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(U) Project 1794 Evaluation

RDZSBA WCLSD-2 1Aug56

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1. In reply to the DF of 10 July 1956, the following comments are submitted. The project has been reviewed from the standpoints of design potential and technical feasibility. (UNCLASSIFIED)

2. The L/D of a circular planform wing at supersonic speeds would not be expected to be as good as a properly designed swept wing. Wind tunnel tests of the wing alone at MIT (AVRO Report 22) show this to be the case with L/D max (wing alone) being in the order of 7. A properly designed swept wing should be higher, theoretically about 10, for an aspect ratio of 3.5 with the same C_{D_0}. Based on the MIT supersonic wind tunnel tests, with and without airflow simulation, the overall AVRO design shows a maximum L/D value (untrimmed) of 6.3. This value was obtained by making extensive assumptions and corrections to the wind tunnel data. The procedures used are open to considerable doubt, particularly as concerns momentum and base drags. This will be discussed in more detail under the internal flow comments. Trim drag for this design at supersonic speeds should be low compared to conventional arrangements since the aerodynamic center nearly coincides with the center of gravity at the geometrical center of the airplane. Values of trimmed L/D max for current supersonic designs at the same Mach number (M = 2) are in the order of 3.5 to 4.5 Assuming that the zero lift drag measurements were as much as 100% in error because of questionable assumptions and data reduction procedures, the max L/D for the AVRO design would still be 4.5. It is concluded, therefore, that the L/D max of the 1794 configuration should be at least equal to that of the best conventional designs. Apparently, although the circular wing itself is not as good as the conventional wing alone, the additional drag items such as fuselage, tail surfaces, etc. are sufficiently detrimental to conventional designs to reduce the L/D max to less than 1/2 of the wing alone values whereas the 1794 design does not suffer as badly with the addition of only the inlet islands. It should be noted that because of the low wing loading inherent with this type of design that the high L/D can be obtained only at very high altitudes. Subsonic L/D has not been evaluated but would undoubtedly be very poor compared to conventional arrangements due to the low aspect ratio ($\frac{4}{\pi}$). (SECRET)

3. Specific Fuel Consumption values of approximately 2.5 at 35,000 ft and M = 2.0 have been estimated for this design. These values are slightly higher than for current afterburning engines and offer no potential in this area. The higher values are due mainly to lower tailpipe temperatures and should be roughly comparable to conventional engines at the same exhaust temperature. (CONFIDENTIAL)

4. The manner in which the engine is arranged in this vehicle is such that a large percentage of the internal volume is used for the engine. With the horizontal fan arrangement, large engine mass flows can be handled for less frontal area than

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required for conventional ducted fan engines. The structural unit wing weight is estimated to be some 20% lower than conventional wings because of the circular arrangement and distributed weight. The result is that thrust/weight ratio should be very high compared to normal arrangements. It is felt that this factor is the one outstanding advantage that this design has as a supersonic vehicle and should permit much better altitude capability than is possible with normal designs. Contractor's performance estimates (unvalidated) indicate ceilings of over 85,000 ft. at M = 2.0. With the crude nature of data available, a quantitative performance evaluation is not possible. The altitude capability, however, appears to be in right order of magnitude. (SECRET)

5. The large thrust/weight ratio permits VTOL capability. The ground cushion effect wherein lift is actually greater than thrust has been demonstrated on a model basis and is considered realistic. (UNCLASSIFIED)

6. The AVRO design, although sound in concept from a mechanics standpoint, poses some rather severe development problems and requires that certain currently accepted design principles be revised. The two major development problems (aside from the propulsion unit which is not treated here) are expected to be the artificial stability and control and the internal flow systems. (SECRET)

a. Conventional design practice to date has not accepted the complete artificial stability concept for man carrying vehicles. Assuming, however, that this change in philosophy is acceptable, it is envisioned that a major effort will be required on stability to satisfy the entire flight regime. It must be recognized that detail problems may evolve during development that cannot be solved in a practical manner.

