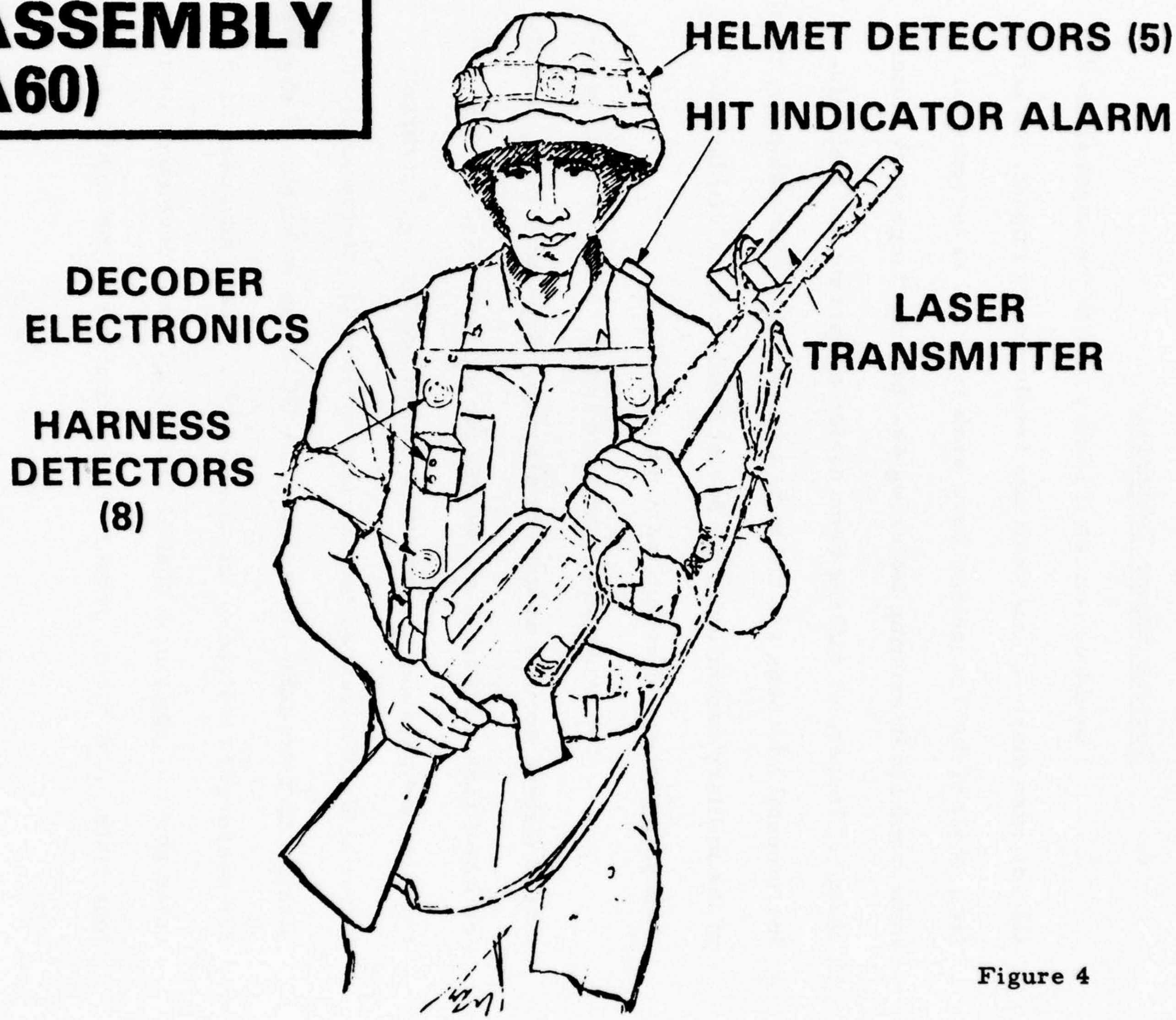


Figure 4

d. Turbine Engine Technology

I would be remiss if I left you with the impression that all--or even most--of our work has revolutionary impact. In actual fact, most of the Technology Base work is aimed at incremental improvements in existing technologies--making things work better, cheaper, longer, or making them easier to operate and maintain. Incremental advances are not to be taken lightly. For example, much of the military capability of the Soviet Union has evolved largely through a process of evolutionary advances.

