The CF-100 weapons system includes, besides airplanes, the radar control & warning network, trained aircrew and ground crew, as well as motor generator sets crew ladders and other ground equipment.

Weapons System for War

By GROUP CAPTAIN H. R. FOOTTIT

"Those who have need of a lamp must take care to supply it with oil."
—*Anaxagoras (circa 400 BC)*

THE TOWN was in a tumult. Anchored in the river, in the shadow of the towering cliffs, was the greatest steamship of her day, the British "Great Eastern". Already the tiny ferries were shuttling back and forth between the vessel and Quebec City docks. So huge was the great ship, with her five funnels, six masts, and two giant paddle wheels, that it would take the ferry boats over two days to get the 2,600 soldiers with their women and children safely ashore. "It is a great occasion," carolled the Journal de Quebec one day during this warm July of 1861. And when the Great Eastern finally weighed anchor, the following month, the Montreal paper, *LaMinerve*, confidently predicted that she would return to Quebec shortly "with 10,000 troops."

Although the Civil War had broken out in the U.S., and the British were busily building up their Canadian bulwark of empire, when the Great Eastern got home the War Office cancelled her charter. The dreams of her owners and stockholders died. The Great Eastern was five times as large as the biggest ship then afloat: she could carry 4,000 passengers—twice as many as the Queen Mary, launched seventy-seven years later—but she couldn't pay her way.

There are many reasons why the Great Eastern was the black sheep of the 19th century shipping world. One of them was that she had been designed and built as a single ship, and not as part of a transport system. Consequently she was too large for most wharves; there was no dry dock in the world big enough to hold her; and she was too wide to pass through the Panama Canal when it was built some years later. Her supporting shore organization was almost non-existent.

Beyond the Ken: To think of the Great Eastern as part of a sea transport system, and design the ship and her shore facilities accordingly, was beyond the ken of the 19th century mind. And no wonder. For even today, almost a hundred years later, we have just reached this systems concept stage in

6102 June/56 AIRCRAFT

aviation. We can think now in terms of a complete air defence system, for example. Such a system, in Canada, includes the personnel, the air bases, the command network, the Pinetree, Mid-Canada and Dew Line radar chains, and the CF-100 all weather fighters. It is vital that we link all these together in one mental entity to ensure tha we have all the components. For, as Field Marshal Lord Montgomery explained recently, all factions must be ready to function together as a unit, since the system "must operate extremely fast, and must function as one system," if it is to counter the threat of an atomic attack by air.

To think in broad terms of air defence systems, air offense systems, air transport systems, and their major components, is relatively easy with a systems concept. But in the design stage, when a part of the system is just sprouting in many minds, even this mental crutch must be subdivided into smaller segments. As Leonardo da Vinci wisely counselled in the 15th century, "Small rooms or dwellings set the mind in the right path, large ones cause it to go astray."

One of the "small rooms" in our systems concept, that has recently arisen, is the "weapons system". In essence, this system is the airborne part of the complete system, as shown in Figure 1. However, it is important that we understand just what the weapons system encompasses, if we are to plan and build complete airborne weapons with minimum cost in minimum time. "We could have just the right power plant fully developed for use in a missile," says the U.S. Air Force's General C. S. Irvine, "but without a guidance system we still do not have a missile; or we can deliver an airplane with the engine, fire control equipment, and all other components working fine, but if we are not at the same time able to deliver the support and test equipment, the airplane cannot be used to perform its mission, and therefore, we still do not have a weapons system."