b. The large nose-down moments produced during transition with positive lift ($J_e = 1.0$) are shown in Figure F-4 of AVRO Technical Report Nr. 12, volume 2. Note that a more complete discussion of the hovering to transition control problem is contained in the Performance Summary Report ID Nr. 56RDZ-19713, under take-off and landing procedures. However, the performance is described only for the type of transitional control used during the test. In the review of reports to date, no discussion of the "hysteresis" in the pitching moments and lift for the hovering condition has been found. It seems that a statement on the control during the beginning of transition should be made. The basic data presented by the contractor in support of the control analysis appears to be correct when spot checked against similar data computed by the Aircraft Laboratory.

c. Because of the aircraft's dependence on power for stability and control, should a complete power failure or exhaustion of fuel occur, it would be impossible to make a forced landing. Whether sufficient controllability would exist, even with ram air at high forward speeds, to enable the pilot to establish favorable ejection conditions is questionable.

d. A major factor in the performance capability of this design is the efficiency of the internal flow system - inlet, diffuser, jet exit and the external drag considerations associated with these items. Although AVRO Report 22 indicates a fairly optimistic picture of the internal flow considerations, detail examination of the data raises several questions.

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(1) The determination of the inlet ram drag is in question because of the rather severe pressure distributions at the measuring station during some of the runs. Reverse flow in one of the inlets is also a possibility for some of the runs. Errors in inlet mass flow cause errors in the aircraft drag.

(2) Although no data are presented to show the inlet capture area ratio, it appears that the maximum capture area ratio of the tests is considerably below the estimated value. The accuracy of the inlet spillage drag is therefore in question.

(3) It is not understood how the jet thrust values were measured during the actual tunnel test. Apparently they were obtained by differences in drags with and without external airflow. This method might yield considerable error.

(4) The intake pressure recovery curve shown in the reports is misleading since;

(a) The measuring station is well ahead of the engine face.

(b) Not all the tube readings were included.

(c) The data appeared to be presented for no mass flow going through the inlet.

Whether or not the internal flow problems can be solved in a reasonable manner cannot be definitely ascertained at this time. Considerable detail testing will be required particularly as regards inlet pressure recovery and losses in the labyrinth type diffuser. Here again, as in the case for stability and control, detail problems may arise that cannot be solved in a practical manner, even though the fundamental concept is sound.

7. The success of the Project 1794 configuration is dependant to a large extent upon its relative aerodynamic cleanliness. Addition of any protuberance or external stores would be expected to have large detrimental effects on the supersonic L/D. No consideration has been given to armament, equipment, or external fuel capacity as yet. If these items must be carried externally because of the limited available internal volume, performance potential would suffer. Downward visibility, with the present arrangement, is poor and a periscope will probably be necessary. (SECRET)

8. The weights and volume for a fire control system are taken from a document dated 13 July 1956, outlining the results of a study effort by Hughes Aircraft Company and the Ramo - Wooldridge Corporation to estimate the requirements imposed on an interceptor aircraft in the 1960 - 1965 time period. The study indicated that the component weight would be 2055 lbs and the volume required is 41 cubic feet. Of this amount, about 8 cubic feet of radar components, as well as a 40" diameter antenna dish must be located in the front of the aircraft. The weights

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and volumes given here are for the fire control system alone. Additional space must be provided for the missiles, unless they are to be carried externally. For an external installation, it is estimated that the additional weight (including 2 missiles) will be about 1500 lbs. Thus the weight of the basic aircraft + fire control system + missiles is nearly 32,000 lbs. In addition to the weight penalty imposed on the aircraft, there will be a substantial reduction in maximum velocity and combat ceiling due to these components which, because of the limited internal volume, must somehow be carried externally on the present configuration. Installation of only that equipment necessary to make a day fighter of the aircraft would increase the gross weight by about 1200 lbs including ammunition. This armament is the same as that found on the F-104A. Since a large percentage of this equipment can be carried internally, the performance degradation will not be so great. (SECRET)

