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Revised Estimate for North American Eagle Land Speed Record Attempt

By Wayne Olson

This is an update to my previous memo on this subject. I obtained from Frank Brown at Edwards some J-79-GE-10/17 thrust data. The following is my reproduction of that data for altitudes sea level, 5,000 and 10,000 feet. Note that there is some sort of cutback at the high end. The source of this data was McDonnell Douglas Report MDC A1158, July 1971. Even though the data is for use with an F-4E, I figured if this same dash number engine were used in an F-104 one should get pretty close to the same thrust.

Postscript: After I completed this evaluation, I took a second set of thrust data provided by Lockheed for the F-104 to check the validity of my thrust modeling I used here. The Lockheed data was for altitudes of 0, 2000, 4000 and 6,000 feet and Mach numbers from 0 to 0.4. Also, they had temperature variations so I could check the temperature effect I used. The temperature variation turned out to be completely different than what I used here. Therefore, I decided that the model I used here would only be useful for standard day.

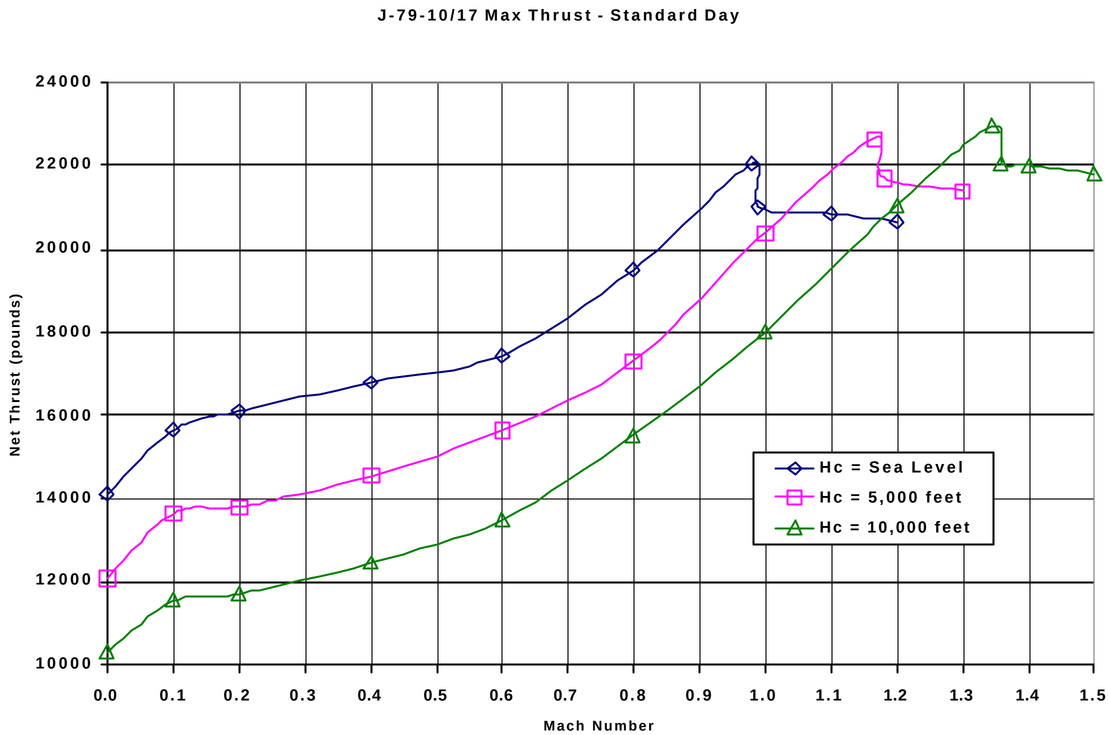

Figure 1 J-79-GE-10/17 Thrust

Next, I wanted to derive a model that would be valid for standard day and also non-standard temperatures. A parameter relationship that worked well for the F-16 was as follows:

$$\left(\frac{F_n}{d_{t2}}\right)\cdot\sqrt{q} = f\left(q_{t2}\right)$$

And that functional relationship was two straight line segments.

So, I thought I'd compute and plot those parameters. I deleted the data below Mach number of 0.2 and also deleted the cutback data.

