

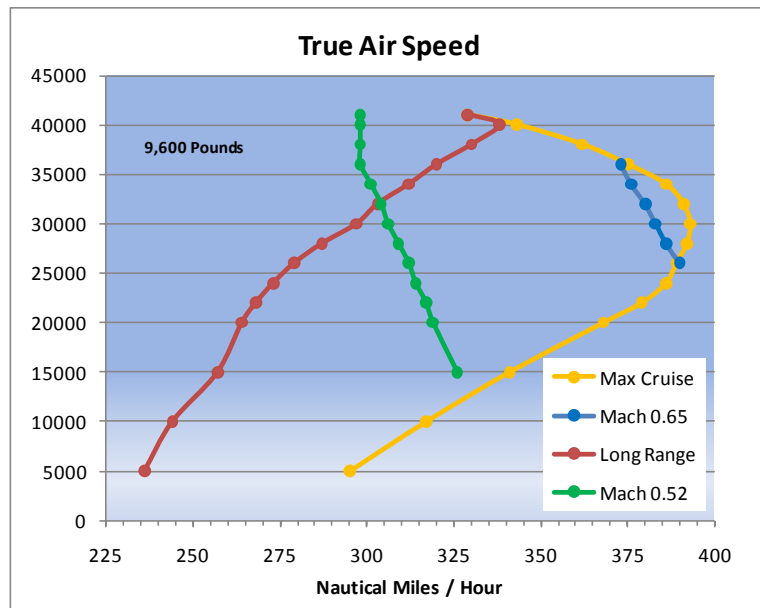
# Phenom 100: Optimizing Speed, Range and Cost

*Provided for educational purposes only. Not to be used for flight planning.*

The Phenom 100 Pilot Operating Handbook has several dozen pages documenting power settings for various speed and range scenarios: Max Cruise, Long Range, Mach 0.65 and Mach 0.52. These are documented at ISA for various altitudes and aircraft weights. It's a lot of data. Most pilots though either want to go as fast as possible, as far as possible, or as cheaply as possible. What's the simplest way of doing this?

## Go as Fast as Possible

Simple. Fly at the Max Cruise setting for all altitudes, weights and winds. Actually, as the chart below clearly shows, there is an optimal altitude for maximizing True Air Speed -- FL300. At that altitude you'll cruise at 390 knots at full gross weight increasing to 401 knots at 7,600 pounds as you burn off fuel. So the airplane actually is faster than its published 390 knot maximum speed for weights below full gross. This is over 100 knots faster than the Long Range power setting which *decreases* from 303 knots at full gross to 267 knots at 7,600 pounds.



What about winds aloft? As you can see from the chart, True Air Speed doesn't change much between Flight Levels 240 and 340. So within these Flight Levels fly at the best altitude for winds to maximize ground speed. However, True Air Speed decreases rapidly above FL340 dropping down to 329 knots at FL410, a 60 knot decrease. So if you truly want to go as fast as possible, there needs to be a significant tailwind advantage to justify climbing to the upper Flight Levels.

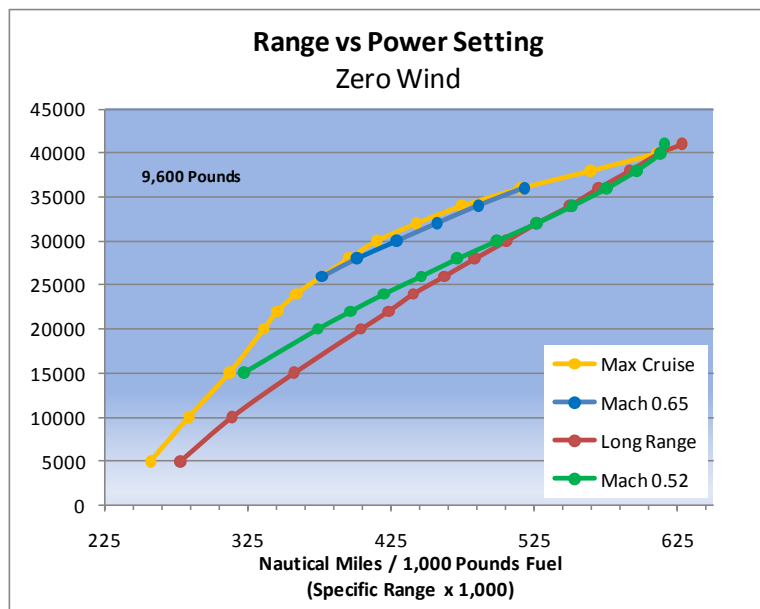
Of course, there's a penalty to be paid for trying to keep up with the airliners, fuel flow. At a mid-cruise weight of 9,600 pounds and FL300 a Max Cruise power setting consumes 948 pounds per hour compared to 588 pounds per hour at Long Range cruise. This is detrimental to both range and trip cost. For example, at FL 300 1,000 pounds of fuel will take you 505 nm at Long Range cruise, but only 415 nm at Max Cruise. Where did these numbers come from? They are each power setting's Specific Range multiplied by 1,000. And what is

