The Light-Weight Fighter Fantasy

By GROUP CAPTAIN H. R. FOOTTIT

"There is nothing so hidden that we cannot discover it . . ."
—*René Descartes (1637).*

AUGUST 13th, 1935, was a day to be remembered. For on that day, Henri Mignet flew the English Channel. It was not the first cross-Channel flight by any means, but it was the first one made by an unconventional new lightplane, the Pou-du-Ciel, or, in English terminology, the "Flying Flea".

The arrival of Mignet and the Flea touched off a smouldering keg of interest among lightplane enthusiasts. His wheels had barely touched the runway when announcements blared out that at least 20 of the Flying Flea types were under construction in England. The Air League of the British Empire formed a "Pou Club". At least one of these 250 lb., single place, tandem wing planes was built in Canada.

Down and Out: By the end of 1936, however, the Flying Flea flurry had pretty well blown itself out. In the interim it took the lives of 11 pilots, and an untold number barely escaped when the Flea showed an uncontrollable tendency to dive on the approach. The French grounded the Flea. Professor T. R. Loudon of the University of Toronto summed up some wind tunnel tests by saying, "My own conclusion is that the Flea had better be scrapped".

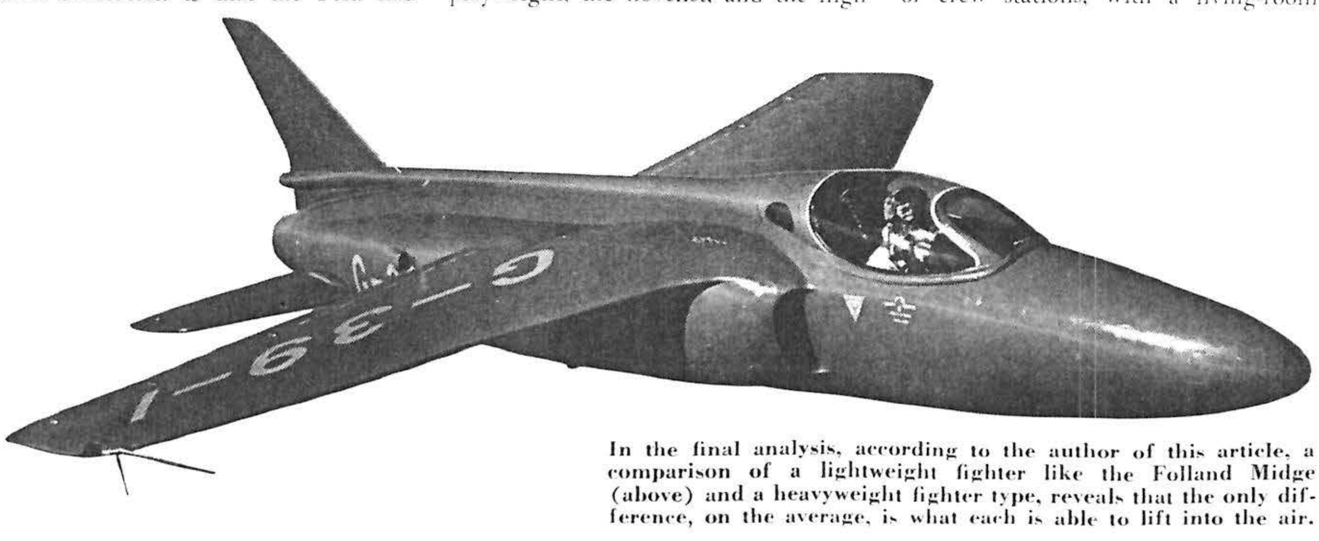
Some 20 years later, the equivalent of the Flea fantasy is now sweeping the military world. Only this time it's the lightweight fighter. In sharp contrast to the Flea, however, today's lightweight fighter is a properly designed flying machine. But the same thread runs through both fabrics. It is the thread of magic. The little Flea had a mystical lure that because it was radically different it must be better. And the lightweight fighter carries wih it this same mysticism, as though some radically new principle of aerodynamics or structures had suddenly been discovered and deeply buried in the design of this new airplane.

Unfortunately this is not true. The same old basic design principles are still with us today, as they were in the days of the Flea. We have advanced the art and science of aeronautical engineering in the relatively slow steps that Carlyle called "the inevitability of gradualness". So a heavy fighter of today's vintage can be compared to the lightweight contender. And when this is done the only difference, *on the average*, is what each is able to lift into the air.

