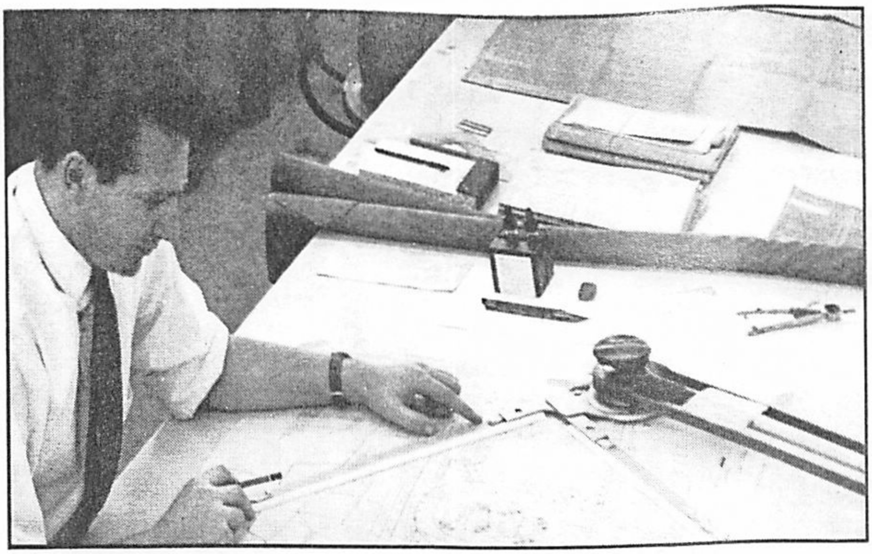


"One man with an idea . . . is worth thousands in uniform."

The Engineering Jig Saw

By GROUP CAPTAIN H. R. FOOTTIT

"A plan must come as part of the organic development of a project . . ."
—*Brewster Ghiselin.*

THERE's nothing like the restful, relaxed atmosphere of New Brunswick when the fall is beginning to unfold over the land. But early last autumn the sleepy summer town of St. Andrews was seething with activity. Twice within a week, in the early days of September, the town was inundated with engineers. First the Professional Engineer's Association and the Engineering Institute of Canada assembled for a joint meeting. Then no sooner had this group passed the last item on the agenda than A. V. Roe Canada Ltd. sponsored a three-day conference that brought a new flood of engineers with their employers into the town. Though the latter session was specifically called to consider the case of the Canadian engineer, both conclaves were acutely conscious of the February report of J. P. Francis of the Department of Labour's Economic & Research Branch: "For the period from 1947 to date we have found that [the statistics] indicate a shortage situation for engineers that is not matched in its extent or its continuity by any other occupational group."

Paradox: A mere four months have slipped by since these important conferences. Yet we in the aeronautical engineering business in Canada find ourselves in another paradoxical situation. If the big and small companies with design staffs did all they were supposed to do, there would indeed be a *shortage* of engineers. But there is a lack of decisive plans and programs with the proper financial support. So if many design departments were cut back to firm and funded programs, we would actually have a *surplus* of engineers. In fact, many large companies would be laying off their engineering staffs literally by the hundreds.

Next week, of course, with a change in the program they may be frantically trying to hire them all back again. Over the years this feast-and famine cycle is repeated over and over again. So it's about time that we stopped and asked ourselves why we have created this Alice-in-Wonderland world? And the answer is easy. It's because we lack a basic engineering plan. Yet such a plan is as simple as a jigsaw puzzle. And it's long past the time when we Canadians should have solved this pertinent problem.

In talking with R. N. Redmayne, manager of the Air Industries & Transport Association, the other day, we both agreed that the industrial history of aviation in Canada has not yet been written. But when it is, I'm sure, we'll find that it is a succession of starts and stops, intense activity and deadly doldrums, as it is today. We then went on to discuss the 1930 era and that famous Canadian-designed airplane, the Noorduyn Norseman. "Noorduyn," said Bob Redmaye, "designed and built a distinctive aircraft that just fitted a basic need in Canadian air transport at the time." He was thoughtful for a minute: then added, "And you know there are operators today who still swear by a Norseman."

