THE RELATIONSHIP OF RESEARCH AND DEVELOPMENT TO REQUIREMENTS

26 September 1946

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Students

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THE RELATIONSHIP OF RESEARCH AND DEVELOPMENT TO REQUIREMENTS

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CAPTAIN WORTHINGTON:

The speaker this afternoon is Colonel Colby. He graduated from the Military Academy in 1929; MIT in 1935; Ordnance School in 1936; the Army Industrial College in 1937; and the Command and General Staff School in 1940.

During the war he held many important positions. For the past ten years he has been considered one of the foremost experts in the country on tank design, research and development, and production.

As a member of the Military Mission to North Africa he was Ordnance Observer and Ordnance Advisor to the British in Cairo, Egypt. He was on a special mission to the European Theater in 1945. He received the Bronze Star Medal, the Legion of Merit, and the Honorary Medal for Achievement of the British Empire.

On his return from the European Theater he became Chief of the Engineering and Manufacturing Division of the Office of the Chief of Ordnance, Detroit, which he held until after V-J Day. He now holds the position of Chief of the Development and Engineering Department, Detroit Arsenal, Center Line, Michigan.

Colonel Colby's subject is, "Relationship of Research and Development to Requirements".

COLONEL COLBY:

General McKinley, Captain Worthington, gentlemen of the Industrial College: I am glad to have the opportunity and the honor to be with you today to discuss this important subject, development versus requirements.

From the mists of antiquity to the present age of the atomic bomb, successful military leaders have based organization and strategy on equipment--"The mass and movement of the offensive." The vanquished have blamed their failures on deficiencies in quality or quantity of materiel available to them--"Too little and too late."

In World War II, the Army Air Forces became semi-autonomous with the airplane, the Armored Force was created around the tank, amphibian forces based their strategy and tactics on the LVT, the Airborne Command owes its existence to the air transport, and the Navy remained master of the oceans because floating airfields became the heart of their operations.

Desert warfare became practical because of track and wheel transportation. Beach landings in the face of hostile power were accomplished by wading and swimming transport and combat vehicles, new Navy landing crafts, and floating docks. The jungles were cleared with the tracklayer and the bulldozer.

Mechanical power became an accepted reality to the military man in World War II. It greatly reduced time and space factors, permitted operations in climate and terrain hithertofore inaccessible to military forces, increased the power density at the front, substituted horsepower for manpower, removed much of the drudgery and discomfort from the battlefield, and made possible the strategy and tactics that led to our speedy and successful conclusion of the conflict.

At the present time all military organizations are undergoing the greatest upheaval of all time. New plans of strategy, new tactical concept, and creation of new or revised tactical organizations are based on gas turbines, gas turbo jet propulsion, rockets, guided missiles, atomic power, and new uses of the internal combustion engine, radar, and others.

It is logical that new developments will continue to be dominant factors determining the outcome of wars between nations.

New developments become available to the fighting man when newly developed items are standardized, incorporated in Table of Organization and Equipment, and reflected in the Schedule of Requirements. Hence, Development and Requirements are closely related; but, like the old questions, "Which comes first, the chicken or the egg," several schools of though debate endlessly on the question "should the needs of the battlefield dictate the development program or should the development program give rise to new requirements?" Should the fighting man, organized technical societies, boards of industrial development or production engineers, or selected scientists be given full control of the development program? In this argument, like so many others, the advocates of extremes are wrong because they are colloquial in their thinking. The correct solution is an intelligent compromise that recognizes the contributions that each group can make to an effective program.

A school of thought among fighting men holds that the user knows the task he is assigned and therefore should prescribe the weapons that are most appropriate to accomplish his mission. This position is rational when he can select from a field of known weapons, but fails when applied to the development program because of a few practical considerations.

First, the fighting man is so concerned with winning tomorrow's battle with equipment available to him that he has little time or patience to consider what may be available to him in the remote future. When presenting the development picture to front line units, their interest, almost without exception, was lost if the equipment shown would not be a reality for their present or next campaign. A commander has to win his battles with equipment available; he is allergic to wishful thinking. True, he sees need for new

equipment, but when that need arises from the battlefield, we are hopelessly behind. To be ahead of our opponent on the battlefield we must be one year ahead of him in production, two years ahead of him in development, and three years ahead of him in thinking.

