GOVERNMENT OF CANADA

STATEMENTS AND SPEECHES

INFORMATION DIVISION
DEPARTMENT OF EXTERNAL AFFAIRS
OTTAWA - CANADA

No. 58/20

THE ROLE OF SCIENCE IN DEFENCE

Address by Dr. A.H. Zimmerman, Chairman, Defence Research Board, to the Canadian Aeronautical Institute, Toronto, May 26, 1958

It is a great pleasure for me to be here tonight and to have this opportunity of speaking to you.

Tonight I speak to you as an engineer, with some experience in both industry and government. In my present capacity my days are spent largely with scientists, and of course the defence research program for which I am responsible is primarily related to fundamental and applied science rather than to engineering development.

My general theme tonight is "The Role of Science in Defence", with special emphasis on its application to aeronautical engineering. I think we might all agree that the technological advances of the 20th Century have far outstripped all of those made in all past history. In the early stages of man's history, his chief preoccupation was to procure sufficient food, shelter and clothing for survival. For these essentials to life, he depended almost wholly on his own physical strength and ingenuity for success. In the sophisticated civilization in which we now live we are still faced with the problem of survival, primarily because man has now mastered such enormous powers of destruction as to make no place on earth safe from attack.

The wheel seems to have gone full circle, with vast technological changes but with little if any progress towards a solution of the original problem -- that of ultimate survival.

The outpouring of new knowledge, in all fields of science, is now such that no one man, or group of men, can hope to understand more than a small fraction of it, and the pace continues to accelerate. As one writer has put it, many people are asking "How long will it last?"; "Will this rate of material progress continue faster and faster?; will it level off -- or will it end in the catastrophe of a war that will annihilate civilization as we know it, ending in a return to the Dark Ages?".

These are the fundamental questions today, and certainly there is no pat answer.

Under all the circumstances, our national course has been, and indeed continues to be, to promote international peace by every available means, but at the same time to recognize that it is only prudent to keep our guard up. It is the leaders of governments and statesmen who must take the responsibility for promoting peace, for discovering new and sure ways by which man can learn to live at peace with his neighbour, but it is the scientists and engineers who are entrusted with providing protection to ensure survival meanwhile.

So, until peace is declared, and can be accepted with confidence on all sides, it would seem that we must continue to press on with technological advances at as rapid a rate as we can afford, and in a direction which is calculated to defeat foreseeable threats.

These are my major points -- that the rate of advance must continue to be rapid, and that the direction of our effort -- in other words, our research and engineering programs -- must be sufficiently flexible to prepare for defence against a variety of threats. I refer particularly to threats from manned bombers, from ICBM's, and from submarine-launched missiles.

We are becoming more aware every day of Russia's intense drive and concentration on scientific achievement. From early school age to graduate level, science is encouraged by real incentives. Bright students by applying themselves to their academic training are rewarded with a higher standard of living than their fellows; teachers are held in high respect and paid very well; first class buildings and equipment are provided on a lavish scale; it is in fact quite clear that an aristocracy of privileged people, largely made up of scientists and engineers, is emerging.

One writer has summed it up by saying that "Russia's national preoccupation is in solving scientific and intellectual problems and indeed to wrest technological superiority away from the West". Another goes even further. He says -

> "It is not only our military, scientific and technological capabilities that Russia has challenged. In a more subtle and profound way it is challenging our system of government. Can Democracy ensure survival?".

Such statements as these only serve to strengthen our determination in the West to keep pace, otherwise we will surely lose the race.

In considering what is a practical rate of advance from the scientific point of view, there would seem to be 3 basic factors, without any one of which further progress would eventually be slowed almost to a halt. I am going to talk about these factors for they are, I think, particularly relevant to the aircraft industry at the dawn of the Atomic Space Age.

They are - the growth of new knowledge, the availability of new sources of power, and the development of new materials.

First, the growth of new knowledge.

It is self-evident that the discovery of new knowledge, of new facts hitherto unknown, or of new natural laws must, in the main, stem from basic or fundamental research, carried out largely at universities or at government research laboratories. The scientist is not concerned with the profit motive. He carries out his researches and his experimants purely in the hope of adding something new to man's store of knowledge of the world about him and of the natural laws which apply to it. Frequently the true scientist does not even know where his work is leading him; often he does not even care, so long as he is adding to knowledge of his subject. But he persists, and from time to time he achieves a "breakthrough" which he thereupon hands over to any one who wants to use it. His discoveries and achievements provide the raw material for the engineer. His end point is the engineer's starting point.