Comparing Extremes: In making this comparison, we must stay with averages. It is a favourite ruse of the playwright, the novelist, and the high pressure salesman to deal in comparisons that tabulate the extremes — the best of one, compared to the worst of another. There is no doubt that there is a scatter to the points on every statistical curve. Airplane designs are no exception. The skill of the designer can make a marked effect on the gross weight. As Robert N. Lindley, Chief Design Engineer for Avro Canada pointed out recently, "There are some 15,000 parts in a modern all-weather interceptor. Save only an ounce on each and you have the best part of 1,000 lbs. as a bonus."

The smart designer saves these ounces, and the resulting pounds, and turns out a lighter and better airplane than his competitor. But even here, there are some limits. There are minimum thicknesses to casting or forging webs, for example. To go thinner than these minimums is to run the risk that the web is improperly made, and therefore will not carry its design load. Similarly aluminum alloy skins have minimum sizes that have proved necessary from a handling viewpoint; and bolts, nuts, cables, instruments, and myriads of other standards cannot be whittled down in size from a manufacturing or usage basis.

On the upper side of this limit is size. If the designer goes all out for crew comfort and designs his cockpit, or crew stations, with a living-room



In the final analysis, according to the author of this article, a comparison of a lightweight fighter like the Folland Midge (above) and a heavyweight fighter type, reveals that the only difference, on the average, is what each is able to lift into the air.

spaciousness, then his airplane will be large — and heavy. Or he may decide to build in more structural strength. Then the pilot will be able to pull more "g" without wrinkling the wing skin. But the designer does this at a cost of increased weight.

The Requirement: Between these limits lies the average, so it is necessary to line up the "mean" heavyweight fighter against the "mean" lightweight. Once this is done the next point to establish is the operational requirement. What must both fighters do, and how far and how fast must they travel? Here again, to make a proper comparison, we must gauge each competitor against a single standard. If the job for the fighter is knocking down the enemy bomber, then we must reduce this to what it takes in armament to complete this mission. If it requires, for example, 50 air-to-air rockets, and a radar gunsight, then both airplanes must carry this equipment. If it is a fighter versus fighter combat that we visualize, then both must hold four 20 mm cannon, and 1,000 rounds of ammunition, or whatever we deem necessary to ensure a kill.

The performance demands, in terms of climb, speed, range, and combat time, must also be the same.

To reduce the airplanes' structure, equipment and performance to averages let's go back to a smoke-filled preliminary design office of some 20 years ago. Here the designers, in laying out the early drawings of a new airplane, used a neat formula for getting out a first estimate of the aircraft's take-off weight. They had found by experience that the load and fuel weight, plus the complete powerplant weight, always added up to about 60% of the gross weight. Twist these terms around and the gross weight formula emerges as shown in Figure 1. The load and and fuel weight is what we usually call "useful load".

This simple formula was based on the averages of the day. Dozens of weight statements of a wide variety of aircraft went in to its build-up. And over 80% of those airplanes which were stripped down for examination fell between the figures of 56% and 64% for the weight of the useful load and power plant, as a percentage of the gross weight.

When we stack up this formula against the operational requirement, it is apparent that it reflects the requirement from the weight side. The job the fighter has to do — fight bombers or knock down fighters — determines the load it must carry. This is the "load" part of the equation. The range specified for the aircraft hinges on its fuel, so this is faithfully represented in the formula. The other performance parameters, particularly the speed, are wound into the powerplant weight. Thus the operational requirement and the weight formula are carefully interwoven.

FORMULA

$$\text{GROSS WEIGHT} = \frac{(\text{POWER PLANT}) + (\text{FUEL}) + (\text{LOAD})}{.60}$$

TERMS

POWER PLANT	FUEL	LOAD
WEIGHT OF:	WEIGHT OF:	WEIGHT OF:
ENGINE	FUEL	CREW
ACCESSORIES	OIL	ARMAMENT
CONTROLS		ELECTRONICS
STARTER SYSTEM		INSTRUMENTS
FUEL SYSTEM		EQUIPMENT
etc.		etc.