(Slide Presentation)

Second, using service specifications are usually wrong in that they ask for immediate possession of that which is impossible within the limits of present knowledge, or they do not encompass those advantages which present know-how can give him. Such items as radar, atomic energy, hollow charges, proximity fuzes, recoilless weapons, gas turbo propulsion, and guided missiles can only arise after long tedious scientific research has unlocked many secrets of nature.

Yet the user has a vital interest in the development program because he must stake his life on his equipment for victory.

For the above reasons, several civilian schools of thought charge the Army and Navy with incompetence and lack of foresight, and demand that a civilian organization, established beyond any control of the military, be given responsibility for research and development. They fail to state that 99 percent of our equipment which dominated all battlefields of this war was designed by, under the supervision of, or in cooperation with, our uniformed services. We have had no experience with full civilian control on which to base comment, but we do have the experience of others. British development under civilian control of the British Ministry of Supply did not produce a single important combat vehicle in this war. Their greatest claims to credit include the Matilda and Churchill tanks, the Bren gun carrier, the DD Device, and the Flail. All are poor in concept, unreliable, lack interchangeability of parts, and are difficult to maintain. Yet, within the British Army are some of the smartest tank engineers I have ever met. They were relatively inarticulate all during the war because they could not crash the walls of the compartments of colloquial thinking.

Early German combat vehicle development was under control of the users. The confusing and impossible specifications so upset German industry that Hitler attempted to solve the difficulty by placing development under the Speer Committee, a civilian organization; but things went from the frying pan into the fire. Under the new arrangement, the panzer forces not only didn't get what they wanted, but got mass production of equipment they didn't want. Near the conclusion of the war, 85 percent of tanks produced in Germany were equipped with front mounted, limited traverse, guns. The panzer forces wanted full traverse turret mounted guns. This was an important factor, leading to the break in morale of German troops.

It is obvious that scientific, industrial, and user activities all contribute to development--none know it all. Requirements give rise to Development, Development gives rise to Requirements, and ideas can come from the strangest places. Therefore, an essential element in the military structure

is an organization whose personnel have received both military and technical educations, who can speak the language of the soldier and the civilian, and who understand the problems of user, engineer, and producer. The functions of this organization should be:

a. To study the military problem and define it for the scientific and engineering worlds.

b. To keep abreast of research and development in order that new discoveries having potential military possibilities may be further exploited and brought to the attention of the user.

c. To promote and support research in new fields.

d. To break down colloquial thinking and the barriers separating these compartments of activities by bringing user, scientist, engineer, and producer together, so that each can see the other's activity and understand the problems that confront each.

e. In general, to act as quarterback for the team which must effectively cooperate in producing winning plays.

It was my good fortune to attend the prewar predecessor of this college, The Army Industrial College, during the school year 1936-1937. I value that year of training more than any other I have ever received. I would, however, like to take exception to one of the findings of that student body. It favored the principle of freezing development at the outbreak of war to facilitate production. The growth of this principle was one of the chief obstacles to our development program during the early years of the war and hampered us to the very end. Since this problem is one of the importance of Development versus its effects on requirements, analysis of this question is considered advisable.

The adoption of new equipment means changes in materiel requirements, adding new items and deleting the old. This in turn means new or revised contracts with facilities who are required to tear up old and establish new production lines. New machinery with new tooling, gages, and fixtures are required. New subcontractors and sources of material must be found. Men must be re-trained for production and inspection. New production bugs always appear. The raw material schedule is upset. Formerly critical materials appear as surplus; others become critical. The mad scramble for priorities is carried to the top level of command.

Modern mass production, accomplished by complex organization through necessarily complex procedures, is easily upset; therefore, requirement changes should be made only when considered judgment shows the advantages of these changes to outweigh the delay, cost, and confusion they cause.

Such cases as where pistol ports were ordered removed from turrets and then, in a few months, ordered back on again, give justifiable rise to resistance to engineering changes. A new plant was constructed to meet the requirements for the Medium Tank M7. However, after production had been initiated, this requirement was cancelled because the M7 largely duplicated the military characteristics of the Medium Tank M4. This time-consuming and costly undertaking could have been avoided by proper evaluation of military characteristics. This was another incident which gave rise to further argument by those opposing development.

