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COPY of ORIG. LETTER FROM BOB COLLINGBOURN IN 1993 of HIS RE-ASSESMENT of PROJECT "Y" (40YRS LATER

OCT/1997 VIA Les W.

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4 pages

Dear Les,

Avro Canada Project 'Y'

Thank you for your letter dated 23 July, with which you enclosed the 1952 Project Y brochure, also for your recent 'phone call. I am sorry I have not replied earlier; as I told you, I have been rather preoccupied with my wife's developing disability, which required her hospitalisation for two weeks in mid-October. She now finds walking very difficult, even with sticks and my help, so we are having to think seriously about wheelchairs and other aids to keep her reasonably mobile.

I have therefore only quite recently got round to fulfilling my earlier promise to study the Project Y' brochure in the hope that renewed acquaintance might jog my memory of the original preliminary assessment I did at RAE. You say my Tech Memo was dated 1953 but I feel sure we first saw a brochure in 1952 and did an assessment in that year, which is the date on the document itself. I'm pretty sure that the copy you sent me is identical with the one we assessed. The evaluation took some time, I seem to remember, because we agonised over some aspects and there were differences of opinion. Our understanding of supersonic performance was rather incomplete at that date. Although, on rereading the brochure a lot of the detail came back to me, I'm afraid I cannot remember our precise comments of 1952.

Be that as it may, I have done my very best to reassess - over 40 years on - at least some key aspects of the project and I guess these would be broadly in accord with RAE views in 1952. This has involved many hours of work over the last week or two (I do not have access to a computer so all calculations have had to be done on a simple calculator) so I beg you not to ask for any more (apart from details of what I have already done, if you need them).

Drag at High Speeds

My estimates of drag in level flight at the tropopause (height 36,090 ft) are as follows, assuming a weight of 25000 lb and that the intake runs full at all speeds (ie no spillage or pre-entry drag)

3500 lb	at	Mach 0.9	(firm's figure 3000 lb)
10,250 lb	at	Mach 1.1	(" " 5250 lb)
10,750 lb	at	Mach 1.4	(" " 6000 lb)
12 500 lb	at	Mach 2.0	(" " 10,000 lb)

The brochure gives no background to the firm's drag estimates. Mine above are based, for Mach 1.1 and 1.4 especially, on theoretical and experimental data not available until the late 1950s. Nevertheless I seem to remember that in 1952 also we thought the firm's supersonic drag estimates were too low, although I cannot recall precise details. I'm afraid I do not have time to evaluate the effects of my higher drag estimates on high speed performance but obviously they would be appreciable.

Engine Aspects

The 1952/3 comments on the power plant design and performance were made by NGTE Pyestock (Peter Ashwood mainly) and I cannot recall any details now. However, after studying the design again in recent weeks I have the following comments which I feel sure would have been made by Peter Ashwood 40 years ago. I have assumed that the firm's estimates in respect of the basic performance of the engine as a gas generator are OK.

i) Would the relatively massive rotating machinery (compressor and turbine rings) be stiff enough to resist adequately the huge gyroscopic forces and moments generated during aircraft pitching and rolling manoeuvres without significant strain deflections, with consequent clearance variation, possible leakages and even rubbing and hence danger of ~~fire~~?

ii) Nowhere in the illustrations of the power plant are any propelling nozzles to be found. As shown, there is a system of 15 pairs of ducts of rectangular cross section linking the radial turbine exit flow with the final jet exits in the wing tips and trailing edge, but these ducts are stated to be of constant cross-section area and no means of causing the high pressure turbine efflux to accelerate from subsonic to supersonic speeds – necessary to propel the aircraft – are to be found anywhere! Clearly, although not shown or explicitly allowed for in the weight breakdown, there would have to be a series of 30 variable geometry, convergent-divergent nozzles to serve this purpose, one for each duct. They could, in principle at least be located in one of two places:–

Either a) at the turbine ends of the exhaust ducts, in which case the flow in the ducts would be supersonic but at roughly ambient pressure,

or b) at the wing tips/trailing edges ends of the exhaust ducts in which case the duct flow would be subsonic but at a very high pressure, particularly at high forward speeds.

I have made a rough assessment of the first of these two options and find that the pressure losses in the ducts would be so high, particularly on account of the large turning angles involved in the ducts dealing with flow through the forward half of the power plant, that the gross thrust would be reduced by at least a quarter and consequently the aircraft would barely exceed Mach 1 in level flight.

Therefore I have considered seriously only the second option and have estimated that the gross thrust losses, due both to friction and duct curvature and also to deflection of the nozzles from the line of flight would be acceptable and fairly similar to those quoted by Avro Canada. The theoretical maximum speed at the tropopause seems to be about Mach 2 in this case, notwithstanding the higher drag I have assumed. However, a major problem, as I see it, which arises with subsonic exhaust duct flow is that the pressure in the ducts would be so high as to be unmanageable, having regard to their almost flat upper and lower surfaces, with any conceivable lightweight structure. We are talking here about internal pressures at the tropopause of around 5 atmospheres at Mach 0.9 flight speed increasing to around 26 atmospheres at Mach 2, – a pressure difference, between the duct and the outer wing surfaces, at the latter speed of about 12000 lb/ft^2 What kind of structure for a surface having hardly any curvature, could stand such a pressure difference? The brochure implies that the 'shallow cone' compressor covers could be designed to withstand 23000 lb/ft^2 working pressure difference but no reference is made to the flatter duct covers. In either case, I do not believe these surfaces could be designed to withstand such pressure differences for acceptable weight.

Stability, Control, Manoeuvrability

Relatively little attention is given in the brochure to the effect of the huge engine gyroscopic couples on the manoeuvrability of the aircraft. It might be stable in level flight but if the aim is to produce a combat aircraft, my guess is that its manoeuvrability would be poor even with fly-by-wire black box assistance. Fighter aircraft nowadays are designed to be aerodynamically unstable in pitch and neutral about other axes to improve response to pilot demand for manoeuvres Too much stability is not a desirable quality in a combat aircraft.

Notwithstanding the gyroscopic stability in the pitch and roll planes, my guess is that a fin and rudder would be essential for yaw stability – leading to higher weight and drag which I have not allowed for above.

Other Miscellaneous Comments.

I have not looked in detail at the weight breakdown. As already noted above, I am certain the structure and system weights have been grossly underestimated

A pitot intake is hardly appropriate for an aircraft aimed at achieving a flight speed of Mach 2 but this is perhaps an unfair criticism in view of the design date. Pitot intakes are very inefficient for speeds above, say, Mach 1·3.

One final point – is it really a good design philosophy to have airframe and power plant so inextricably integrated? In modern aircraft if an engine develops a fault the whole unit can be removed and another engine substituted in a few hours. With Project X such a logistic advantage would be completely absent.

Kind regards and best wishes for a safe and comfortable trip home (in a high aspect ratio, subsonic aircraft with ~~a~~ removeable, high pressure ratio, high bypass engines!)

Bob Collingbourne.