Low Ebb: In the early 1930's, when Noorduyn was just getting started on the Norseman design, the Canadian industry was at a low ebb. The gloomy fog of the depression had just blanketed the land. Says a British magazine (The Aeroplane) in its January 8, 1936, edition: "Since 1931 . . . aircraft construction in Canada has been practically at a standstill, chiefly because Mr. Bennett, the former premier, had preferred to spend the government's money on broadcasting stations, in the hope of prolonging the life of his own Government, instead of on the RCAF and air mail operations. Also there has been a lot of old stuff to use up."

Against this depressive backdrop Noorduyn pressed on with the drawings of the Norseman. So by the mid 1930's the newly formed Noorduyn Aircraft Ltd., was eking out a slim existence and the Norseman was hitting its stride on its first flight tests. In subsequent years the Norseman gradually weaved its way into the expanding fabric of the Canadian scene. In 1938, for example, a Norseman was part of the first flight of a new air mail service from Vancouver, B.C. to the Yukon. Under the personal direction of Grant McConachie, president of the newly formed Yukon Southern Air Transport Ltd., a Fleet seaplane and a Norseman seaplane were readied for the job. Then, at seven o'clock on the morning of August 4, both aircraft took off from Vancouver and headed north with a record 26,000 pieces of mail.

In the same year the RCAF took delivery of four Norsemen which had been specially equipped for navigation and radio training. Other operators were already on the Noorduyn bandwagon. In fact, as the magazine "Flight" stated at the time: "For a long time America produced very nearly all the machines of the rather special character which were required by Canadian operators, but during the last year or two the Canadian-built Noorduyn Norseman has had a virtual monopoly in this single engined high duty class."

Late the following year Hitler began his march over the plains of Poland, and the war drums sounded throughout the world. The Norseman was already on active service with the RCAF.

But before the peace treaty was finally signed in 1945, the versatile Norseman was to see service all over the globe. For it was soon being produced in quantity by the Noorduyn company for the U.S. Army Air Forces. The UC-64, as it was tagged by the USAAF, filled a transport need that could not have been completely filled by any other design from any other country.

Hard to Measure: After some twenty years of Norseman operations, I don't suppose anyone can truly assess the impact of this airplane on the Canadian panorama. It played a major peacetime role in opening up the far northern reaches of our land; it played an important transport and training role during war operations; it provided the production foundation for a plant that did much more during the war than turn out just Norsemen. And all this started from a small engineering group, sponsored by private capital, who designed the Norseman in the thick of the pre-war depression.

Though we should understand today just what a nucleus of engineers can do for a country, our understanding seems thin and superficial when judged against the yardstick of positive action. It reminds me of Carl Hinshaw's statement when he was president of a sub-committee reporting to the U.S. Joint Committee on Atomic Energy. "Do we *really* appreciate the tremendous dependence of our nation on the scientists and engineers? Do we *fully realize* that one man with an idea on how to guide an intercontinental missile to its target with accuracy is worth thousands of men in uniform?"

On the surface we seem to. For just a short time ago a Royal Commission was set up, under the chairmanship of Walter L. Gordon, to survey Canada's economic prospects. Last year the Commission was busily studying briefs from J. Geoffrey Notman, president & general manager of Canadair Ltd., in Montreal, and Crawford Gordon, Jr., president & general manager of A. V. Roe Canada Ltd., in Toronto. But both these industrial leaders tell the same old story. Says Notman, "One of the major problems of the industry in the past, both in Canada and the United States, has been instability due to successive expansions and contractions which are costly to the defence effort and wasteful to the economy." He then goes on to point out that there can be waves in the employment level with 500 percent difference between the peaks and the troughs of successive programs.

Hard to Get: What this does to a skilled engineering department is obvious. "Much has been written," says Notman, "of the flight of our engineers and scientists to the United States due to the possibility of more gainful employment and greater opportunity. The aircraft industry is becoming increasingly dependent on such engineering and scientific personnel and unless we can offer them opportunities for research in some long range development program, they will not be available to us either for our current activity or in the event of a crisis."