FIGURE 1

GROSS WEIGHT ESTIMATE

Mitchell's Spitfire: This useful tool for the preliminary designer was in service in those days when R. J. Mitchell was laying out a fighter at the Supermarine plant in Southampton to meet Air Ministry Specification F36/34. He meticulously took the engine, pilot, armament and equipment and drew the smallest possible outline around them. Though this was still in the day of many biplanes with fixed undercarriages, he insisted on an elliptical cantilever wing and a retractable landing gear. When his creation flew in June, 1936, it was singularly unimpressive. Trouble with the oil system forced the pilot to make a dead stick landing. But several years later it was to spark the imagination of the world. This was the famous Spitfire.

Mitchell's fighter, the Spitfire I, had a gross weight of 5,900 lbs. It was a slightly heavy airplane for its age. The Curtiss Hawk, P-36A, grossed only 5,692 lbs., and the Gloster Gladiator 5,400 lbs. But Mitchell designed the Spitfire so that the weight of the bare airframe structure was 32% of the all-up weight.

This structure weight is the largest single weight factor that remains when we subtract the load, powerplant and fuel weight, in our formula of Figure 1, from the gross weight. Consequently, if this figure remains about the same today as it did in Mitchell's time, then it is the first indication that our formula still holds good.

light vs. heavy

TO CHECK this, let us move to Le Bourget, France. Here, on June 29th, 1953, W. E. W. Petter, Managing Director and Chief Designer of Folland Aircraft of England, addressed the Association Francaise des Ingenieurs et Techniciens de l'Aeronautique. The subject of the talk was "Design for Production", but it was keyed around a comparison between a heavyweight fighter of 16,500 lbs., and a lightweight contender of 5,500 lbs. The lightweight fighter is in the same weight as the Folland "Gnat", the prototype of which, the "Midge" was first seen in the Society of British Aircraft Constructor's show at Farnborough in September, 1954. And the Gnat is the airplane that has heralded so much publicity as a possible NATO purchase for a lightweight fighter-bomber.

In the course of the lecture it developed that the bare structure weight of the light fighter totalled 30% of the gross weight. This, in itself, indicates that, with the Spitfire at 32%, the art of airframe design hasn't altered greatly with the passing of time, though the modern fighter has to withstand greater loads that are associated with its higher performance. Moreover, in direct comparison to our average standard that the power plant, load and fuel should add up to 60% of the gross weight, Petter's lightweight fighter totes up to 58.5%. Which only confirms the fact that the formula of Figure 1 still holds good even in this day of supersonic jets.

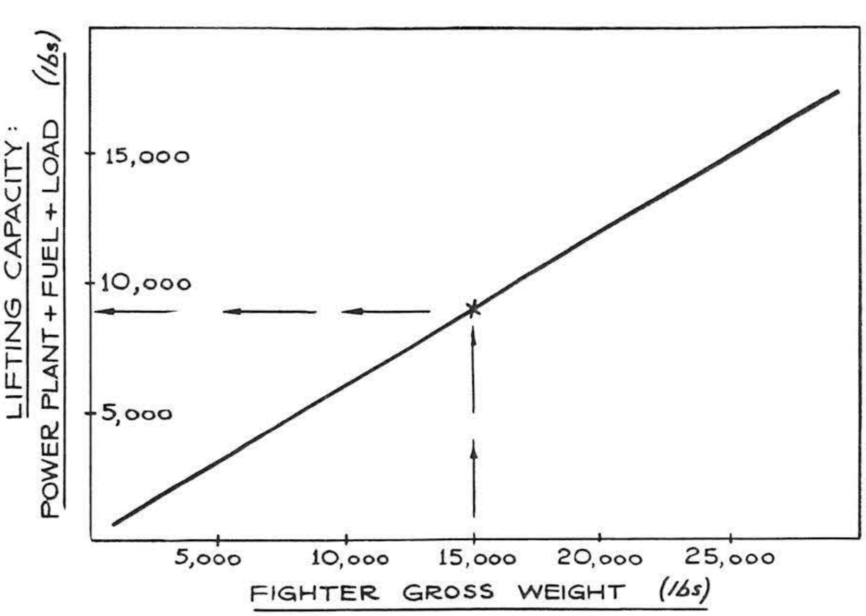


FIGURE 2
LIFTING CAPACITY

True to Form: If you want to sit down and run through some weight breakdowns of modern fighters, you will find that on the average, this is true. If we call the total load, powerplant and fuel weight the "lifting capacity" of the airframe, then Spitfire, Sabre, Canuck, or Gnat, will have a fixed lifting capacity for a fixed airplane gross weight. This capacity is plotted in Figure 2, based on the standard, average, 60% criterion. A 15,000 lb. fighter, for example, has a lifting capacity of 9,000 lbs.