The engineer, on the other hand, must be concerned with the profit motive. It is up to him to take the raw material of the scientist and put it to practical use, in a form, and at a price, that makes it both attractive and useful to a customer. This is true whether the product is one which can be sold to the public-at-large by the million, or whether it is extremely costly, such as a complex weapons system, with but a single customer - the government. My point is that the engineer and the scientist must work together as a team. If the rate of advance I mentioned a few moments ago is to continue, they must communicate continuously with one another for, in fact, they are mutually dependent.

The second factor essential to rapid advance lies in the need to make available new sources of power, again a problem for scientists to discover and for engineers to put to use.

We have seen in Canada the successive discovery and development of power from several sources - from the early use of the water wheel located on the banks of fast-flowing rivers to drive the crude machinery of the early saw mills, flour mills and textile plants; to the use of steam power derived from coal; to the giant hydro-electric plants of today, and to the many uses of oil as a prime source of power.

If I may digress for a moment, my mention of giant hydro-electric plants reminds me of the new St. Lawrence Power and Seaway Development. Between Iroquois and Cornwall the fact of nature is being changed on a grand scale, including a tremendous dam at Iroquois to control the level of Lake Ontario and an International Power Plant at Cornwall designed to generate 1,640,000 kw by 1960. In the process some 20,000 acres of land will be flooded, necessitating the removal of several entire villages to relocate 6,500 people on high ground in newly-built communities. Long stretches of main highways and rail lines must be moved -- even cemeteries cannot be left to the flood. This project is a modern saga of the historic St. Lawrence Valley on a scale unlikely to occur again in our lifetime. If you have not already done so, I can strongly recommend a visit to the site, from which I am sure you and your children will return with a sense of pride in this great Canadian achievement. But you will have to hurry - the flooding is scheduled to take place during the first four days of July.

Beyond the sources of power I have mentioned, we have the promise of nuclear power, both by fission and by fusion, now in its infancy.

As applied to defence problems, we already have nuclear propulsion available for ships, which may well change and extend the strategic role of the Navy.

Last December, I was privileged to go for a short cruise in the USS SEA WOLF, the second nuclear-powered submarine built for the US Navy. The relative simplicity and reliability, coupled with high speed, of this new source of power was most impressive. In the reactor room, lined with instrument panels, control buttons, switches, meters, gauges and flashing lights, there was a brass plate mounted on the head of the reactor itself which read:

"Property of U.S. Government - DO NOT OPERATE

BEFORE READING INSTRUCTIONS".

This did seem like a slight over-simplification.

Some day the problems of weight and safety may be solved to the point of making nuclear power practical for flight in one form or another.

In the meantime, a great research effort is going into the so-called "exotic" fuels, to provide efficient power for supersonic and possibly hypersonic flight in outer space, through the use of either liquid or solid propellents.

Again in the Space Age, man's ability to fly ever higher and faster is dependent on the availability of new sources of power.

The <u>third factor</u> we must consider is the need for new materials. Having mastered the sonic barrier -- although there is still much to be learned about that strange phenomenon -- we face the thermal barrier, which as you all know is the speed of flight at which high temperatures affect airframe skins and structures adversely. In addition there is the great problem of finding materials which will withstand and contain the hot gases produced by the new sources of power.

Many research attacks are being made on these problems, including experiments on a wide variety of surface coatings on what might be called conventional metals; on new alloys using rare metals and on various combinations of metals with ceramic materials. Satisfactory answers are essential if the engineer is to further widen the horizon of space flight.

In summary then, we find that the scientist must be encouraged to continue in his role of contributing to the growth of new knowledge, discovering new sources of power, and inventing new materials.

The engineer, however, has several equally important responsibilities -- one is to identify and interpret his own needs to the scientist, in order to stimulate research in useful directions; another is to exercise creative imagination in putting scientific discoveries to use. Since he cannot do everything, he must be selective in his projects, and here a correct evaluation of the time factor is of supreme importance.

From a defence standpoint, considering the very long lead time required for the development, production and deployment of a complex weapons system -- usually from 7 to 10 years or even more -- there is little merit in spending the national wealth on a project which matures too late, or is obviously obsolescent in the face of probable enemy threats.

Let me explain for a moment what I mean when I refer to a "complex weapons system".

It is natural that you in the aircraft industry, spending most of your waking hours thinking of aeroplanes, may think of an interceptor fighter by itself as being a weapon for defence against an attack by manned bombers. It is, in fact, only one part of an extremely complex weapons system, which to be at all effective, must include such vital elements as the ground radar early warning and detection system -- 3,000 miles of it across the Far North, the Mid-Canada Line radar chain, the ground environment for control and data-processing necessary to place the fighter in a position to intercept the enemy; all of the essential split-second communication links between these lines; the integrated electronic fire control, navigation and communications equipment installed within the aircraft, finally the guided missile with which the aeroplane is equipped.