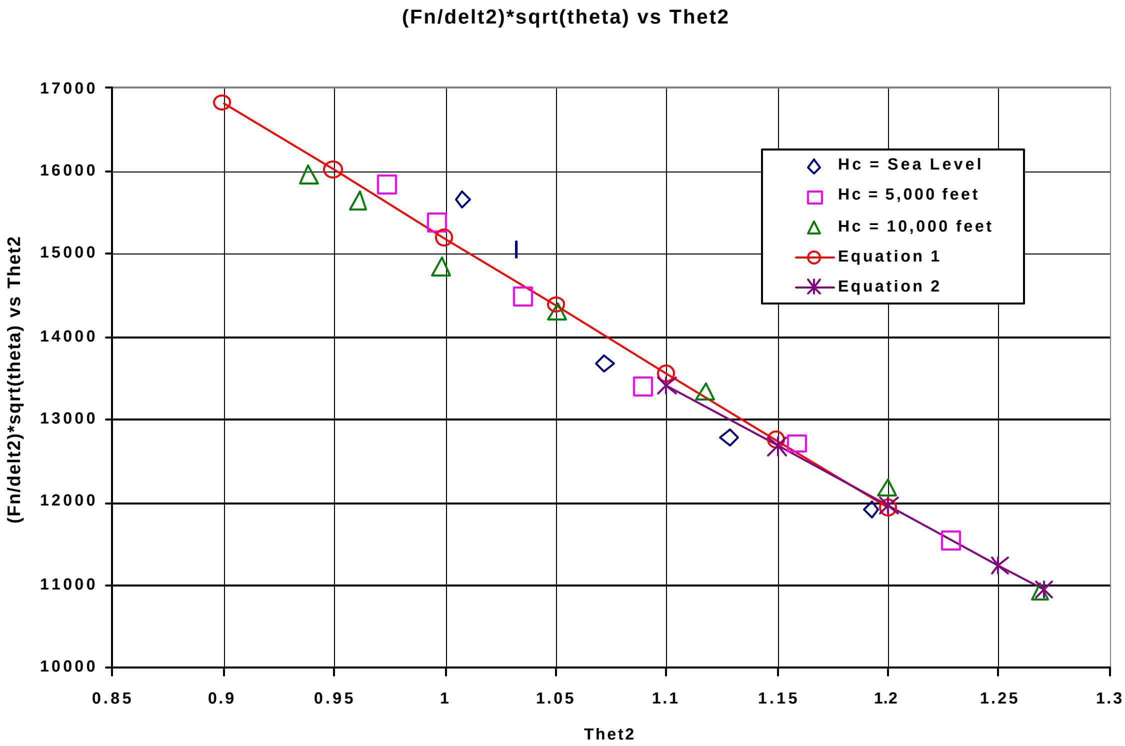

Figure 2 Referred Thrust Parameter versus total temperature ratio (below cutoff)

Not perfect, but not too bad. The $1-s$ standard deviation is 267 pounds, which is 1.9% of the mean value of the thrust parameter. In the event the speed exceed the cutoff, we also need to model the thrust above the cutoff and have a model of where the cutoff occurs. I assumed a simple Mach versus altitude for the cutoff point.

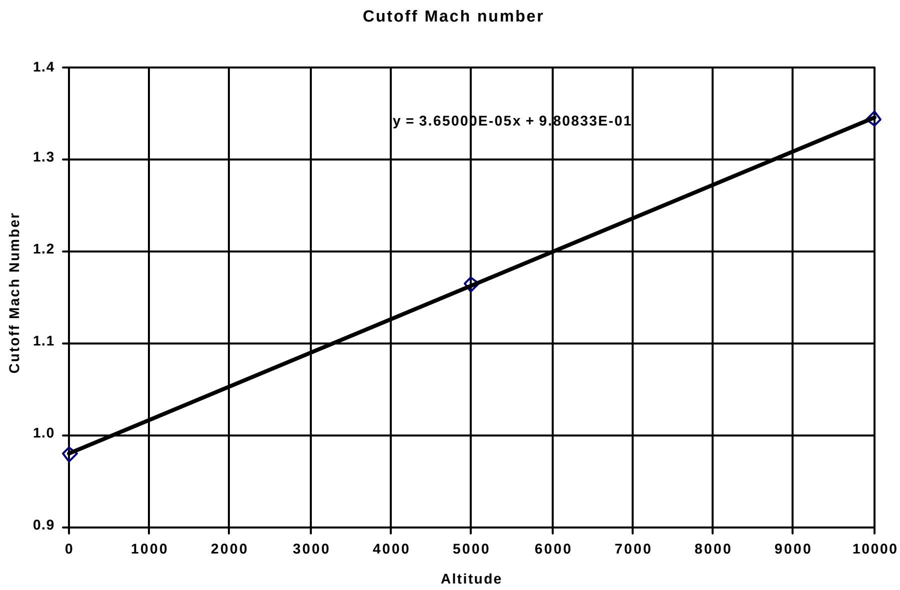

Figure 3 Thrust Cutback Mach Number

The equations 1 and 2 in Figure 2 are as follows:

$$\left(\frac{F_n}{d_{t2}}\right)\cdot\sqrt{q} = 31501 - 16305 \cdot q_{t2} \;\; for\, q_{t2} < 1.18 \qquad (1)$$

$$\left(\frac{F_n}{d_{t2}}\right)\cdot\sqrt{q} = 29374 - 14509 \cdot q_{t2} \;\; for\, q_{t2} \geq 1.18 \qquad (2)$$

Now, the taking the data in Figure 1 above the Mach cutoff point produces the following.

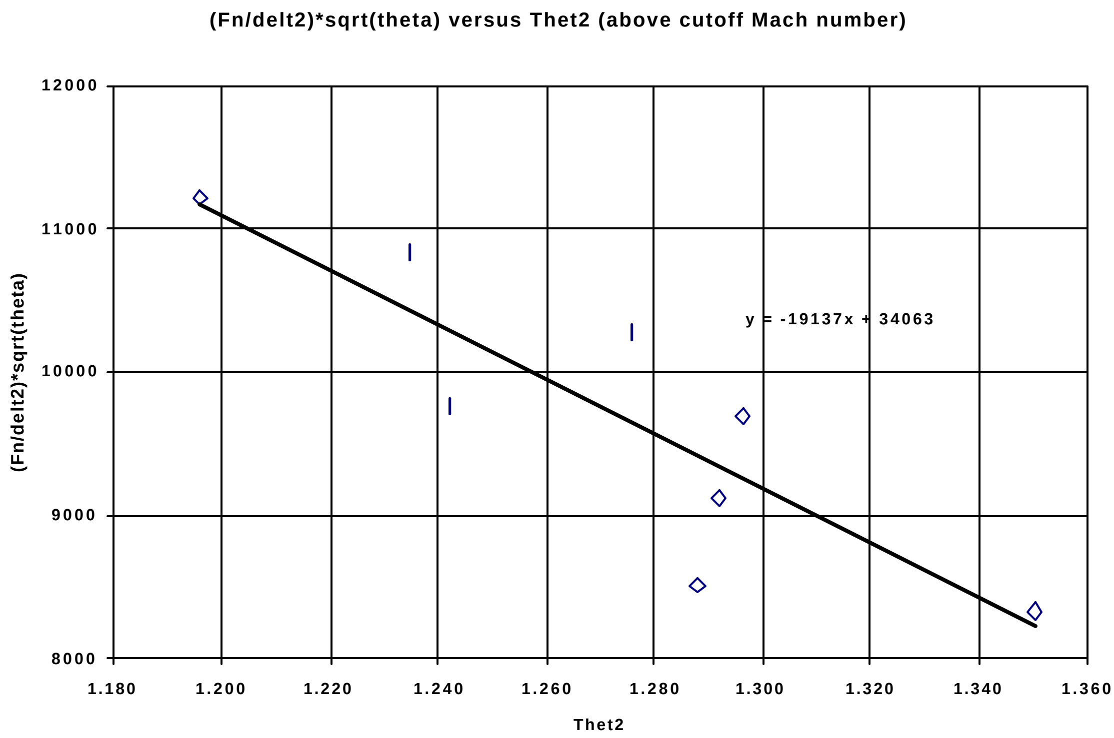

Figure 4 Referred Thrust parameter versus total temperature ratio (above Mach cutoff)

Admittedly, this didn't model quite as well. However, it turns out that only the very highest speed points are affected. Only a small error in our results will occur. Here is the resulting distance versus ground speed. I used a start gross weight of 10,500 pounds and assumed a simple fuel flow model of a thrust specific fuel consumption of 2.50.