The evolutionary advance I have chosen to talk about is that of turbine engines as used in aircraft, ships and, most recently, the XM-1 tank. Figure 5 shows how far we have progressed in reducing the physical size of engines required for a given thrust. These kinds of advances explain why our latest fighters can climb straight up from take-off, and why the DC-8 can be stretched to carry 250 passengers instead of the original 190. These advances have come about by applying a host of Technology Base developments in materials, structures, processing and controls to the engine technology area.

IV. How We Manage and Coordinate the Program

These examples are obviously a small part of the Technology Base program. You might well wonder how we ever keep track of--let alone manage--a program of this size. It is a challenging task.

ENGINE TECHNOLOGY IMPROVEMENT

ENGINE SIZE IMPROVEMENT — COMPARATIVE THRUST ENGINES

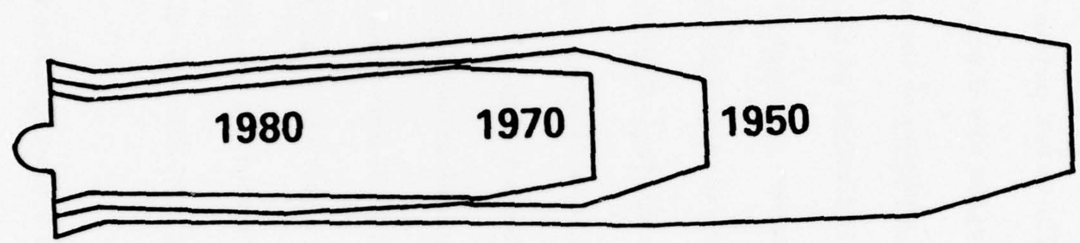


Figure 5

The first requirement of managing such a diverse activity is to know what is going on. Consequently, we devote considerable effort to program documentation. The three primary forms of such documentation that cover all Service programs are discussed below. (Of course, these documents are produced in addition to the usual technical reports and papers generated from the individual work units.)

The "work unit data base" is a highly automated, computerized data base that contains an up-to-date one page summary of each of our 20,000 work units. The Technology Coordinating Papers (TCPs) and the Technical Area Descriptions (TADs) represent periodically updated documents covering the various technical areas. There are 13 TCPs, each of which covers a technical area in great technical and management detail. They are limited distribution documents. The TAD covers the technical areas in more of an overview fashion in a single document. It is prepared to be given widespread distribution to encourage dialogue on the Technology Base program throughout government, industry and the academic community.

Good documentation is a prerequisite to good management, but is only an adjunct. We augment ours by a great deal of dialogue. The Service staffs and my staff have frequent face-to-face discussions with DoD laboratories and contractors to keep abreast of their technology. These dialogues are augmented by technical reviews of the program carried out at all management levels. For example, my staff conducts tri-Service "topical reviews" each year which delve in-depth into the technical nature and quality of the program. We cover about one-third of the entire program each year with some areas of intense activity covered more often. This year, for example, we have scheduled 22 such reviews to cover such topics as underwater countermeasures, flight simulators and engine R&D.

We also conduct two administrative reviews of the entire program each year as part of the normal budget cycle. Problems that surface in these reviews are dealt with jointly by the Services and ODDR&E in regular and special meetings keyed to the budget cycle. Major issues are worked out by my staff with the Service staffs, and between the Service Technology Base managers and myself. If agreement cannot be reached at those levels, the issues are escalated to the DDR&E or in a few cases even to the Secretary of Defense. Both DDR&E and the Service Assistant Secretaries have authority to defer funds in programs with unresolved issues and this authority is indeed exercised, as needed.

In many technologies we also have standing committees to perform continuous reviews. Some committees are under the Service auspices and some under DDR&E. An example of a standing committee is the High Energy Laser Review Group. It is comprised of representatives from ODDR&E, the Services, DARPA, ERDA and outside consultants with observers from NASA and the intelligence agencies.

Many of our review groups have membership from outside DoD and NASA membership is especially prominent.