Crawford Gordon, Jr., tells a similar story. "The aircraft industry cannot be started and stopped, like mining or lumbering, and still remain efficient. Building aircraft and aero-engines is essentially a technological race." He advocates a long term plan. Such a plan, he says, should cover the "consideration of a production program to ensure continuation of operations at a level which would permit the industry to retain essential engineering and production staffs."

Well, why don't we prepare such a plan? It is abundantly clear that it has been in the back of Canadian minds for decades. Somehow, however, we fail to come forward with it in final form. As A. N. Whitehead says in his book, *Adventures in Ideas*, this is often

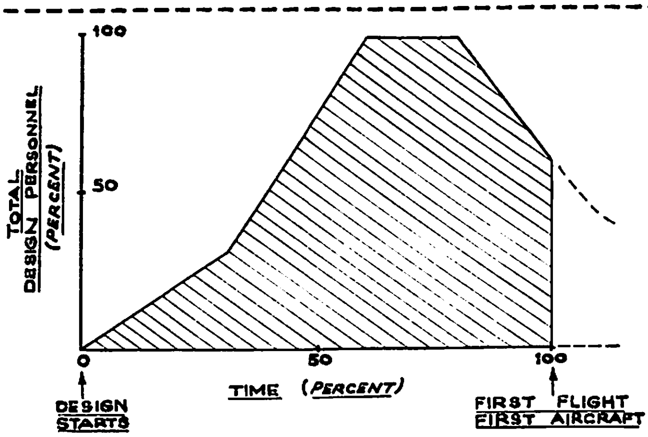


FIGURE 1
DESIGN STAFF REQUIREMENTS

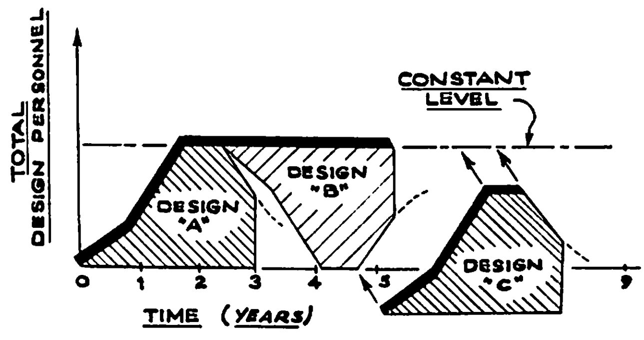
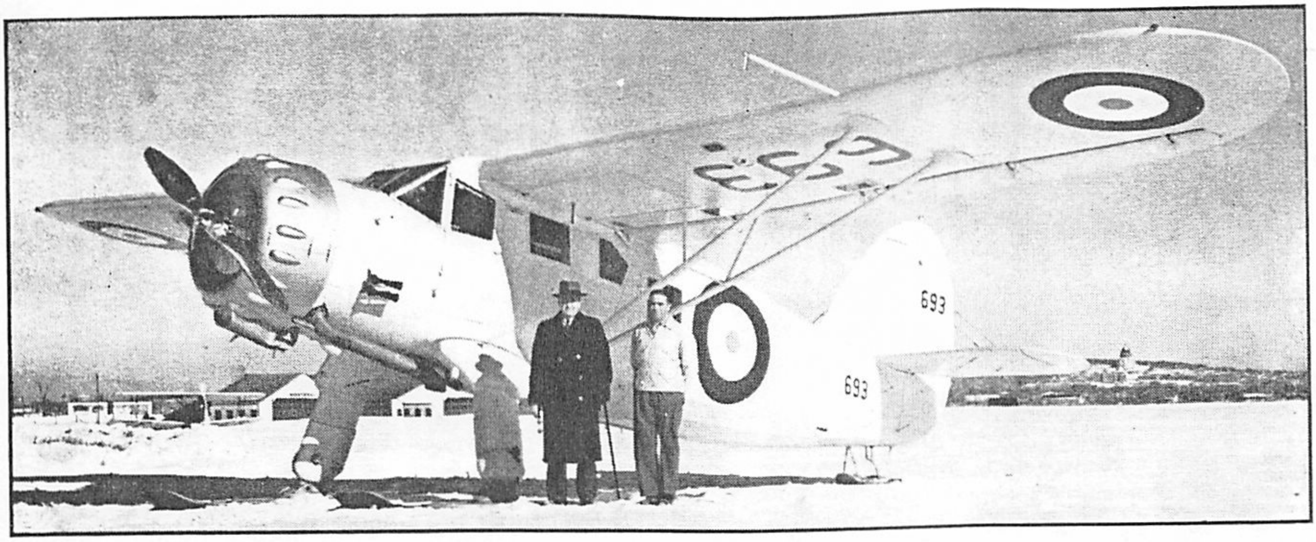


