# PROJECT 'Y'

A note on the feasibility of vertical take-off and landing techniques, from a preliminary estimate of the transient response to "throttle" control.

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## 1. Introduction

This note presents further estimates of the behaviour of the Project 'Y' design, in vertical flight close to the ground.

The importance of exploiting the greater-than-one S.L. thrust weight ratio of this design and achieving direct vertical take-off and landing as a safe practical operation needs no emphasis.

Preliminary estimates of transient response contained in a 'Report on acceleration and starting performance', (by Donald L. Mordell, November 1, 1952) have been used in compiling the graphs in this note.

## 2. New Undercarriage Layout

An alternative undercarriage arrangement to that first proposed in the Project 'Y' statement dated July, 1952 (See Fig. 1) is now suggested. This is illustrated by the sketch on Fig. 1 of this note. It will be noticed that the aircraft appears different in planform: this is due to an improved final nozzle arrangement.

Sooner or later the straight up and down technique will have to be acquired and it is thought that a direct attack on the problem is as likely to be acceptable to pilots as the previous half-and half solution proposed; whereby techniques could range from fully vertical to conventional flying off and on.

This two-wheel long-travel undercarriage is now suitable for fully vertical descent. It provides better structural attachment and removes the wheel situated between the hot exhaust gases on the previous scheme.

## 3. Rotation of Seat

An additional fairing under the wing for the second wheel leads to an agreeable total symmetry about the horizontal (flying) plane. It is now proposed to provide for rotation of the pilot's seat through a large angle so that take-off and landing can be accomplished sitting upright. The view forwards and downwards through the under canopy should be an improvement. (See Figure 5, p.17 for an impression of the previous scheme). The transparent canopy behind and also the view sideways behind the top surface of the wing should be a considerable assistance in a vertical altitude.

## 4. Take-Off

The variation of thrust with time, accelerating the engine at the maximum rate, is given on Fig. 2. It is pointed out in the 'Report on acceleration and starting performance' that acceleration is very rapid compared to what could be expected from a geometrical scale-up (p.3). This is presumably due in part to the moment arm of the turbine as compared with the radius of gyration of the rotor being much larger than usual.

4. Take-Off (continued)

Fig. 3 depicts a possible take-off flight path. Significant help in the time and fuel economy of this manoeuvre is obtained by the elimination of the actual take-off run and by the fact that height and speed is being gained before the engine has reached max. rpm and fuel consumption. In practice it will probably be the rule to level off somewhere about 1000 ft. and accelerate in level flight at this altitude.

5. Landing

Fig. 2 shows that at thrusts upward of 20,000 lb., which is the approximate minimum landing weight, the rate of increase is very good. Thus with the engine being used to support the aircraft it is well into the regime for rapid acceleration.

Fig. 4 gives an indication of the margin available to a pilot during a vertical landing manoeuvre. For simplicity the extra thrust available immediately upon opening the throttle i.e. the thrust resulting from increase of temperature at constant rpm has been neglected. This may be of the order of 500 lb. The resulting picture is, therefore, somewhat conservative. To place the initial vertical descent speed in perspective a typical value for a transport aeroplane during a final approach is easily evaluated. An approach angle of 5° and a landing speed of 80 knots is a rate of descent of nearly 12 ft./sec.

Fig. 3 indicates that the 50 ft. point could be passed at 21 ft./sec. and it would still be possible to destroy this rate of descent at the ground. In practice of course this actual procedure would lead to bouncing up again. This graph thus gives only an indication of the margins available.

6. Conclusion

It appears that a completely vertical take-off and landing procedure will not be particularly difficult. For landing the desirable rate of approach to the ground and the way to manipulate the throttle control for a soft landing can be learned with a large margin of thrust rapidly available against misjudgement.