Future V/STOL Combat Aircraft

B. P. Laight of HSA discusses design and operating techniques

After nine years of intensive development the Hawker Siddeley Harrier V/STOL close-support/reconnaissance fighter will enter service with the RAF next spring. This successful conclusion to the proving of the vectored-thrust concept will give battlefield commanders a new flexible weapon for the early 1970s. It will also provide the world’s air forces with an opportunity of developing their own capabilities with this new type of aircraft.

And this is just the beginning. With the wide acceptance of the vulnerability of concrete runways, this is the start of the military V/STOL jet era, both for land-based and seaborne aircraft.

Quite apart from obvious further developments (warload/range) inherent in the Harrier design, Hawker Siddeley Aviation has made a deep study aimed at making the maximum use of the total thrust available from present jet engines to achieve short take-off and vertical or short landings from surfaces of opportunity. This new work is aimed not only at providing jet V/STOL aircraft supersonic capability, but also at widening the roles of the new-generation aircraft. It cannot be doubted that these techniques are being studied in Europe with reference to the proposed international combat aircraft.

In charge of such studies at Hawker Siddeley Aviation is Mr B. P. Laight, MSC CEng, AMPht, MEng, FRAeS, executive director and chief engineer, and he recently lectured on the subject to the International Council of the Aeronautical Sciences in Munich. His paper, Future Developments of V/STOL Combat Aircraft, is reproduced here in part.

Before useful statements can be made about what form future aeroplanes might take [said the lecturer] it is first necessary to consider what the operational requirements may be for future developments of this class of aeroplane.

One principal duty is combat support for ground forces, or strike sorties behind areas of combat. For both of these functions the flight is likely to be carried out at subsonic speed at low altitudes so as to avoid radar detection and interception. However because in the future there will be fewer types of aircraft in each air force, reconnaissance and search, support capability are thought necessary and these requirements can lead to the need for the type also to be supersonic. The size of such an aeroplane is broadly determined by the load to be carried and the radius of action required, together with other requirements such as manoeuvrability and the general level to which the aeroplane is equipped. Size is quite vital to the cost of the aeroplane and therefore important in any particular design, but I want to discuss rather the design principles for this class of aeroplane, in particular the application of V/STOL.

Coming to the question of field length, there is no doubt that serious consideration has been given on a world-wide scale to getting away from aerodromes. The V/STOL aeroplane of course offers the ultimate flexibility but while the technical feasibility of the supersonic V/STOL aircraft can be accepted the decision is lacking yet for it to appear as a production aeroplane, doubtless because of concern so far over the economics of the type.

The best so far achieved for supersonic production aircraft in respect of airfield requirements is to improve on the conventional aeroplane by the use of high-lift wings together with high thrust for take-off, and reverse thrust for landing. The approach in fact is the most critical manoeuvre for a STOL aeroplane and the best figures so far declared are approach speeds in the region of 160kts with a roll of about 1,500ft. From an operational point of view, interest lies in the question as to what overall field length should be provided for safe operation of an aeroplane such as this. Clearly this could vary with the military situation, and risks could be taken for small numbers of operations. But a major air force operating in combat conditions would be carrying out enough sorties for the statistical level of the risk to make itself felt. Appropriate safety allowances would have to be made for variations in the accuracy of the approach. It is necessary to consider the effects of weather and perhaps night operations. Such limited studies that exist on the effect of these variables suggest that the field length would need to be at least twice the ground roll. This gives a field length certainly very much less than that of the military V/STOL jet era, both for land-based and seaborne aircraft.

The V/STOL aeroplane, when used for short take-off and landing, is inherently capable of doing better than this, and can with lighter loads give progressively shorter runs down to zero distance in the vertical mode. Achievement of this capability has of course to be kept in mind at the design stage which, in practical terms, means providing enough wing area so that significant amounts of extra weight can be lifted at moderate forward speed. It is, however, not necessary to provide more wing area than will probably be needed in any case for a combat aircraft to provide adequate manoeuvring capability.

It is of interest to note that the conventional aeroplane has to do some thrust-vectoring if it is to stop in a short distance when landing. If the thrust can be turned through 180° to stop the aeroplane it is of interest to consider what could be achieved if it was first turned 90° and used to support some of the weight in the landing approach. The weight of the equipment to do this, additional to what is already provided in the aeroplane, is likely to be similar to the weight of typical high-lift devices.

This argument is illustrated in Fig 1, which shows at the top the landing conditions when using aerodynamic lift only and, below that, the conditions if thrust is used to support part of the weight. If all other factors were equal the ground run would be reduced in the second case in proportion to the reduction of lift on the wings. In fact lift coefficients may not be so high for the aeroplanes using engine lift but for this aeroplane to lose all the benefit it would require the conventional aeroplane to have a lift coefficient 2.5 times as great (for the figures shown) and this is far more than will occur in practice. This simple analysis demonstrates that the engine can be an extremely powerful high-lift device and this is borne out in practice by the fact that the Harrier when operated in STOL modes can demonstrate ground rolling distances much shorter than STOL aircraft which do not use engine lift.

If engine thrust is used, in the way discussed, only to achieve STOL it does not give the full operational flexibility of the V/STOL aeroplane. It is therefore of interest to consider how much extra thrust this class of aeroplane may need beyond what is required for in flight use, to provide the vertical mode of operation. Strictly this can only be answered within the context of stating how much load is to be carried