If the weight picture hasn't changed markedly since Mitchell first sketched out his ideas on the Spitfire, what has been achieved in the last 20 years in fighter aircraft design? And how is it that the lightweight fighter can be even thought of, if so static a situation exists as that shown by the weight breakdown? In the first place, the modern airplane engine is comparatively lighter than its counterpart of the '30's. But the demands for increased performance have led to larger engines, which eat up vast quantities of fuel, so that the overall engine-fuel weight situation has not changed greatly, though we get a lot more thrust and performance for each pound of powerplant weight.

On the equipment side the necessity for radar gunsights, air-to-air rockets, fast firing cannons, navigation and landing aids, and all the other components that are vital for tomorrow's war, have multiplied the number of individual items that the modern fighter must carry. These equipments are lighter than ever before. But we have to carry so many more of them that this, too has nullified any advantage that we might have gained from the weapon viewpoint.

Putting on Weight: Today's fighter pilot is even heavier. The old standard of a 180 lb. man with a 20 lb. parachute is no longer applicable. The present day pilot, with such things as his flying clothing, "g" suit, oxygen equipment, headphones, and parachute, usually checks in between the 220 and 230 lb. mark.

While this indicates a certain stagnant situation this is not altogether correct. The key question is "What armament load must the fighter carry to kill the enemy fighter or enemy bomber?" If one designer says a single gun is enough, then his fighter will shrink in size and gross weight, as compared to the designer that thinks in terms of six 20 mm cannons. Similarly with the gun sight, the amount of ammunition, the necessity for a supplementary armament of of rockets or missiles, all these make the fighter smaller, which in turn reduces the engine size, and the fuel, for the same performance.

If the visualized theatre of war operations has only a limited area, such as the United Kingdom as compared to the vast northland of Canada, then the ground radar screen is restricted, and less range and less fuel are required in the fighter. And the result again is a smaller airplane.

Matter of Timing: There is another facet, too, that brings forward the lightweight fighter such as the Folland "Gnat" or the USAF's Lockheed F-104. This is timing. If the design is started on the drawing boards at just the right moment to take advantage of a technological advancement in, say, powerplant design —so that a lighter, higher thrust engine is available and which was simply not in the hardware stage when the heavyweight fighter was started on the boards—then there is an additional bonus.

W. E. W. Petter explained this in his lecture in France, when he came to the conclusion that the light fighter was a more efficient load carrier than the heavy one: "Admittedly, this derives in part from the employment of a more up-to-date or at least specialized engine, which, economics and time will probably prevent from being available in a larger size for the larger fighter."

Thus when the technical timing is right, the lure of a reduced weight fighter will always appear on the aeronautical horizon. And once the designer starts down the lightweight road, the impetus he gives to the equipment manufacturer, the engine manufacturer, the armament manufacturer, and even his own design team, often produces an airplane even better from the weight viewpoint than the average would indicate.

But the average is still the only fair

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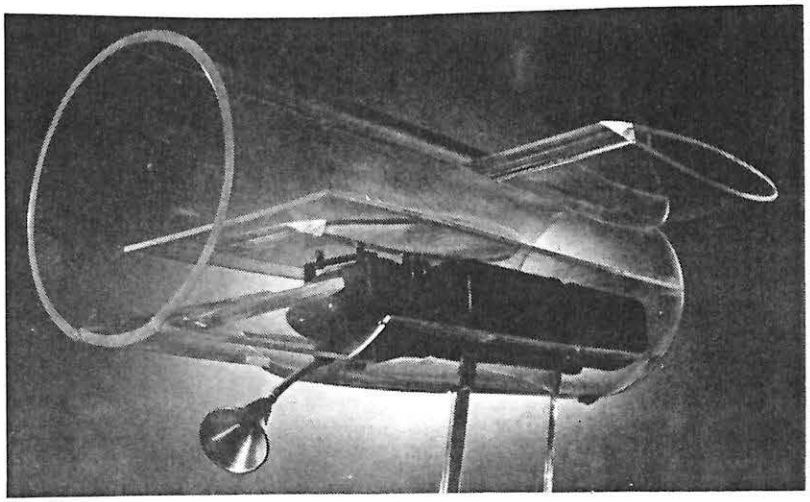