FIGURE 2
ENGINEERING PLANNING



Bob Noorduyn, Norseman designer, is shown at left standing in front of one of the early production models.

a basic difficulty that dominates the history of great ideas. "There will be a general idea in the background flittingly, waveringly, realized by the few in its full generality — or perhaps never expressed in any adequate universal form with persuasive force." We have certainly expressed the dire need for a plan. Yet somehow, some way, we in the aviation business have not put it forward in universal form with persuasive force. It's time we did.

Simple Concept: Possibly we are perplexed by the amount of money and man-hours necessary to produce a plan. Although there are very complex roots to such an undertaking, the basic concept can be very easily expressed. It's as simple as a jigsaw puzzle. The key lies in an obscure article that appeared in the Journal of the Royal Aeronautical Society in May, 1951. It's called "Planning and Aircraft Development", written by F. Olaf Thornton, who was then with the Technical Development Plans Division of the U.K.'s Ministry of Supply. What Thornton did was take statistical data on the percentage of design staffs used during the engineering of a fighter for the RAF. He plotted this against time, in percent, from the start of the project to the first flight of the first aircraft. He then averaged out the irregular lines of the true graphical presentation for a number of fighters, and made up a linearized version as shown in Figure 1.

As Thornton points out, there can be wide variations in this diagram owing to such variables as "the particular design team undertaking the project," and "the inherent complication of the particular design proposed." Still it is accurate enough to illustrate a concept for future planning. This, then, is the key piece for our puzzle.

Since the object of this plan is to keep an constant level of design personnel in Canadian industry, each company must have such a fundamental plan. However, a typical case can be composed by using the diagram of Figure 1, but reducing it to "men" and "years", instead of the previous percentage figures. All you have to do, then, is to fit a number of these key pieces together, as shown in Figure 2, and presto — there is the plan. It is immediately apparent from this plan exactly when a company must start a new aircraft design in order to maintain a constant engineering payroll — which was the object of the exercise. For example, we know from average statistical evidence that it takes a certain number of years to design a modern transport. Say from the start of the design to the first flight of this new airliner is three years. Then from Figure 2, and the fit of the pieces of the jig-saw, the company must commence a new transport design slightly less than every 2½ years.

No End: It is also apparent from Figure 2 that the basic pieces of the puzzle do not fit together exactly. In fact, when you extend out the line of design personnel required after the first flight it tends to go on and on. For no matter how we try, in this aeronautical engineering game, we can never really finish off cleanly with an old design, wrap up all the drawings, and start afresh on a new aircraft. There is always a steady stream of modifications. These tie up a diminishing portion of the engineering organization long after the first flight. The upshot of this tendency is to cause the engineering staff to increase over the years, instead of remaining constant.

I spoke to W. K. Ebel, Vice-President, Engineering for Canadair Ltd., about this. "It is certainly true," he said, "that some work goes on the whole time an aircraft is in service. For example, it's some years now since Canadair manufactured the North Star transport. Yet we still get odd modifications going through Engineering that tie up a small element of the staff. However, you can always go on overtime work for a period, and thus keep your engineering staff at a constant level."