definition

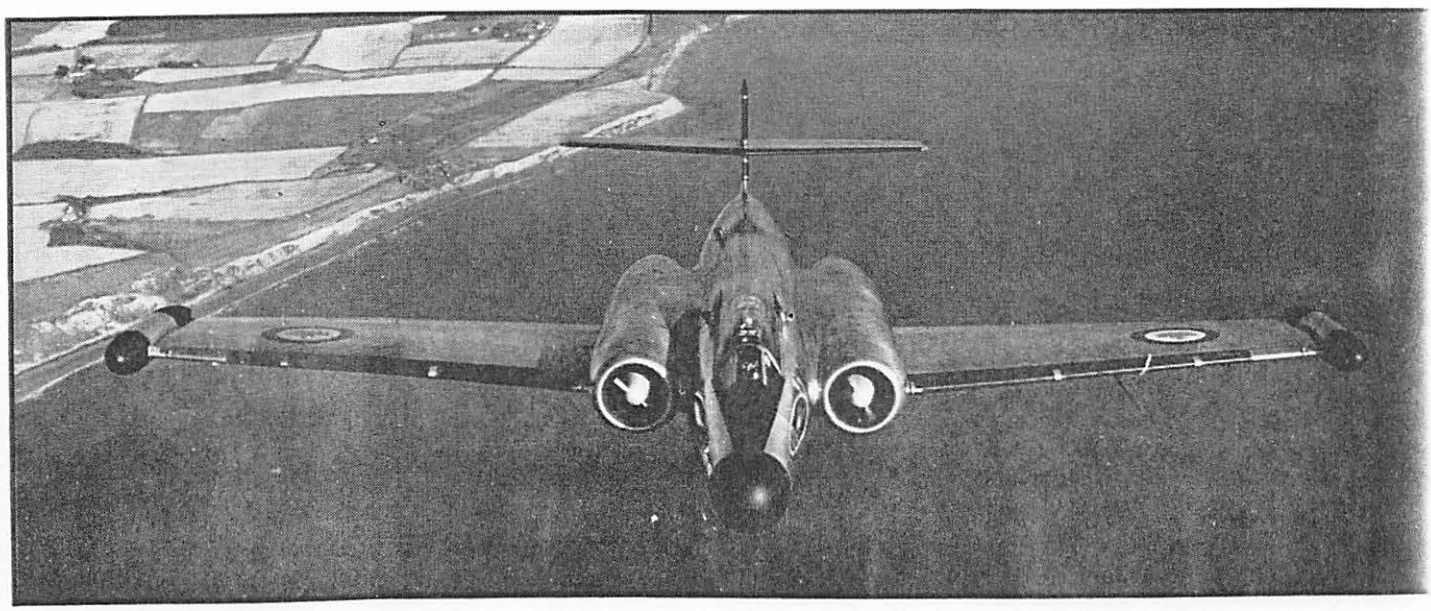
THERE ARE two aspects to this weapons system concept: (a) the scope of the system, including the equipment and personnel, and (b) the organization of the system to ensure that it functions efficiently to produce the proper product. But before delving into each aspect separately, let's look look at a definition. A weapons system has been defined as "an instrument of combat, such as an air vehicle, together with all related equipment both airborne and ground based, the skills necessary to operate the equipment, and the supporting facilities and services required to enable the instrument of combat to be a single unit of striking power within its operational environment."

As a typical example of today's weapons system take the Avro CF-100, the all-weather fighter that stands guard as part of our air power system for defence. When the Canadian Commercial Corporation, the government's postwar purchasing agent, signed the contract for this airplane, neither the Corporation, the RCAF, nor the contractor had a weapons system concept in mind. As a result we ordered a flying machine equipped with guns.

Before the first flight of the first aircraft, however, some meetings were held with the contractor on some items of ground equipment. As time went along further items were considered and evaluated, courses for the ground crew were adopted, and the logistics support items and test equipment were looked over and decided upon. But it wasn't until the CF-100 Mark 4 came along that all loose ends, that really make up a true weapons system, were tied together. Thus it took many months before the CF-100 finally came to fruition as a complete system—"a single unit of striking power within its operational environment."

Clear Purpose: The purpose of the weapons system concept is clear. If the CF-100 were being designed today, weapons system thinking would be sidled in from the start. This would ensure that all aspects of airborne radios, gunsights, fire control systems, rocket pods, and rockets, are considered at the same time as starting energizers, hydraulic test equipment, maintenance stands, and wheel jacks. Furthermore, the crews to maintain the airplane and equipment would be fully trained and waiting. And all this would go on from the first line on paper. In other words, by weapons system thinking it would be possible to complete the development of a fully operational CF-100, with all its supporting equipment and personnel, in minimum time.