PACKAGE FEEDING: Designed by Flight Refuelling Ltd., Blandford, Dorset, England, this new package-type aerial refueller unit can be installed in an appropriate aircraft in little more than 30 mins. This pack unit is the latest development in the probe and drogue system of flight refuelling. It combines the hose reel from which the drogue is trailed and the fuel supply tanks in a single unit, thus eliminating the need to draw from the tanker's own fuel supply for the refuelling operation. The unit is self-contained, and may be regarded as auxiliary equipment, so no special modifications to aircraft are required for installation.

brochures will be forthcoming sooner, due to the advanced information.

Proper administration of this plan can and will result in a substantial saving in cost, but perhaps more important, it produces aircraft in quantity approximately *two years ahead of other known methods* and thus makes available more nearly up to date equipment in order that we may always stay ahead in the armament race. Variations of this theory are now in use in the United States. An article in "Aviation Week" of April 12, 1954, outlines briefly the current thinking of the United States Air Force along these lines. The article states that the Boeing B-52, the North American F-100, the Convair F-102, McDonnel F-101, Douglas C-133 and Lockheed C-130 are all being produced under modifications of this program.

The content of what I have said is a summary of the thinking that has been taking place at A. V. Roe Canada Ltd. Our reasons for concern in this matter are patriotic as well as selfish. We feel that we have an obligation to Canada and to all free countries, to keep abreast of anything that is possible in other countries, friendly as well as unfriendly, and we are definitely obligated to our Company and to ourselves to produce as economically as possible.

It is indeed unfortunate that so much of our thoughts and efforts must be directed toward protecting ourselves against aggression. It is our fervent prayer that this situation will be changed as soon as possible, and that we can then concentrate on the peacetime development of our country.

SENIOR OFFICER

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World War II present special circumstances and must be considered on their individual merits. Moreover, during the rapid expansion of the RCAF, it has not been possible, in many cases, to give even non-veterans the ideal training and employment specified by the plan. Nonetheless, it is intended that, when the approved manning ceiling is reached, the plan will be followed.

Promotion: The general principles of the RCAF's promotion policy are designed to ensure that:

- Only those officers who are suitable in all respects are promoted to higher rank.
- Officers of outstanding ability are granted due recognition by being promoted ahead of officers more senior but with significantly less ability and potential.
- The opportunity to progress at a reasonable rate to a reasonable level is given to the great body of average officers—on whom, of course, the general efficiency of the Service is largely dependent.

With the above principles in mind, a Central Promotion Board, consisting of the Senior Personnel Staff Officers of all Commands, convenes semi-annually with personnel officers at AFHQ to consider the promotion all officers eligible by virtue of minimum seniority. This Board reviews the officers' confidential files, which contain confidential personal assessments, promotion narratives, course reports, qualifying examination reports, and recapitulation of Service experience. The limitations of each of these sources of information are generally appreciated, but they are being reduced by constant research and, more important, by education of officers with respect to their responsibility in assessing and counselling officers under their commond.

The Central Promotion Board reviews the reports of Unit Promotion Boards' and Command Headquarters' remarks. These, taken in conjunction with the file study, are used to categorize officers finally recommended for promotion as "Very Suitable" or "Suitable." Candidates within each group are then listed in order to relative seniority, and are recommended for promotion to a Senior AFHQ Board, composed of officers whose rank is at least two levels above that of the officers being considered.

LIGHTWEIGHT FIGHTER

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comparison if we are judging lightweights versus heavyweights. And, as we have seen, there is no magic in the comparison. So we can say, with one of the fathers of modern science, Rene Descartes, "There is nothing so hidden that we cannot discover it, provided only we abstain from accepting the false for the true, and always preserve in our thoughts the order necessary for the deduction of one truth from another."

TCA VISCOUNT

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a quality necessary for the low temperature operation of turbine engines, would have to be specially refined from imported crude oils. As a result, JP-4 is one to four cents per gallon cheaper than kerosene and will enable the Canadian air line to save some $190,000 yearly in fuel costs in its Viscount operations, as well as avoiding certain low temperature operating problems.