Only those who have worked in the engineering department of an active company can really appreciate the personal necessity for maintaining some consistency to this vital work. For who can work efficiently when it becomes obvious that the company is going down hill with no new project on the horizon? Who will be laid off tomorrow? How will I meet next month's bills? What about the house I bought? Or the new car? Men with thousands of dollars worth of engineering training, and men with invaluable years of practical experience are forced to ask themselves these personal questions. "There are serious effects on the morale of employees bred by an atmosphere of uncertainty," J. G. Notman of Canadair told the Royal Commission, in discussing the necessity for

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are spectacular. They are probably the only movies in existence of an actual mid-air. They are also graphic evidence of the danger involved in the business of bringing to earth in pictures this bright new world of high-altitude. Such incidents also make it interesting to note that the RCAF does not pay its flying photographers any of the risk allowance granted to other airborne tradesmen.

But money is no incentive really. Not in this game. Many photographers want no part of the sport. Others would give their eye-teeth for the opportunity. The opportunity that belongs to the few like Herron and Mackechnie.

CHIPMUNK TRAINING

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tasks. Once the flying phase begins, their existence rapidly becomes the "half-day" life. The excruciating half-day of ground school lectures filled with anticipation of flying for the next half. And the occasional interrupted day-dream:

"You there. Stand up and tell the class what I have been saying for the past ten minutes. I thought not."

Their time and their eventual memories of Centralia revolve around "flights." The hangar-line, and in particular, their own flight room. The briefing booths where they sit with their flying mentor. This is the man with all the answers. Or so it seems when you are young. And learning to fly.

Washed Out Days: And then there there are the duff-weather days. The days when they polish a flight room floor that carries a layer of wax put on by sprog-pilots of World War II. The floor that dusty-footed instructors so unfeelingly walk on. And the rows of glittering windows which are wearing thin under the cleaning rags of cadets joed for extra duties. And the patch of grass outside where they watch a buddy make his first solo circuit.

Over this entire new existence for the flight cadet hangs the big sword called "CT" (Cease Training). They hear it in the first welcome speech when they arrive: "Your syllabus here is in three parts: flying, academic, and officer training. Failure in any one will mean C.T." This fear will remain with them until the day they receive their wings—a day which seems hopelessly far in the future for all of them.

The avowed purpose of the PFTS training on Chipmunks is to weed out those students not suited to flying before they are sent on to the Harvard phases of Flying Training School. "After leaving here, there should be no CT's at FTS." Conversely, many students who would have failed the Harvard course before, are saved. Learning to fly the easier Chipmunk, they are better prepared for the difficulties of coping with the more complex Harvard. Another important consideration is the fact that the cost of operating a Harvard trainer far exceeds the cost of flying a Chipmunk for the same period. In addition, Chipmunk maintenance is cheaper.

The Air Force does not expect the results of this primary training to show before 1958. In the meantime, the thousands of flight cadets and NATO trainees which will go through the system will all start out on Chipmunks. They won't be concerned with the new graphs and charts that will be made on their progress. At least not for a few years. Right now these young men are concerned with two things: getting into the air, and getting through the course.

ENGINEERING JIG SAW

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some stability in the industry. "It becomes more difficult both to attract and retain skilled and scientific personnel."

Planned Program: Surely the least we can do is to sit down and figure out how we can save these priceless personnel by a planned program — clearly decisive and firmly financed. Moreover, it is in the interests of our defence and our own economic expansion. "If we don't do it soon," says Ken Ebel, "we'll end up with a couple of half competent companies in the engineering field, and after that they'll dwindle to nothing. Then when we want them the most, they just won't be there."

So all we have to do is to solve this engineering jig-saw puzzle. With such a straight-forward concept the vital details will soon fall into place. "A plan must come as a part of the organic development of a project," says Brewster Ghiselin in his book *The Creative*

Process. He goes on to add that this plan must be devised "either before the details are determined, which is more convenient, or in the midst of their production, which is sometimes confusing." But in planning our engineering program, unless we do our thinking ahead of time, there will always be confusion. Must we tolerate this turmoil? Lets get on with our plan. this turmoil? Let's get on with our plan.