Similar thinking would produce



similar results for a ground-to-air missile, such as the Boeing Bomarc, an anti-bomber pilotless airplane. In this case there is probably even more supporting equipment and skills required than for a combat airplane. But the outcome would be the same.

Let's turn now to the organizational side of this weapons system coin. Western nations have been discovering that today's airplanes and missiles are far too complicated to have a small government group primarily responsible for sifting and ordering all the weapons system components as they did in the past. Gone are the days when the RCAF could merely order the engine, the radio equipment, the gunsight and the guns, and have the designer simply stow them in the aircraft.

To design and develop a proper weapons system, with the highest possible kill probability, requires a skilled staff of war weapon analysts. In the days of fighters and guns, for instance, this was not so important. Nor was the tailoring of equipment to aircraft so stringent. But now we have fighters with air-to-air missiles. And it is the kill probability of the airplane-missile combination, as a complete weapon, that really counts. Suppose, for example, we decided that the F-86 Sabre should be equipped with an air-to-air missile to make it an effective bomber destroyer. Moreover, the enemy's bomber is estimated to have a 5,000 ft. altitude advantage over the present Sabre. In other words, bombers are expected to penetrate our air defence system at 55,000 feet while the fighter has a combat ceiling of only 50,000 feet.

Improving the System: There are two ways of improving the weapon system to ensure the kill. One way is to improve the thrust and aerodynamics of the fighter and so raise its combat ceiling to that of the bomber. The other way is to fit air-to-air missiles that can climb after launch, and so make up the altitude differential. Between these two extremes, there are all manner of intermediate solutions. But it can be seen that the performance of the fighter and the performance of the missile need considerable detail analysis to ensure that the optimum solution, with minimum cost, is achieved. We must not raise the fighter's or the missile's ceiling needlessly. In fact, the fighter plus missile's ceiling must just match that of the bomber, or we may find we have improved both, at great expense, when such is not required.

Such analytical ponderings as this have led the United Kingdom and the United States to partial policies for concentrating a weapons system development in one key organization. The British Minister of Supply and the Minister of Defence summed up the situation to the U.K. Parliament last year: "An aircraft must be treated not merely as a flying machine but as a complete weapons system . . . Since the failure of one link would make a weapons system ineffective, the ideal would be that complete responsibility for coordinating the various components of the system should rest with one individual, the designer of the aircraft. Experience has shown that this is not completely attainable but it is the intention to move in this direction as far as practical considerations allow."

