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Operational Research

Remarks by George R. Lindsey
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At the age of nearly ninety years, the periods which I have found to be the most interesting and exciting have been World War Two, post war and terrorism. When the war began in 1939, I was an undergraduate at University of Toronto in mathematics and physics and had enlisted in the Canadian Officer's Training Corps. A very serious effort was made for the member countries of the British Empire to make their most effective contributions to what was predicted (and proven to be) a long, costly and demanding war. One of the requests for Canada was to identify university students of scientific subjects, of which the most important were those related to radio and other electric fields, and encourage them to earn their degree and then enlist in the armed forces.

When we asked the British visitors what they wanted us to do, they said it was too secret but we would find out when we enlisted. In fact, the secret was radar, the new device which became a major factor in winning the war.

After enlisting for active service in the Royal Canadian Artillery in early 1942, I was delighted to be given a very well-organized training in radar, especially designed for defence against aircraft. This was followed by attachments to the National Research Council, the British Army Operational Research Group and the Canadian Army Research Group. Most of the duties were related to ground-based defence against aircraft, employing studies of both exercises and actual military operations against enemy aircraft. Combined with similar research by other organizations of the army, navy and air force against enemy air, land and sea forces, this type of analysis became known as operational research and gradually extended to many other activities. The general elements were using mathematical and other scientific methods to measure the effectiveness of what was being done, and calculate how the methods could be improved.

The post-war situation, influenced by the notable success of the two nuclear weapons delivered on Japanese cities by American bomber aircraft, which brought the war into rapid conclusion, made nuclear weapons the most important item for determining the strategies which have been chosen for the following years.

While the end of the war left Germany, Italy and Japan very weak, it left the USA, the British Empire and Western Europe, with their supremacy in long range bomber aircraft, somewhat stronger than Russia, with its communist tendency and its neighbouring countries being assembled into the Soviet Union. However, the Soviet Union was quick to build a powerful long-range bomber air force equipped with nuclear weapons.

The Canadian government was very generous in encouraging its war veterans to develop the capabilities for other useful employment and undertook to support them for further education for a period as long as the time they had served during the war. I was struck off strength in 1945 and went to Queen's as a graduate student in physics, obtaining an MA degree, followed by four years of research in nuclear physics at Cambridge, financed by the Royal Commission of the Exhibition of 1851.

Dr. Omond Solandt, a Canadian who became head of the British Army Operational Research Group during the war, returned to Canada to become the first Chairman of the Defence Research Board, created in 1947 as a fourth arm of the Canadian National Defence Department. Dr. Solandt invited a number of scientists whom he had met during the war to enrol in various positions in the new Defence Research Board. In 1950, I joined the Defence Research Board in Ottawa to pursue military operational research, as a civilian. Then followed roles ending as Chief of the Operational Research and Analysis Establishment, from 1968 to 1987.

So, after spending nine years in universities and 41 years in defence, I have been allowed 22 years officially retired, but still active. How can one do something useful while retired but still active? One is to study what has been changing and try to forecast what is likely to be different before long.
Fields with which I have had some recent as well as earlier studies include radar, sonar and missile defence. After extraordinary contributions to detection, location and tracking of targets in the air, the sea and the ground achieved during World War Two, remarkable improvements are continuing, such as electronically scanned and synthetic aperture antennas with a capacity to present fine details or movements of the targets. Countermeasures against an opponent's radars can be to jam his transmissions or to reduce the fraction of energy directly reflected back to him from his targets (a method usually described as stealth).

Some of the things that radar is doing for us in the air, space and to some extent on the ground are being matched by what sonar is doing in the sea and to some extent on the ground. Mines may be detected by active sonar. The transmission of sound through the water can be used to determine ocean depths, temperatures and currents. In Arctic regions much can be determined about the location and movements of ice. Much can be learned from passive as well as active sonar, such as the tracking of surface ships, submarines and torpedoes.

While missiles, such as stones, bullets, artillery shells, air-launched bombs and torpedoes have been available for many years, the last year of the Second World War saw the appearance of long-range guided missiles with the German V1 and V2, followed by a long (and still growing) series of many types of missiles based on the ground, on ships, submarines, aircraft or even space vehicles. Their ranges extend from short to intermediate to intercontinental. Their damage and kill capabilities may depend on high-speed physical collisions, explosives or poisons (which could possibly be nuclear). Defence against these missiles could be directed against their location before they were launched, in their boost phase just after they were launched, in the midcourse of their trajectory or in the final phase as they approach their target or release smaller weapons.

Of all the things that are changing here on Earth today, an outstanding one is the extension of the activities beyond the Earth’s atmosphere and into the huge and nearly empty dimensions of outer space. A momentous development is the launching of vehicles achieving velocities sufficient to send them into paths that keep them cycling around the Earth instead of soon reentering it. This provides long periods of observation of huge areas of the Earth's surface, especially if the information can be collected and returned to Earth quickly and without the need or management or judgment by humans located up in the space vehicles.

The growing ability to obtain continuous control of the activities of unmanned aircraft is even more valuable if it can be provided for space vehicles, especially because of the much longer extent of their continuous time aloft. Many of the space vehicles will eventually become out of control (perhaps because of exhaustion of fuel, an irreparable fault or old age), be demolished in tests or collisions or discharge smaller weapons which subsequently scatter many fragments of targets which they have destroyed. While tiny particles floating in the upper layers of the Earth's atmosphere will be slowed down and soon return into the lower and denser layers and melted, larger fragments may remain in orbit for a long time and present a danger of colliding with an operational space satellite. Both will be moving at high velocities and the satellite will probably be destroyed. Consequently, there will be an increasing need for the detection and subsequent tracking of these dangerous threats, as well as the tracks of the active spacecraft.

Many of the problems that have just been described are likely to involve those countries occupying the largest areas on the earth and depend on their relative locations. The second largest of these is Canada, likely to find itself deeply involved. This could be for missile defence of North America, for clearing space from the dangers of collision of important vehicles with debris scattered from previous activities, perhaps for collecting information useful for many purposes other than defence, such as weather forecasting, ice conditions, the state of crops or providing successful search and rescue following accidents on land, sea, air or space.

In addition to the reinforcement of national security and sovereignty, particularly in the Arctic, Canada may be able to assume a role in devising a new and as yet completely undefined UN-NATO partnership in an international peacekeeping activity, primarily directed against terrorist organizations other than nationally identified governments.

Whether the primary objective is sovereignty, security or peacekeeping, or even future prosperity, science and technology will be important and the role of Operational Research could be critical. Overhead surveillance of Canada's enormous areas of land, nearby sea overhead atmosphere and outer space, and a combination of space-based and airborne technologies may provide the solution. The challenge for Operational Research will be to develop a package which includes the use of existing assets, both government and commercial.

Maintenance of Canadian sovereignty and security, and perhaps also her future prosperity, is likely to depend on her capability to provide effective overhead surveillance of what is happening in Canada's enormous areas of land, nearby sea atmosphere and outer space.

I hope that those older Canadians like me, who have been fortunate enough to have served in scientific research related to the type of problems described in the last few minutes, will continue to think about them and discuss them with those who are now in charge of solving them.