V. Some Problems and What We Are Doing About Them

Despite its demonstrated value to the country, our Technology Base is not without its problems. The last decade has seen DoD RDT&E continue to increase in scope. New technologies have been born that we must nurture and capitalize upon, so the breadth of the Technology Base has had to expand. Meanwhile, our tight management of the weapons acquisition process has increased the conservatism in weapons system development. While this has been generally good, it has reduced the amount of new ideas that used to be borne--and paid for--in the Engineering Development portion of the program to solve unforeseen development problems. Of course, these solutions then became part of the Technology Base. Finally, as I'll dwell on more later, the technology gap between the U.S. and the USSR has narrowed, making it more difficult--and more expensive--for us to understand some of the things we see coming out of the Soviet program.

Thus, the demands on the Technology Base program have escalated. The resources have not.

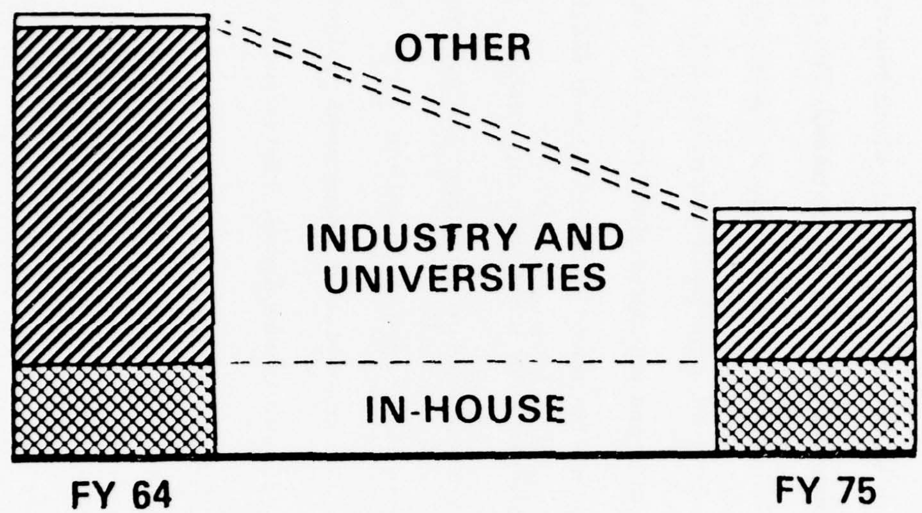
From 1965 to 1975, the Technology Base was essentially level funded. Thus, inflation reduced the level of effort--that is, how many scientists and engineers we can employ--to only 55% of the level of the mid sixties. Furthermore, Research and Exploratory Development have declined from 24% of the RDT&E budget in the mid 60's to only 16% now.

If these trends were to continue our next generation of weapons systems would have to be developed with only about two-thirds of the Technology Base support of previous generations. The result has been a need for more than a belt tightening. We have reduced experimental work because it is the most costly form of R&D. We have substituted paper studies and computer simulations for experiments. To a degree this is good, but there is a limit beyond which our confidence in the reality of such substitutes diminishes. We have also deferred upkeep of our present equipment and purchase of needed new equipment as we were pressed by spiralling costs. We have also tended to concentrate our resources on recognized problems, placing less emphasis on the pursuit of new areas. These factors all combine to raise fears that our program is not as innovative as it was a decade ago.

Figure 6 indicates that the distribution of DoD work among the classes of performers has changed markedly. The decrease in level of effort has been borne almost entirely by our industrial and university participants. The level of effort in the DoD laboratories--the "in-house" category--has remained almost constant.

We thus are faced with three trends that we consider major concerns--an erosion in level of effort, a major decrease in our

TECHNOLOGY BASE PROBLEMS



RESEARCH AND EXPLORATORY DEVELOPMENT LEVEL OF EFFORT
(BUDGET IN CONSTANT DOLLARS)

- 45% DECREASE IN LEVEL OF EFFORT
- INCREASE IN BREADTH
- TREND TO IN-HOUSE EXECUTION

Figure 6

industrial and academic participation and concern about our productivity of really new ideas.

The funding issue, from the DoD viewpoint, comes down to a difficult matter of choices. Money invested in our future via the Research and Exploratory Development programs is money that cannot be spent today for urgently needed personnel, weapon system development and procurement. On the other hand, the Department recognizes that failure to maintain an adequate Technology Base will surely extract a price in future capabilities. After carefully weighing these alternatives, DoD decided that the Technology Base funding erosion should be stopped. In 1974, prior to the FY 76 budget preparation, guidance was given to the Services to increase Research 10% per year above inflation through FY 80 and Exploratory Development by 5% per year above inflation through FY 78. At the expiration of these periods, the funding in both categories is to be maintained at the fraction of total RDT&E that the above increases will produce. We are grateful that this policy has been supported by the Congress. It has been successfully implemented for the past two years and is also reflected in this year's budget submission.