It takes little imagination to see why it takes so many years for a weapons system to be researched, developed and built, and it is easy to understand why still later research and development may cast a long shadow of obsolescence ahead of it.

In short, the problem of long lead time has never been more crucial. Expensive projects become fruitless if they cannot be carried out rapidly.

In one of our applied research labs there hangs a sign which reads, "If it works, it's obsolete". While, hopefully, that isn't often true at the applied research stage, it tends to become progressively more true as further years of development and production mount up.

This points up the need for maintaining a continuous momentum of research even though the later use of it may not carry through to production.

Perhaps the solution is to design the research and development program in such a way that successive projects will overlap in time, but not necessarily implying that they will all be carried through to production. Such a system would, however, keep our knowledge up to date and would enable us to produce a given type of weapons system in perhaps half the time required if we wait for complete production of one before beginning on another.

Now I would like to say a few words about the status of aeronautical research in Canada, with respect to its application to defence problems.

As Canadians, we can take considerable pride in the fact that, since 1945, some 25 types of aircraft have been produced in Canada, almost half of them of native design. But we cannot feel so happy about research for which our resources are relatively meagre. There are reasons for this situation. The results of research and design in the US and UK have been available to us, and we have been able to use many of the facilities in the US for model testing and applied research generally.

We in the Defence Research Board have recognized that this is not a healthy, balanced condition for the future and we are doing something about it in several directions.

The keystone of any continuing research program is a supply of competent scientists and engineers for the research establishments and industry. To this end, the Defence Research Board grants approximately $300,000 per annum to the various universities to provide facilities and support research projects for training in the Aerodynamics and Gas Dynamics fields. Similarly, in the Structures and Materials field, DRB grants to universities are of the order of $130,000 per annum.

As many of you know, there is now a well-established Institute of Aerophysics for post-graduate training and research at the University of Toronto. This is physically located at Downsview and has been largely financed by DRB. Similarly, a smaller laboratory has been established at Laval University in Quebec, also financed by DRB, in order to encourage another centre for the training of aerodynamicists. In the propulsion field, DRB has supported a Gas Dynamics Laboratory at McGill University in Montreal for several years.

Early this year the Government gave its approval to construct a $6,000,000 Wind Tunnel at Ottawa. This is being jointly financed by DRB and NRC, and, it is hoped will be ready for operation by 1960. This tunnel, with a 5 foot square test section will have a speed range from zero to Mach 4.5, resulting in Reynolds Numbers up to 15 million per foot, which represents a tenfold improvement over our present supersonic testing capabilities. This tunnel will have sufficient flexibility to test models of any type of airborne vehicle whether manned aircraft or unmanned missile, and even certain types of propulsion systems such as ramjets.

And at our Canadian Armament Research and Development Establishment in Quebec we have an 800' Aeroballistic range in which models can be tested and photographed in free flight up to hypersonic speeds. As an adjunct to the CARDE activities, we also maintain a fully instrumented Free Flight range at Picton, Ont., where much of the dynamic stability testing on the CF-105 aircraft was carried out.

Perhaps one of the most revolutionary advances to be made in aviation will be the achievement of true vertical take-off and landing which has now become practicable with the advent of lightweight gas turbine power plants. Recognizing this potential, the Defence Research Board has sponsored a number of research contracts with the Canadian aircraft industry in both the STOL and VTOL regimes and the associated propulsion systems. You will hear preliminary reports on the results of some of these activities in your technical sessions tomorrow morning.

These are some of the measures we have taken to encourage careers in solving problems in the evolution of flight, and to provide much-needed research facilities in Canada.

In conclusion, I have attempted to indicate very briefly something of the role of Science in Defence, which hinges largely on the relation of the scientist to the engineer.

The world now stands on the threshold of the Space Age. Perhaps it could be more simply called the Scientific Age. In very recent years we have seen spectacular developments in the speed of flight, in the power of the atom, and in the myriad uses of electronics. The future staggers the imagination.

In 1948, Professor Einstein is reported as saying this:

> "Our situation is not comparable to anything in the past. It is impossible therefore to apply methods and measures which at an earlier age might have been sufficient. We must revolutionize our thinking and revolutionize our actions."

Yes, we sense many new and as yet unknown developments ahead, even though we cannot yet fully understand their implications.

In today's exploding technology it is surely the scientist and the engineer who will lead the way.

S/C