The human factor must also be considered. Men responsible for production gain their reputation by producing large quantities at minimum cost. Activities which adversely affect the statistics of production and cost are not always favorably considered by many production men.

But production conversion can be made. Every combat vehicle in production during the fall of 1942 had, by V-J Day, been obsoleted and superseded in production by new and greatly improved types. The production of several others of new concept had been initiated.

Tables of Organization and Equipment are basic documents used in the computation of requirements. When new equipment is adopted, new organizations must be developed around the equipment. This is a difficult task, conciliating the many different opinions of tactical employment, size, of units, and organizational framework. Revision of organization affects manpower requirements and rates of mobilization, with questions arising that can be settled only at the top echelon of command. Training schedules are altered. School courses, text books, and training and technical manuals covering tactical employment and care, operation and maintenance of new equipment must be revised. New strategic and new tactical concept require that these instruments of instruction be restudied and rewritten.

The adoption of new equipment may need radic revision, require longer runways on airfields, run counter to fuel standardization programs, necessitate new bridges of greater width and weight-carrying capacities, or cause the Navy to revise ship and dock handling equipment or develop new transport and landing craft.

These problems and the fear of confusion they cause on established programs of production, manpower mobilization, and training, gave rise to the principle of "Freezing development for the duration at the outbreak of the war". These arguments have much thought, are logical in their presentation, but they fail because of the omission of one important premise. They do not consider the important of new equipment to the man who fights. In our necessarily highly complex organization we are again confronted with the difficulty for individuals to see beyond the four walls of their compartment. These activities are not ends in themselves, but are created to render service to fighting organizations. The guiding objective of all is to aid the fighting men to reach their objectives with the minimum loss of life. This is best done with superior equipment.

Thus far, I have dealt with the problems caused by the adoption of new developments as requirements. Seldom discussed is the fact that an intensive rational development program is not only essential to meet requirements with a good product, but actually simplifies the problems of the many compartments of the military service which base all or part of their activities on the schedule of requirements. For data to substantiate this statement, I will draw largely from that product field with which I am most acquainted--Combat and transport tank-Automotive vehicles. The fact that this nation could enter the war two years late with combat vehicles that dominated all battlefields of this war and which operated with great reliability under extreme conditions of climate and terrain was not by accident or because a group of engineers spent a night in a smoke-filled hote room, but was due to hard work on development from 1932 on, which resulted in the adoption of the controlled differential type of steering, rubber-jointed tracks, power plants of high horsepower-to-weight ratio. Lack of funds was the great handicap. The first controlled differential test was conducted in an old Light Tank T1E1. The controlled differential unit was given to us by a commercial concern whose only reward was to be called a "merchant of Death." We engineered the conversion, using gun design drafts-men. The pattern for the cast-iron housing was made by carpenters. The pattern was taken to a near-by foundry where a couple of jovial Irishmen were humored into tamping out a mold. This mold was placed in front of a furnace where management took pity on us and filled the hole with molten iron at a cost of 8¢ a pound. We snagged, chipped, cleaned, and machined the housing in our own shop, assembled the vehicle, and ran the test. To over-come the shortage of personnel, high-ranking majors and others, including the infantry representatives, in turn performed the duties of draftsmen, foundry men, mechanics, and relief test drivers. Our big handicap was not inertia of the mind or undue conservatism, but lack of funds.

The original rubber-jointed track was designed, built, and given to us at no charge by a Detroit industrialist who has given unselfishly of his time and money in the interest of national defense. This track, tested on the Track-Development Chasis T2, ran to the destruction of its metal parts with no apparent damage to the rubber joints. Here Lady Luck was with us. Had this track failed, as many experimental tracks have since, we would not have had this important advantage in this war.

The radial air-cooled engine, only engine available at that time with high horsepower-to-weight-and-bulk ratios, proved satisfactory in tests of Combat Car T2.