Our second major action is aimed at reversing the trend toward a predominantly in-house program. The optimum mix between industry, the universities and the DoD laboratories is ultimately a matter of judgment. Figure 7 shows that the laboratories' share of

PERCENTAGE OF RESEARCH AND EXPLORATORY DEVELOPMENT DONE IN DOD IN-HOUSE LABS

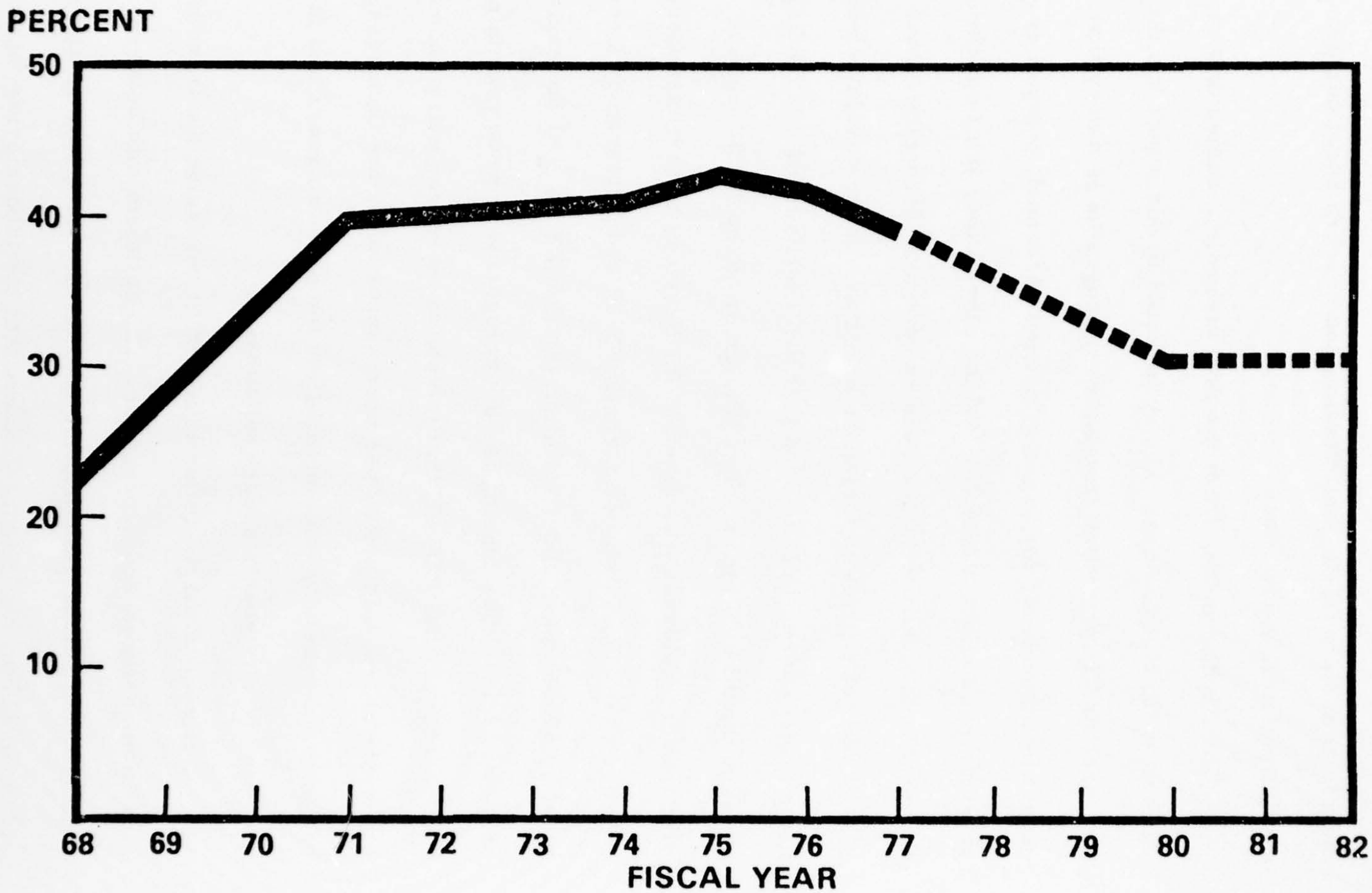


Figure 7

the Technology Base program increased from about 23% to about 43% as the program shrunk, since the labs did not absorb their share of the shrinkage in level of effort.