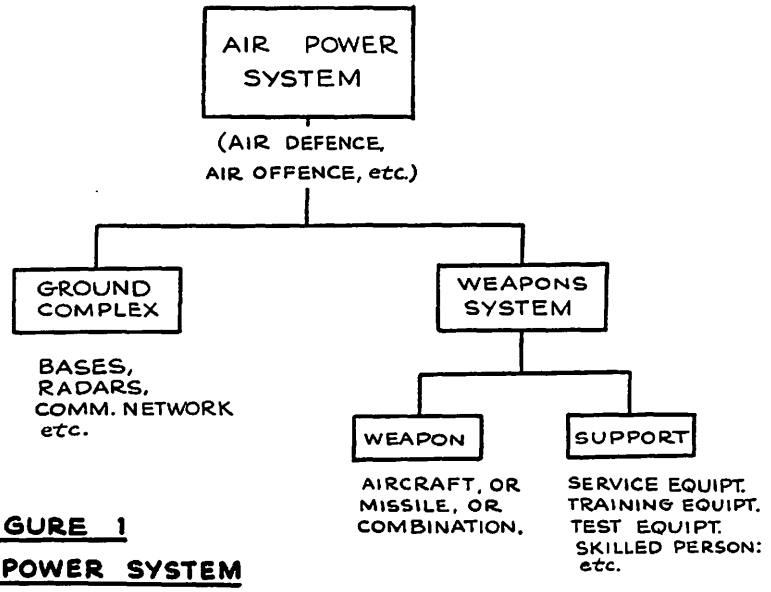


FIGURE 1
AIR POWER SYSTEM BREAKDOWN

There are some reservations to giving the airframe manufacturer the complete air weapon responsibility. However, in general, both airframe contractor, engine designer, and equipment supplier agree with the principle. As J. M. Brian, Director of Sales & Engineering for Aviation Electric Ltd. of Montreal, says, "The weapons system concept has been evolved because of sheer necessity. Today's aircraft or missile is so complex that it is extremely difficult to have, in any one organization, all the necessary know-how for the design, development and production of the specialized components." He then goes on to point out one of the key reasons, from an armed service viewpoint, for the weapons system organization. "The system offers," he says, "tremendous advantages from the standpoint of eliminating divided responsibility. One organization becomes responsible for the successful completion of the whole system."

No Panacea: The weapons system organizational concept, however, is not the complete panacea that it appears on the surface. There are certain industrial drawbacks. If the airframe manufacturer goes out and orders his auto-pilot or electronic equipment tailored to his requirements by the specialist suppliers, then the situation is not too serious. But he may choose to start manufacturing this equipment himself. As Ray J. Conrath, Aviation Manager of Railway Power & Engineering Corporation Ltd. in Montreal points out, "It would seem that when the aircraft manufacturer enters these fields, that were formerly the preserve of the equipment suppliers, a multiplication of existing facilities results. The consequence of this action may aggravate the critical specialist personnel situation. Costs, also, may tend to rise through elimination of the competition which presently exists between the established suppliers of such equipment."

There is also the possibility that, even with subcontracts to the equipment supplier, one aircraft contractor may develop a fire control system which is operationally similar to another one being developed by another aircraft contractor. Thus, unless there is some overall control over the system managers there may be some duplication of effort.

(Continued on page 82)

vessel, the C.G.S. Baffin, according to the Dept. of Mines & Technical Surveys. The Baffin is now nearing completion at Montreal.

A government spokesman estimates that the Model 47G Bell helicopters will help speed up Arctic charting operations by 60 to 80% working either independently or as a team from the 3,700-ton icebreaker's heliport. The Baffin is packed with all the latest electronic measuring and navigating devices. Following a christening ceremony, the 285-foot-long ship is scheduled to leave on her maiden voyage to chart the coasts and sea lanes of both the Western and Eastern Canadian Arctic Archipelago.

In service, two or three shore-based hydrographic survey units will be discharged from the Baffin at a time, either by helicopter or aboard the six specially-constructed landing barges carried by the ship. As the units are established at predetermined points they will become self-sufficient, dependent on the ship and helicopters for supplies only. Whenever heavy ice conditions make landing barge operations impossible, however, the helicopters will be called upon to facilitate triangulation control and to undertake specialized aerial photography to pictorially record the high and low water lines of the coast.

Other jobs assigned to the float-equipped helicopters include ice reconnaissance flights to help the Baffin navigate through ice-choked Arctic waters. Should the ship become frozen fast in the ice, the helicopters can scout ahead for possible escape routes through the ice.

Extra-Curricular

Fifty-two people were rescued from the sea during 1954 by weather ships manning the ICAO's North Atlantic ocean station network, according to a recent report. The network consists of nine stations manned by vessels supplied or paid for by ICAO member nations.

Canada, France, the Netherlands, Norway, Sweden, the United Kingdom and the United States have accepted the resposibility of providing ships to man the stations, while Belgium, Denmark, Germany, Iceland, Israel, Italy, Spain and Switzerland make cash payments to defray certain of the costs of the service. By an agreement with the U.S., Canada operates a Pacific weather ship, while a U.S. weather ship fills in at Canada s allotted station in the Atlantic.