These successful tests marked the transition from World War I mobility to the mobilities of World War II. They solved the fundamental problems of the high speed track layer. The Light Tank M2, built in 1934, gave way to the wartime Light Tank M3 and M5. The Medium Tank M2 formed the basic chassi of the Medium Tanks M3 and M4. Research and development, prior to World War II, though wholly inadequate, determined whether or not the product produced to meet requirements was of service to the soldier on the battlefield.

Conversely, lack of development is costly in time and material and denies the fighting man instruments of war which give him the chance to live in accomplishing his mission.

As far back as 1932 the development and test of the torsion bar suspension, automatic transmission, and power pointing and stabilization of guns were urged. These were not done before the war because of lack of funds. The above were developed and incorporated into production vehicles during the war. Had funds been available prewar to develop and test these items and incorporate them into our early schedule of requirements, our early production would not have been subject to early obsolescence; production facilities would have been less troubled by changing designs; school courses and training literature would not have required as drastic revision; and troops would have had better equipment from the beginning.

Reliability of operation is a most important characteristic of military equipment. To accomplish this necessitates extensive operation in actual or simulated extreme conditions of climate and terrain. Much was accomplished to achieve reliability in proving ground and service test and operation. But lack of funds made it necessary to wait for the war before we could move to deserts, jungles, snowfields, frigid temperature zones, and saltwater beaches for thorough reliability and functional tests. In addition to Aberdeen, General Motors, Tank Arsenal, and Studebaker Proving Grounds activities, trainloads of equipment were sent on successive winters to Kapuskasing, Shiloh, and the Alcan Highway, for cold-weather operating tests. Camp Seely, in the Imperial Valley, was established to solve problems of fuels and lubricants, vaper lock, engine cooling, sand flotation, and dust. Extensive tests at Phoenix, Arizona, were the basis of solution of the air cleaner problem. 23,000,000 truck miles of operation at Camp Normoyle and Camp Bullis provided basic data which assured us good synthetic tires for military use. Fort Story, Fort Pierce, and Fort Ord provided tests for beach operations, deep water fording, swimming equipment and the effects of salt water corrosion. Camp Hale, Colorado, and Lake Louise were centers of testing on deep snow fields. The results of this late, expensive, and time-consuming testing flowed into the production lines in a continuous stream of engineering change orders. Increased costs due to retooling, obsolescence of semi-finished or finished components, and delays would have gone a long way toward paying for a rational prewar development program, with resulting less confusion to all concerned and better equipment for the man who fights.

Today, activities at all proving grounds except Aberdeen Proving Ground have terminated. We are hoping that sufficient funds will be provided to bring these extremes of climate and terrain to a new Components Laboratory planned for the Detroit Arsenal.

The points which I have desired to stress are these:

1. The product produced to meet requirements is only as good as its development concept and design engineering.

2. To have equipment on the battlefield when the need arises necessitates that we be three years ahead of the battlefield in our thinking. This requires tactical as well as technical vision.

3. An aggressive development program during peacetime simplifies the problems of requirements, and the activities of industry and the services related thereto.

4. Because this democratic country will never provide adequate funds for development in peacetime, the policy of freezing development for the duration at the outbreak of war should be thrown in the wastebasket, and the policy of intensifying development at the outbreak of war should be enunciated.

5. The greatest handicap to our development program during the war was not the system but, rather, individuals who, in our necessarily compl organization, could not see beyond the four walls of their compartment of activities.

6. There is no one compartment of our military organization that knows everything. Good equipment means good teamwork.

7. In every case where the development program has been turned over to civilian politics, the needs of the man in the battlefield have been neglected. Because the munitions of war are one of the three essential of combat, the development of these munitions must be under the direct contr and supervision of the uniformed services.

CAPTAIN WORTHINGTON:

Any questions?

A STUDENT OFFICER:

Colonel, you made the statement that 450,000 parts had been reduced to 80,000. Did that include armored vehicles, or was that all ordnance materia

COLONEL COLBY:

Only tank-automotive: Trucks, armored cars, tanks, etc. Tank automoti only.

CAPTAIN GRANUM, USN:

Will you discuss the transition from development to production, includi the differences in peacetime and wartime procedures, and including at what point you start to translate those into Tables of Equipment and lay your plans for production and set up facilities in order to avoid delays.