We believe that a strong contract program is important to the vitality of the Technology Base and to its effective transfer to system development. Consequently, we conclude that we are now putting too small a share of our Technology Base funds into industry and the universities. Among the reasons for this conviction are:

(1) The U.S. is committed to using industry as the prime source for the development and production of almost all new military hardware. Therefore, it is necessary that new technology ultimately find its way into industry to be effectively applied. For new technology to be effectively and wisely applied, industry must understand it and feel that they can produce it. The technology transfer problem is therefore facilitated if much of the technology is developed in industry in the first place.

(2) Industry has particularly high technology skills in certain areas and large investments in special facilities that we cannot afford to duplicate in-house, e.g., for the production of solid state electronic devices and systems and for precision machinery, such as gas turbines. To be able to use our most recent fabrication technology for further advances, we must use the best available fabrication capability.

(3) Our well-spring of effort in the fundamental sciences--

the strong suit of academia--is in danger of running low.

On the other hand, industry and academia cannot do it all. There are compelling reasons to maintain a healthy DoD laboratory system. First, in areas of limited industrial or academic interest, such as explosives research, explosive ordnance disposal technology, and chemical warfare, the DoD laboratories are virtually our sole source of expertise and certainly our best source. Second, even though we must often turn to industry for fabrication of experimental devices and apparatus, it is often appropriate and highly desirable to have the experimentation, testing and evaluation done in whole or in part in the DoD laboratories and to use their familiarity with Service problems to decide in what direction the technology should be pushed. It is often necessary to do the testing there, since many of our labs have unique test facilities. Lastly, in order to be smart technical buyers, we must maintain a cadre of people with state-of-the-art knowledge who do not have commercial allegiances and who can provide a quick response to urgent DoD problems. This cadre must be reasonably permanent to provide a corporate memory of past problems, successes and failures and to preclude repeating previous mistakes. We feel the best way to achieve this is via an active and technologically involved in-house laboratory community staffed by career people. To maintain their skills and to command the respect of our contractors, they must personally be involved in technology.

As a result of these considerations, we have concluded that we should move back toward the mid 60's in-house ratio. However, industrial interest has decreased in some areas in the interim. Balancing these factors, we concluded in 1974 that a DoD goal of 30% in-house, as shown in Figure 7, was appropriate. As DARPA has very little in-house involvement, a ratio of 30% can be reached if the Services achieve a 35% in-house ratio. In consonance with this action, a reduction in the size of the laboratories and the entire in-house R&D establishment was undertaken at the same time. The reduction levied by DDR&E is about 10% and is being taken by attrition.

Our third major concern is that there appears to have been a decrease in innovation in the Technology Base program over the last decade. The major contributing factor is the decrease in the size of the program--which we have reversed. However, a closely related factor is the superposition of many layers of detailed management and the resultant conservatism. It seems axiomatic that if we put enough people into the approval chain, all with authority to say "no," then the chances of innovative ideas surviving become pretty small.

Therefore, we have recommended to the Services that the "headquarters" people--in the Services and OSD--should concentrate on policy setting, prioritization (investment strategy) and assessment of performance. Laboratory leaders--those close to the technology--should do the detailed structuring of the program--both the in-house and the contract program. In addition, they should have some flexibility in conducting their programs. To accomplish this we have suggested that all Services adopt the "block funding" approach for their laboratories similar to the method the Air Force has been using and the Army has recently adopted. Under this method of operation, each laboratory is allocated a Research and Exploratory Development dollar level as part of its annual budget guidance. This level is set by the Military Department's headquarters organization in response to the needs perceived for that laboratory's technology area and the laboratory's past performance as a manager and executor of its Technology Base program. The laboratory management then devises a program, allocates the in-house and contract funding, and presents it for approval to their Service headquarters and, through the normal review process, to DDR&E. The laboratory management is allowed reasonable authority to deviate from the details of the plan in order to maximize output but their changes are subject to after-the-fact review.