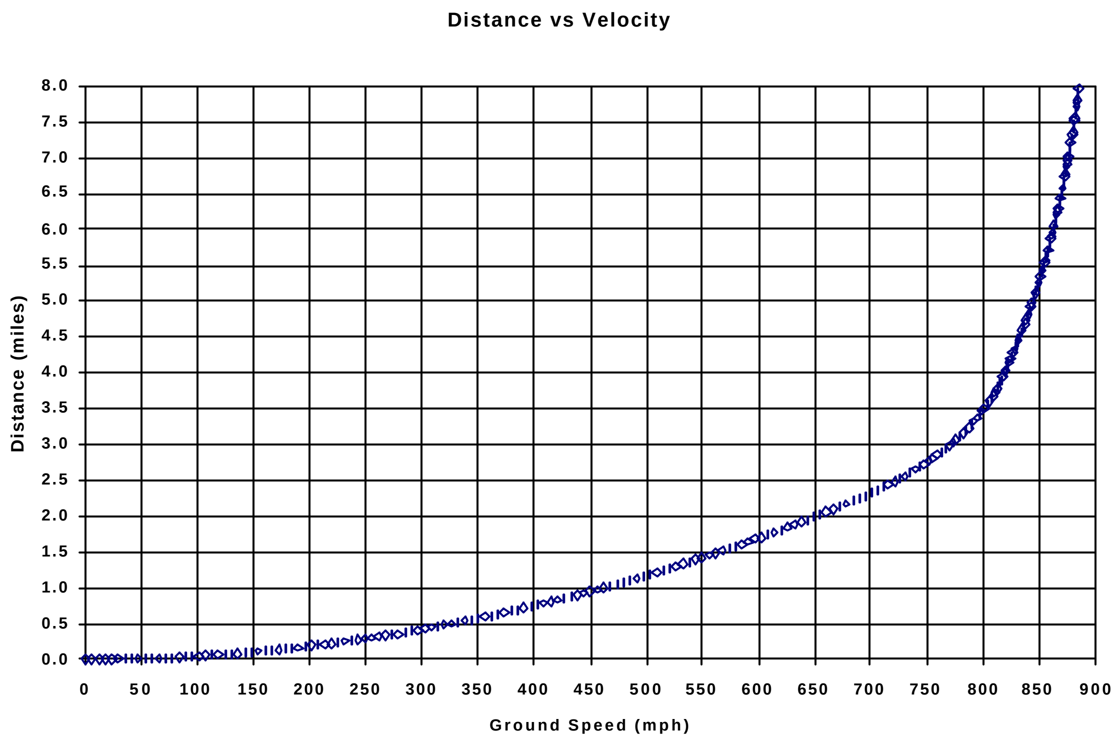

Figure 5 Distance versus Ground Speed

As one can observe above, we reach our goal speed of 800 knots right at 3.5 miles. This is about ½of the length of the longest Edwards lake bed runway. This corresponds to a Mach number of 1.058 for Edwards (2,300 feet), standard day (50.8 °F).

Finally, Figure 6 illustrates the forces versus Mach number. The rolling resistance force is not shown. I assumed zero lift and a coefficient of friction of 0.015, so the friction force was about 150 pounds. Notice the step decrease in thrust and excess at about 1.06 Mach number due to the engine cutback. Also, I assumed a very simple drag model with a linear change in drag coefficient beginning at 0.90 Mach number. Figure 7 shows the drag model I used. The drag calculation is based upon a reference area of 196.1 feet^2 : the wing area of the F-104. Also, I revised the drag based upon F-104 thrust data of 17,900 pounds at 910 mph as a basis for computing supersonic drag coefficient. I used a new thrust value of 19,300 pounds (at 910 mph, SL, M = 1.196) provided by Lockheed. This compares to about 20,600 pounds from Figure 1, which is the thrust I used for this analysis. That is just over 6%.