WEAPONS SYSTEM

(Continued from page 25)

In spite of such possible pitfalls, everyone agrees that a weapons system organization is a "must" if we are to speed development and reduce the time to operational squadron use. The United Kingdom and the United States have officially recognized the weapons system concept, and have proceeded some way along this path. Canada has not officially put forward such rules and regulations. Nevertheless, both the CF-105, the Avro supersonic fighter, and the CL-28, the Canadair maritime reconnaissance version of the Bristol Britannia, are proceeding within the weapons system framework.

There are probably more difficulties in trying to establish this system officially in a small country like Canada, than there are in large industrial complexes like the U.S. and U.K., since

ERRATUM

In the story about the Project Vanguard work being undertaken by The Glenn L. Martin Co., which appeared in the May edition of *Aircraft* ("Science Non-Fiction", P. 30), it was said that: "The vehicle will comprise three stages, made up as follows: the first stage, approximately 4 ft. in length and . ." The length should have been, of course, 45 ft.

we have a relatively small number of sub-contractors. We must always be careful to protect these small industries and suppliers, for if a war started these firms would form a solid foundation to our vital war effort. If we lost them, the big companies would be swamped with war work, and undoubtedly we would have a mad scramble trying to set up a new sub-contractor baseline, to replace the one that had been eroded by the skimpy contracts of peacetime defence.

Drawbacks: J. M. Brian sums it up this way: "The drawbacks of such a contracting system as we see it, particularly in Canada where there are few contracts of this nature, are that it puts a tremendous competitive advantage in the hands of the contractor who is given cognizance over any given system. Naturally he tends to keep as much work as possible within his own or affiliated organizations, thus preventing the general industry from being able to participate as fully as they might."

However, Brian also suggests a solution: "This could be minimized by the Government directing that the Weapons System contractor spread a specified percentage of the work around to companies that are not a part of his own organization or affiliated with it."

While Canada and the nations of the West are still experimenting with the organizational aspects of the weapons system concept, it is safe to say that the system as a whole is certainly here to stay. For it is only through such a system that we can keep our thinking straight. And straight thinking, in turn, ensures that we have all the components that make up a complete air weapon—or the oil for the lamp, as Anaxagoras said to Pericles in Athens nearly 2,000 years ago. As the great philosopher John Dewey phrased it in his book, *Reconstruction in Philosophy*, ". . . notations, theories, systems, no matter how elaborate and self consistent they are, must be regarded as hypotheses . . . They are tools. As in the case of all tools, their value resides not in themselves but in their capacity to work as shown in the consequences of their use."

DELIVERUM

(Continued from page 19)

the hour, estimating Luxembourg at one-five."

Near destination, you call the section into echelon formation.

"Random Charlie is cleared to the break on runway three-three."
"Charles on the pitch!"

As you shut-down the engine for the last time, an excited group of squadron pilots gather to look at The Six.

"How is she? What's she like at altitude? How long to climb to forty-five?"

The Overseas Ferry Unit, in two and a half years of operation, has delivered more than five hundred Sabre aircraft to Europe. The unit has accomplished this feat without the loss of a single pilot. Hence their motto " Deliverum Non Dunkem". The OFU holds the record for a trans-Atlantic ferry flight with a 45 hour crossing. Another achievement was the elusive "Triple Hop," smoked through by Random Eighteen, flying from BW-1 to Germany in a single day.

Since the advent of the two-hundred gallon drop tanks, much of the sweat has gone out of the Operation. Nevertheless, the scarcity of alternate aerodromes along the route, plus the unpredictable weather of the North Atlantic, still make the seven hours of actual flying a challenge.

ORENDA SERVICE

(Continued from page 47)

sound and color film and the actual parts, teach the students the facts about all types of Orenda engines. Then the students go downstairs to the large engine strip-and-build room, which is equipped with overhead crane, vertical build stand and all the required tools, and carry out overhaul exercises on actual engines.

Pilots are given short courses so that they will understand the newest developments on the engines they are flying.

Pictures: Another big job of the Sales & Service Department is to keep the