Of course, in any system in which significant management authority is vested in the laboratories and in order to promote a close, synergistic relationship between our laboratories and our contractors, steps must be taken to deal with the possible perception of industry and the universities that the laboratories are sitting as both judges and competitors. We believe that maintenance of a tight and visible headquarters control on the size of the in-house program is necessary to this end and we have set up a procedure to henceforth control the in-house level.

In summary, we believe our productivity of new ideas and concepts will be enhanced if emphasis is placed on putting the technical decisions at the place in the Service where--on the average--the best technicians are found, giving them a priori guidance and careful post facto review and feedback. By "feedback" I mean making sure that those who perform well are rewarded and corrective actions taken on those who don't.

VI. Progress Report

I'm pleased to report that we have made significant progress on these problems, with help and support from Congress and the top levels of DoD.

We have reversed the trend of a decreasing level of effort, with increases averaging over 10% per year. We are putting the funds to good use. Some of the funding is going to support expanded programs in key areas. Some is being consciously applied to expand into more speculative R&D in areas relevant to DoD. Some is being used to upgrade experimental equipment to enable more qualified people to do the necessary, but comparatively expensive experimental work needed to push technology forward.

The combination of increased funding plus an announced intention to push out the frontiers a bit has had an unexpected by-product--an upswing in the morale, vitality and enthusiasm of the U.S. R&D community. This, too, is paying dividends in terms of increased interest in defense problems and increases in the quality and quantity of proposals we receive.

It should be emphasized that the increase has been applied selectively. Many areas are not being increased at all and some that hold less promise will be diminished.

Our in-house ratio is declining toward 35% for each Service and the size of our laboratories is decreasing. Most of the personnel drawdown is now behind us.

The Army has continued its self-initiated trend toward placing more of the Technology Base management in the laboratories and has implemented a formal planning and guidance system. We are working with the Army to see that in-house ratio controls are instituted and used. The Navy, which previously funded essentially all Technology Base work in the laboratories on a work unit by work unit basis from headquarters now has block funded a substantial part of its Technology Base.

VII. Comparison by U.S. and USSR Defense Technology Bases

Now that I have given you the flavor of our Technology Base, I would like to conclude by giving you some impression of how we believe ours compares with that of our principal adversary--the Soviet Union. I will first explicitly examine our perception of our comparative postures in the two areas that represent the key underlying technologies on which most military systems are based: electronic sciences and the closely coupled disciplines of materials sciences and manufacturing technology. Then, I'll discuss a representative area of high mutual interest and then generalize on how we in ODDR&E see the total picture.

a. Key Underlying Technologies

We can start on a positive note. One of the great U.S. success stories has been in the technology of electron devices. We estimate that the Soviet Union is still 5-10 years behind the U.S. in the state-of-the-art in practical electronic device production, due mainly to the lack of a Soviet equivalent to the vigorous U.S. electronics industry.

Despite the fact that in the USSR the defense establishment controls production and uses the bulk of the output of the Soviet industry, only a few contemporary Soviet systems are believed to use the integrated circuits common to late model U.S. systems.

The Soviets have recognized this disadvantage and have been making an intensive effort since 1970 to upgrade their production capability. They have been seeking Western joint agreements, visiting Western factories, and acquiring--largely by clandestine means--Western equipment and technical assistance.

The picture with respect to materials and manufacturing technology is more mixed. The Soviets have long appreciated the importance of some of these more traditional technical areas related to weapons production. For example, they have worked diligently to gain new initiatives in the metallurgical manufacturing areas and many of their efforts have paid off much more so than their efforts to date in electronics. Judging from what we see of their production weapons systems, we still have a slight overall lead in materials and manufacturing. They lead in a few specialties and we lead in many others. Figure 8 indicates a few of the specialized areas in which each country leads. The reasons for this situation do not appear to reflect any "master strategy" on the part of either nation but rather selective choices and the conviction that the specific technology in question was important to their objective, while we elected a different technical route to the same goal.

b. A Potential Breakthrough Area--Directed Energy Weapons

Let us now examine briefly a particular area that is of high mutual interest and is illustrative of some typical problems in obtaining Technology Base intelligence: directed energy weapons.

With respect to HEL's, the level and quality of basic laser science in the Soviet Union is apparently close to that in the U.S. Their books and papers on lasers are widely used and respected in the U.S. They publish ahead of us in some areas and shared the 1964 Nobel Prize for the invention of the laser with the U.S.