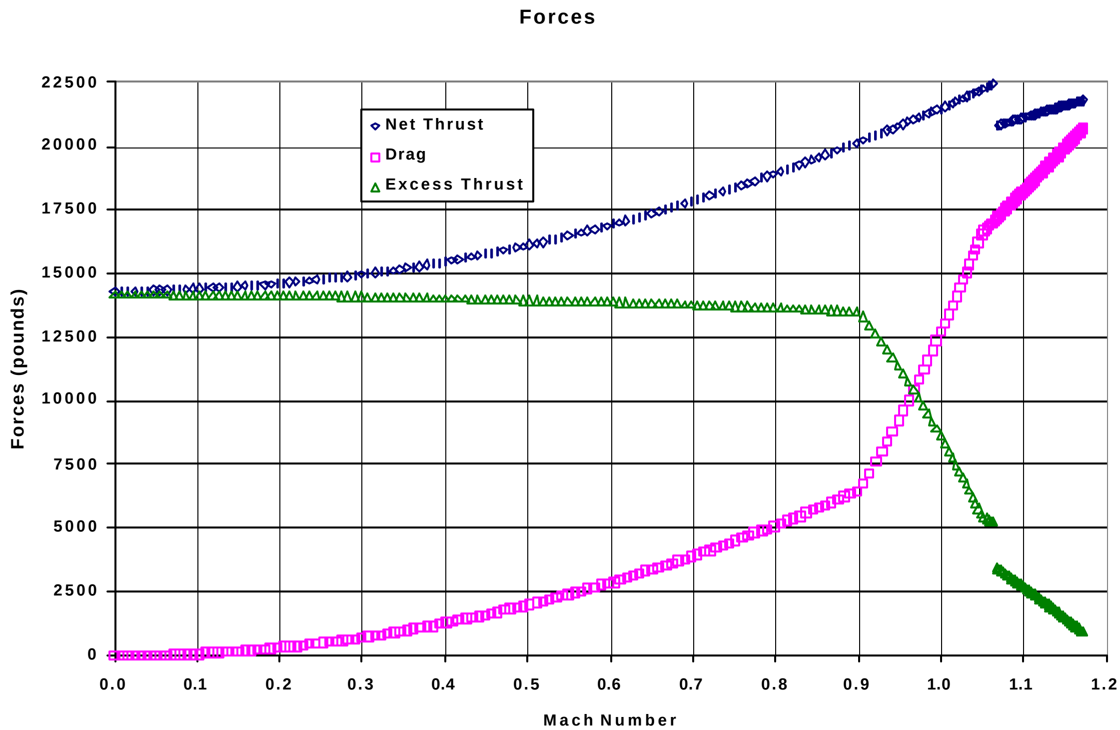

Figure 6 Forces

There was also a runway resistance term included in the acceleration calculation based upon a rolling coefficient of friction of 0.015, which produces a resistance of 150 pounds at a weight of 10,000 pounds, since I assumed zero lift.

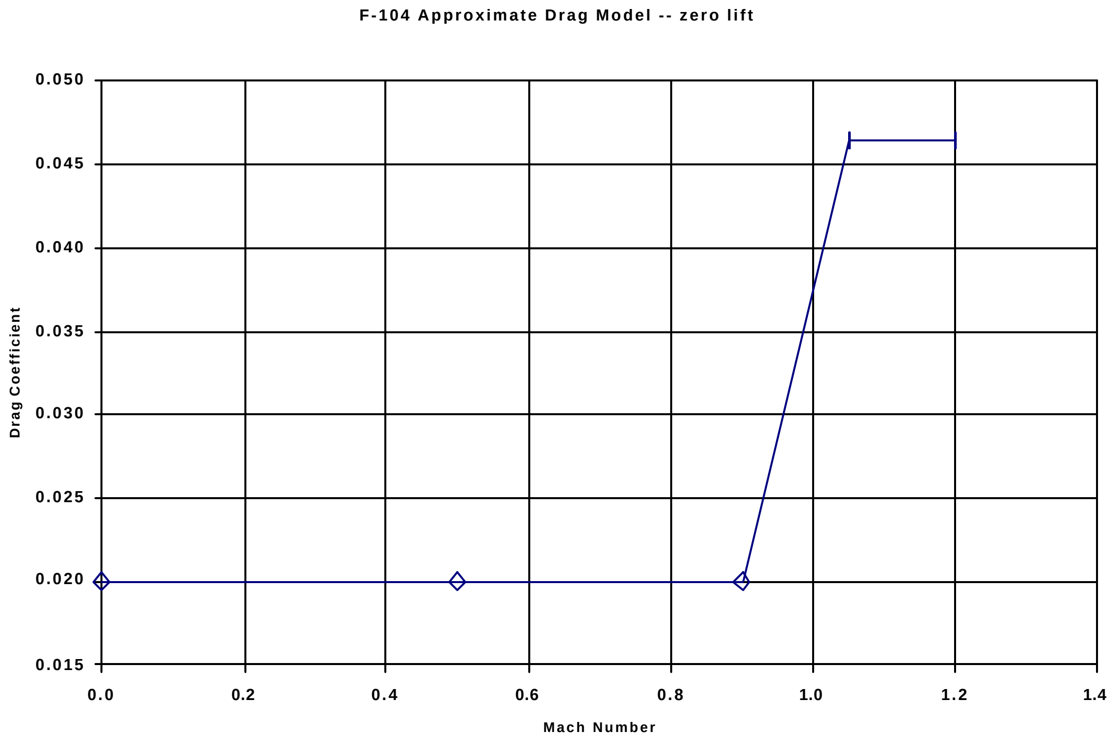

Figure 7 Drag Coefficient

The drag coefficient used to compute drag for this memo was that in Figure 7 plus 0.0100 to account for drag of the wheel structure.