Specific Range? It's True Air Speed divided by Total Fuel Flow, or a measure of how far a pound of fuel will propel the airplane. Multiply the Specific Range by the weight of a gallon of fuel and you get Nautical Miles per Gallon, about 2.8 NM/Gallon for Max Cruise at FL300. Long Range cruise would be about 3.4 NM/Gallon under the same conditions.

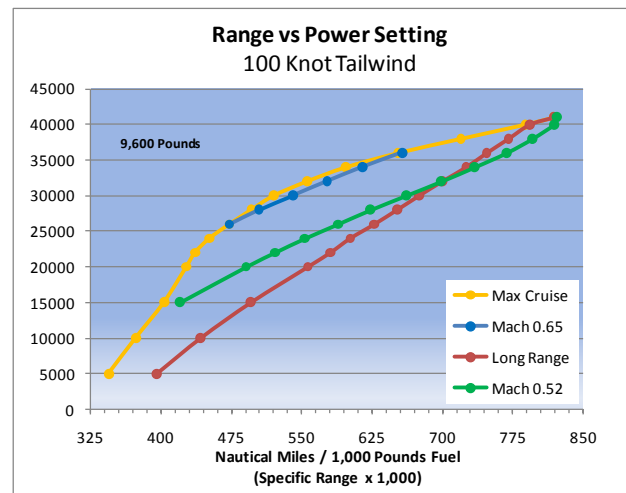
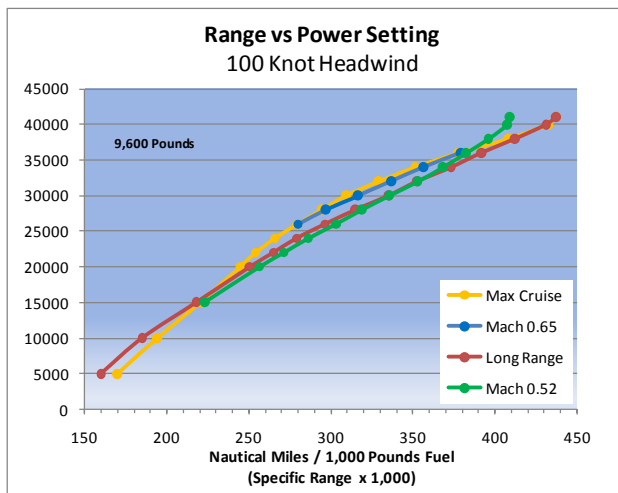
If you want to get there fast, fly Max Cruise at FL300.

### Go as Far as Possible

The Long Range power setting provides the best range, and economy, for almost all situations. As the chart below shows, range increases nearly linearly with altitude; approximately 2.3 percent for every additional 1,000 feet of altitude; climbing to FL410 from FL310 increases range by nearly a quarter. So as we all know get high and stay high as long as possible.



How do winds affect selecting the best power setting for maximum range? Not very much. Consider the two charts below for 100 knot head and tail winds.



In both cases, Long Range cruise provides the best range except for two altitude extremes. Theoretically, Max Cruise delivers more range when flying into 100 knot or more headwinds below 15,000 feet. But how often does that happen? More realistically, with strong tailwinds slowing down to Mach 0.52 between Flight Levels 340 and 400 adds a little range, but it hardly seems worth the trouble.

Note how headwinds compress the range curves and tailwinds stretch them. So if you're flying into *strong* headwinds you only pay a small range penalty for flying at Max Cruise -- and you travel much faster over the ground. A 100 knot headwind at FL300, for example, would slow your ground speed to 197 knots at Long Range cruise, but only 293 knots at Max Cruise. Remember though, you need to be facing headwinds of nearly 100 knots or more for this to make sense. It's not like piston planes for which flying faster into any headwind usually is more efficient. Jets are different.