TWIN PIONEER

(Continued from page 18)

rudders 9.1%, elevators 7.8% of the gross wing area) and, therefore, powerful. They are all fully balanced to make them light, but the elevator has a bungey counter-balance to give it the feel appropriate to an airliner. Apart from the obvious fact that this prevents the airplane being thoughtlessly thrown about at higher speeds, it also, coupled with the airplane's marked stability, prevents speed fluctuations on the approach, since it has the effect of introducing a slight lag in elevator response.

Single-engine flight with one Leonides feathered is simple indeed. The trim changes which occur as the one engine stops and the power of the other is increased can be comfortably held on wheel and pedals, until one has trimmed aileron and rudder to give a straight course and slightly raised "dead" side. Turns either way were perfectly normal and were again done more by the airplane than by me. Letting speed fall off meant more and more rudder to keep straight — all without unpleasant foot load — until Vmca* was reached at about 58 kts. IAS, when she turned gently toward the dead engine with wing and nose going slightly down.

Penalty: This single-engined safety speed is high in relation to the stall and drastically penalizes the slow-flying airplane when airline techniques are used. It means that, when the 1.3 Vmca margin is applied, 75 kts. have to be reached before climbing and also maintained for the approach. This results in the curious brochure performance: unstick, 312 ft. — run to safety speed, 740 ft. — to 50 ft., 1,130 ft.; minimum landing run, 420 ft. — from 50 ft. 1,100 ft. This is due, of course, to the time taken to accelerate (or lose, respectively) the extra 15 kts. above the 20 kts. stall margin climb and approach speeds used by Scottish Aviation pilots.

My own experience of the stalling behavior was impressive. At 60 kts. in landing configuration it required almost full backward stick movement to reach the stall — and it takes quite a time to get there. When it happens, it is preceded by mild, but unmistakable buffeting. In itself, the stall is more of a mush than anything else; the nose nods down, speed builds up and little height is lost — it acts like the best-behaved of post-war light airplanes. Throughout, the controls are fully effective. My further experience of approaching in rough weather at 60 kts. showed that the Twin Pioneer is far less susceptible to speed variation due to gusts than would have been the case with a light airplane — although the IAS was similar.

It all supported the Scottish Aviation contention that there is need for a new approach to flying techniques. It is unfair to penalize the Twin Pioneer by treating it like a stall-and-spin multi-engined airplane. Certainly as far as the approach is concerned, the question of a single-engined overshoot (or undershoot) should never arise with experienced pilots. Little power is used on the approach (none is necessary to maintain lift, since the slats need no slipstream) *and* the pilot is not belting in at 120 kts, he is making a steep, slow-motion arrival.

That, however, is something for the makers, the licensing authorities, and the operators to sort out, I am simply reporting.

Small Circuit: The circuit is much what one would do with a light airplane and has similar proportions. The view of the landing area is, of course, complete at all times and the roof panel gives a comforting outlook to starboard over the top of the wing — or a useful inward view of the circuit if one is going righthanded. The nose-down trim change due to extension of slats and flaps is not great and one trims it out for comfort rather than necessity. Full nose-up trim certainly helps the achievement of a three-pointer, not because the elevator loads are hard to apply, but simply because they do not fade out as speed falls off — probably it is only the bungey one is feeling. Obviously, this point is one due to lack of familiarity with the airplane and it would sort itself out after half-a-dozen landings when one had also become more accustomed to the attitude, for there is little in front of one's face to indicate when the tail is down.

It came in, with a little power, at 60 kts., at which speed it is possible to turn in quite as steeply as any airliner should. The indicated speed remained steady, once trimmed into the glide — even during a Marilyn Monroe approach caused by my having to cope in a strange airplane with a gusty 20 kt. wind at 30 deg. to the runway. At this approach speed a considerable

*Vmca = Speed, minimum control, asymmetric flight.