COLONEL COLBY:

The procedure is fundamentally the same in peace as in war except that we try to cut many corners under pressure of war. The War Department directive to the Ordnance Department to conduct specific developments is the Ordnance Committee Item which normally has the concurrence of all interested agencies. The pilots after design and construction are sent to Aberdeen Proving Ground for engineering test, and to the appropriate Service Board for service test. If the Service Board finds there are tactical requirements for the unit, they recommend standardization. Standardization of a new weapon must be approved by another Ordnance Committee Item. The new weapon is then placed in the Tables of Organization and equipment. When Tables of Organization are established, then with the rates of mobilization and other factors, out come the schedules of requirements. From the schedule of requirements we then get our approved authority to procure. That is the procedure that has to be followed.

During the war we would frequently release items for production actually before we ever got any written approved authority to do it. Paper work always followed, not only to legalize the action, but to insure the coordination that resulted from processing the paper.

Does that answer your question?

CAPTAIN GRANUM:

I think so, in the time available here. There will be some other questions I would like to ask about.

A STUDENT OFFICER:

As I understand it, Colonel Colby, it is your contention that the civilian people or the using services should not have too much of a finger in the development of weapons and vehicles; that it should be a technical service problem. Am I correct there?

COLONEL COLBY:

You are incorrect. They all have a vital interest, but no one knows it all.

A STUDENT OFFICER:

That is correct. In other words, we need an over-all head of that development rather than either the using service or the civilian alone.

COLONEL COLBY:

The machinery now exists.

A STUDENT OFFICER:

It does?

COLONEL COLBY:

Yes.

A STUDENT OFFICER?

The point I would like to have you discuss is this: Some hue and cry developed from the using services that it took such a long time to get into production. I began in the Nineteen Thirties to work on automotive equipment at the Tulsa Winch Company, down in Oklahoma, in coordination with the Field Artillery. We tried to develop and put over a front-mounted winch which took a long time to put into production; in fact, it took several years. The same thing, I believe, was true in the push to get the four-wheel-drive vehicle developed. I realize that was not Ordnance responsibility at the time. But I know that the company, coordination with the using service on some sort of an unofficial basis, had a lot to do with it.

Am I correct? I wish you would discuss that, if you care to.

COLONEL COLBY:

I am not familiar with the specific case you mention, but the mechanism for realistic coordination now exists. But in all of these compartments are elements of colloquial thinking. Sometimes a majority in a compartment will block procedure. This can happen at the using service, the technical, or staff level.

Some problem of changing some textbook, or of revising a Table of Organization that would affect manpower, or change to a production order or production line, or the problem of spare parts may appear to be more importan than the advantage of new equipment.

My criticism is not against the organization; it exists. But if we want the coordination, we have to deal with people.

One of the great aids which the Germans had working for them in this war was our own Army Regulation 850-15. Whenever they came into my office I always threw them in the wastebasket because, frankly, I haven't built anything of importance in this war that was not in violation of Army Regulation 850-15. They were subsequently revised to legalize the status quo. Much that was done in this war had a nonconcurrence on it because it exceeded the weight and dimensions limitations set up by Army Regulation 850-

COLONEL KOCH:

Was there likelihood of continued reduced appropriations for the develop ment of ordnance? I am thinking now particularly of general-purpose Army

vehicles up to 7½ to possibly 10 tons. Wouldn't it be desirable to encourage development on the part of your commercial manufacturers of trucks and to have some stimulant of some kind to have them do their development in line with military requirements and not to wait until war comes and then to go through the sweat that we went through?

Will you give us a comment on that, please?

COLONEL COLBY:

Yes, I think your theme is right. It is correct. But the great trouble now is that American industry which contributed to this war program is now back in the peacetime struggle for economic existence. Most did little or no engineering on their own commercial product during the war. When they have completed their No. 1 important job of filling our long neglected civilian needs, we can expect more working assistance from them.

This close working assistance with industry is essential. Our present contacts with industry are largely in the field of tank-automotive components. If we can keep commercial facilities interested in design and production of components for tank-automotive equipment, we will have gone a long way toward establishing the mutual confidence, respect and know-how that is essential to wartime teamwork.

Does that answer your question?

COLONEL KOCH:

Yes that does.