Also, during descent, as you level off at intermediate altitudes, don't nurse fuel flow by pulling power back too much. If you're interested in maximizing range (and Fuel on Board after landing) fly at the Long Range power setting. At 10,000 feet, for example, you'll burn around 730 pounds per hour. Indicated Air Speed will only be about 200 knots, well under the 250 knot speed restriction below 10,000 feet, but that's the most efficient fuel flow for that altitude. (Increasing fuel flow to about 950 pounds would increase IAS to about 245 knots.)

### Go as Cheaply as Possible

To answer this, let's consider two scenarios: 1) an owner/pilot who keeps his aircraft indefinitely and isn't concerned about the aircraft's value depreciation, and 2) a charter operator which pays pilots by the hour and sells the aircraft after a few years so is sensitive to the aircraft's book value. Assume the Owner/Pilot's costs for airframe and engine maintenance plus miscellaneous other expenses are \$600 per hour. The Charter Operator pays this plus another \$600 per hour for pilot time and the airframe's value depreciation for a total of \$1,200 per hour. Below are the costs for cruising 500 nautical miles for several scenarios.

### Total Variable Costs to Cruise 500 Nautical Miles

Variable Cost per Hour Not Including Fuel:

Owner/Pilot: \$600 per Hour // Charter Operator: \$1,200 per Hour.

Max Cruise at FL 3000 // Long Range at FL410

	Owner/Pilot		Charter	
	MaxCruise	Long Range	MaxCruise	Long Range
Hours	1.27	1.52	1.27	1.52
Fuel Pounds	1,206	796	1,206	796
Hourly Variable Cost	\$ 763	\$ 912	\$ 1,527	\$ 1,824
\$ 2.00 per Gallon	360	238	360	238
Total	\$ 1,123	\$ 1,150	\$ 1,887	\$ 2,061
\$ 3.00 per Gallon	540	357	540	357
Total	\$ 1,303	\$ 1,268	\$ 2,067	\$ 2,180
\$ 4.00 per Gallon	720	475	720	475
Total	\$ 1,483	\$ 1,387	\$ 2,247	\$ 2,299
\$ 5.00 per Gallon	900	594	900	594
Total	\$ 1,663	\$ 1,506	\$ 2,427	\$ 2,418
\$ 6.00 per Gallon	1,080	713	1,080	713
Total	\$ 1,843	\$ 1,625	\$ 2,607	\$ 2,537
\$ 7.00 per Gallon	1,260	832	1,260	832
Total	\$ 2,023	\$ 1,744	\$ 2,787	\$ 2,656

As you can see from the spreadsheet, it's almost always cheaper for the Owner/Pilot to fly Long Range cruise. The crossover point is somewhere between \$2.00 and \$3.00 per gallon (\$2.42 actually), but who's paying that for fuel these days? The Charter Operator, with a higher variable cost per hour, does better to minimize flight time by flying Max Cruise at FL300. Here the crossover point is between \$4.00 and \$5.00 per gallon. Since most Charter Operators are presumably paying less than this, flying as fast as possible makes the most economic sense; and their customers arrive sooner.

### Rules to Fly By

Well, all this has been quite a bit of work to get some pretty simple, common-sense answers. We can summarize everything into a few basic rules to fly by:

- To go as fast as possible, fly Max Cruise at FL300.
- To go as far as possible, fly Long Range cruise at FL410.
- At intermediate altitudes, don't nurse fuel flow. Flying the appropriate cruise setting for your weight and altitude will maximize speed or range, as required.
- To fly as cheaply as possible, fly Max Cruise at FL300 if your hourly variable costs are high otherwise fly Long Range cruise at FL410 if your hourly costs are low.

Simple as they are, these rules work the majority of the time, the primary exception being head and tail winds exceeding 100 knots; slow down when you're high and speed up when you're low.

### Haven't had enough?

For a truly comprehensive discussion of jet aircraft performance and fuel economy, see the two Airbus papers available on JetBrief.com at:

[http://www.jetbrief.com/library/getting\\_to\\_grips\\_with\\_aircraft\\_performance.pdf](http://www.jetbrief.com/library/getting_to_grips_with_aircraft_performance.pdf)

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Together, they total 296 pages. Corrections and contributions to this and other papers are welcome. Visit

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Fly safely.

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