9. Although the landing gear is not mentioned in any of the contractor's reports, it is believed that there will be no problem. In view of the VTOL and non-taxi requirements of the system, it is anticipated that compact, lightweight landing gear can be employed. However, ground handling requirements must not be overlooked. (UNCLASSIFIED)

10. It is strongly recommended that an analysis of the configuration be conducted at elevated temperatures. The problem area is the outer portion of the wing which contains the afterburners. When the afterburner temperature approaches 1200° K (1700° F), the durability of the exhaust deflecting vanes and the ability to change their position may pose a rather difficult problem. (SECRET)

11. At present, no information is available on the flutter or vibration characteristics of a configuration such as this aircraft. It is believed that considerable vibration may result as a consequence of the complex propulsion system duct configurations. Because of the large thrust output of the engine, noise induced vibrations are an important factor also. It is suggested that: (SECRET)

a. The contractor develop an adequate procedure to conduct a rational theoretical flutter analysis on the aircraft or develop a method by which the configuration could be adequately scaled in a dynamically similar model to be tested in a wind tunnel.

b. A special program be initiated to study the vibration aspects of the aircraft, including vibrations which may be excited as a consequence of the complex propulsion system duct configurations.

c. The contractor investigate in detail;

(1) The single degree-of-freedom flutter of the shutter vanes

(2) Panel flutter.

(3) The effect of heating (both internal and external) on the aircraft's structural rigidities and the resultant effect on aeroelastic characteristics.

12. Since the noise produced will probably be very high, a noise investigation should be carried on during the early planning stages to eliminate costly changes later. If the noise level in the aircraft is high enough, it may cause structural failure, equipment malfunction, and be injurious to the occupants. It is therefore recommended that noise estimates be made and steps be taken to qualify the structure and equipment for reliable operation. Also steps should be taken to insure that the cockpit noise level is within the requirements set forth in Part A, Chapter 5, Section 7.1 of HIAD, 10th Edition revised up to and including 1 April 1956. (SECRET)

13. The data supplied as weight substantiation is insufficient to check the overall validity of the structural weights for the Project 1794 aircraft. Based on membrane analysis (Foppl and Hency) the skin stresses would be approximately 50,000 psi. At an operating temperature of 1200° F, the 300 series stainless steels have a stress for rupture at 100 hours of 28,000 psi. For an assumed skin thickness of .043, the operating stress would be 27,000 psi; therefore, it appears that a minimum of .043 inch steel skins would be required in the outer wing. This results in an outer wing weight which is 1200 lbs heavier than the contractor's estimate. The inner wing weight was found to be slightly less than the contractor's estimate. As time did not permit further weight investigation, the other weights must be accepted. Thus, the aircraft structure will probably be 1100 lbs more than that given in the reports. Since the outer wing life is limited to less than 100 hours, even this weight may be unconservative; however, it should be adequate for the research aircraft. (SECRET)

14. The center of gravity of this aircraft will not be in the center of the circular planform (except in level unaccelerated flight) because of the shift of the fuel center of gravity. This effect can be reduced, but not eliminated by baffling. It is recommended that the contractor investigate the effects on the C.G. shift due to fuel shifting. (SECRET)

15. Although Project 1794 shows considerable potential as a supersonic high altitude vehicle, there are many problems which must be solved before a practical vehicle can be obtained. The major questionable development areas are stability and control and internal flow. Also the addition of equipment necessary to make a weapons system of the aircraft will tend to degrade its performance to that of conventional aircraft. The combined high speed, high altitude and VTOL capability gives this aircraft a potential which no other known aircraft possesses; however, there are many difficult problems which must be solved before such an aircraft can be developed. If these problems ever can be satisfactorly solved, the aircraft may not have the performance capability which the contractor proposes. For a weapons system, it is doubtful if the aircraft possesses any great advantage over conventional aircraft other than the VTOL capability. (SECRET)

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16. This DF is classified SECRET because it contains performance and design information associated with Project 1794 which is classified SECRET. (UNCLASSIFIED)

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