A VISITOR:

Aren't you getting--

COLONEL COLBY (interposing):

Hello, Art.

A VISITOR (continuing):

--an interchange of thought between the Engineers and SAE being constantly advised now as to Army requirements and also the Engineers in the Army becoming familiar with the new developments in industry to see how they fit into the military program? Isn't that true?

COLONEL COLBY:

That is true; yes. Art was with me in the war and he did some very valuable development work during the war.

Let me give you an example: Last week we had in our office our Ordnance Advisory Tire Committee. We presented our military problems to them and they are now finding industry solutions.

All during the war we worked intimately with the War Engineering Board of the SAE. Whenever we had an engineering problem, we got together as an industry Ordnance team. The technical committee of the SAE is an outgrowth of, and is patterned on the War Engineering Board. This group will work very closely with us in the same way that Art mentions. They are very sympathetic with our problems.

A STUDENT OFFICER:

Colonel Colby, from the point of view of the technical services, what is going to be the effect of this new Research and Development Section? I mean what specifically can they do to help the technical development of the technical services, outside of getting more money?

COLONEL COLBY:

Well, getting more money is an important function. In other words, they can support us on the highest realm of command. There is one thing about this Army: It is always best to have the backing of the highest man in command. For example, a colonel can always do better with the backing of a general; a lieutenant colonel can always do better with the backing of a colonel; a major can always do much better if he has the backing of a lieutenant colonel. You see, it is always best to have the backing of the highest echelon of command.

Another important function is preventing duplication. Like functions should always be concentrated as much as possible. The only thing I fear when we do that is that, from the lack of funds, we will not be able to do what everybody wants. For example, to me, the most important thing in our whole development program is getting basic components of vehicles developed, because if we have components of the basic vehicles developed then we can build new vehicles of new military concept in a short while. But if we do not immediately go out and build some new gadget for a particular service who feel it is the most important thing in the world to them, they will say, "If the Ordnance Department won't do it for us, we'll do it ourselves." The is always a constant struggle between concentration and decentralization.

What the solution is, I do not know. We cannot do it satisfactorily unless we have a lot of money. If we could get, say, 12 million dollars a year guaranteed to us, we would have some beautiful tank-automotive equipment that would pretty well cover the field. And it has to be just about that much money, 12 million dollars. It would not be a drop in the bucket if the bucket represented World War II procurement, it is so small.

A STUDENT OFFICER:

There is increased attention in this country on the intelligence angles of modern warfare (and also peacetime) as evidenced by the thinking along the line of creating a national intelligence agency. During the war, as you know, there was considerable information brought back on enemy equipment. Now how do you propose, with your limited funds and your limited personnel, to hope to keep track of developments in the foreign nations and try to get ahead of the people in Europe?

COLONEL COLBY:

This problem is being solved on a high staff level.

A STUDENT OFFICER:

That is a big problem in my mind and I wondered if you would want to comment on it.

COLONEL COLBY:

It is very important to know the trends. As I said, we must be three years ahead of our opponents in thinking. Therefore, it is very important for us to know how they are thinking.

Now let me tell you how this M-26 was developed. I took the first light tanks to Africa in June of 1941. Then our M-3, Medium Tank came into the picture, which could knock out a German Mark III within 2700 yards. That was the biggest tank they had at that time. Well then I came back and General Barnes and I discussed the problem. We said, "We finally have the Germans on the run with the 75mm, now what are we going to do? Obviously, the Germans, being realistic, are going to come back on that Mark IV with a high-velocity 75mm gun. What should we do? We should design a tank that can withstand that penetration of the high-velocity 75mm and which would have a gun that would blow the wits out of the German Mark IV." We designed the M26 which was initially released for production in August of 1942. These decisions were made without foreign information. We were trying to out-guess the German thought process. It is very valuable to all of us to know what their thinking is. This does not mean that we should pattern our thinking after theirs. We should know what they think in order to assure ourselves that we are beyond them in our own thinking. This is very important.

Our Ordnance Technical Intelligence teams during the war were certainly invaluable to us. I had in my office a group of about four people who did nothing but take in intelligence reports and screen them for any valuable information.

CAPTAIN WORTHINGTON:

Thank you, Colonel Colby, for a very interesting talk.