Although there is no hard evidence that they initiated a high

MATERIALS AND MANUFACTURING COMPARISON

SOME U.S. LEADS	SOME USSR LEADS
ORGANIC FIBERS & COMPOSITES	FIBER REINFORCED CERAMICS
CARBON FIBERS & COMPOSITES	
COMPLEX SECTION CONTOUR MACHINERY	THICK SECTION TITANIUM WELDING & FABRICATION

Figure 8

energy laser development effort for possible weapons applications as early as the mid 60's U.S. effort, they have come on strong with a large and varied high energy laser activity. They have several major experimental installations and appear to have programs addressing land, sea and space applications. We cannot assess the Soviet intent with regard to specific HEL weapon application at this stage of development. All we can say is that we are sure that several test facilities exist and we are fairly confident of the size of their effort and the military involvement.

There is some evidence indicating that the Soviets are working on R&D that could be applicable to particle beam weapons. We know of their efforts to build high current, high voltage accelerators but the evidence of weapon applications is not unequivocal.

c. Assessment

From these examples and other evidence we have, I think we can make some general statements and draw some general conclusions.

We have good visibility into some of the Soviet Union's science through the open literature and we are generally aware of the size and purpose of most of their facilities. We also see--with varying degrees of clarity--the results of their Technology Base in the form of the fielded systems. In other words, we see the beginning efforts and the end products of the Soviet Technology Base. Unfortunately, we see very little of what is in between. In part, it is because Technology Base work is easy to hide in a closed society, especially one where the civilian applications of technology are usually far behind those of the military. Thus, anything we say about the Soviet Union Technology Base is based upon a little bit of information and a great deal of extrapolation. With that caveat, let me give you our opinion of our Technology Base versus that of the Soviet Union.

Their scientific effort is comparable to or larger than ours and apparently growing faster. They have clearly stated their goal to overtake us in science. What we see is usually impressive--first rate publications from large facilities that seem to be well-staffed and increasingly well-equipped. The best Soviet scientists are as well trained, intelligent and vigorous as are their best U.S. counterparts. However, the Soviet output of technologically sophisticated systems is not--by U.S. standards--commensurate with the size of their Technology Base effort.

We believe that they are presently hampered in forming good science into sophisticated hardware by (1) the lack of automated manufacturing techniques common in the West, especially for production of electronic devices and the consequent lack of advanced electronic design and test equipment, (2) a lack of the vitality produced in the U.S. by the DoD-private industry synergism, (3) a lack of the modern management techniques found in the U.S. (which may be foreign to the Soviet cultural background and therefore more difficult to assimilate into their society than in ours), and (4) limited numbers of highly skilled workers in their labor force to make the products and the technically trained military manpower pool to use them effectively.

Lest complacency result, let me clearly state that the Soviets may currently be in second place in the development of new technology, but they are superb engineers. They have surmounted their deficiencies by deploying large quantities of good, albeit not high technology, military hardware in an innovative and effective mix; and they have provided the manpower necessary to maintain the credibility of their potential.

Furthermore, and perhaps most important for the long run, the Soviet leaders are aware of their technological deficiencies and the disadvantage this puts them in. They are working hard to overcome our advantage. The comparative level of investment in manpower and facilities suggests they will do so if we are not alert. We can postpone the day that this happens by two courses of action. We can delay or prevent Soviet acquisition of Western know-how and we can invest the funding and the effort to keep U.S. technology moving smartly ahead. I believe it is clearly in our best interest to do both and that is what we are working to do.

VIII. Conclusion

This essentially concludes my prepared remarks. I hope I have conveyed to you the following six points:

(1) The DoD Technology Base is vital to our defense policy and posture.

(2) It continues to be productive in new ideas and in improving on old ones.

(3) It has continued to do so despite some adverse trends in support and the erosion of our contract programs with industry and the universities.

(4) We have taken vigorous--if somewhat painful--steps to correct these problems.

(5) In recognition of the value of the Technology Base to DoD--and to the nation as a whole--we work hard to assure that it is well managed, intelligently managed and aggressively managed.

(6) We face potential adversary who is aware of the value of technology and is striving hard--and with some success--to overcome our lead. We can ill-afford to let that lead slip away.

Let me close then with the statement with which I opened--the *DoD Technology Base is a national necessity and a national asset*--I believe it deserves your vigorous support.