Capabilities of Turbocharging

By Bill Compton, Eagle River, Alaska

Bill Compton is a 10,000-hour ATP and CFI who has lived in Alaska for 40 years, including two years in the Arctic. He is co-owner of a Bonanza V35TC.

My son and I have operated a 1966 Bonanza V35TC for 4,500 hours. The '60s vintage turbo system transforms the Bonanza into a very capable aircraft. Comparison of the 1966 Bonanza V35 and V35TC in Figure 1 comes from their respective POHs. It helps one appreciate the capabilities and advantages of turbocharging. We have tip tanks and do some long range trips, so we're especially interested in range performance (nautical air miles/gallon).

	V35				V35TC			
	ias	tas	ff	nam/g	ias	tas	ff	nam/g
					111	174	11.8	14.7
28000					122	192	13.7	14
					118	172	11.8	14.6
					129	189	13.7	13.8
24000					137	200	15.7	12.7
					104	142	10.0	14.2
					124	169	11.8	14.3
					135	184	13.7	13.4
20000					142	195	15.7	12.4
					130	166	11.8	14.1
					140	179	13.7	13.1
16000					148	189	15.7	12
					135	162	11.8	13.7
					145	174	13.7	12.7
12000	110	142	9.7	14.6	154	184	15.7	11.7
					149	168	13.7	12.3
8000	150	169	13.35	12.7	158	178	15.7	11.3
4000	163	172	15.3	11.2	162	172	15.7	10.9
SL	165	165	15.3	10.8	166	166	15.7	10.6

Figure 1: Speeds, fuel flows & range comparison of the 1966 V35 & V35TC, 3,400 pounds, standard conditions. Mixture "Lean." Data from POHs.

Normally aspirated (NA) numbers are 75% power or maximum available for altitude.

Turbocharged numbers (TC) are 75% power at 15.7gph, 65% at 13.7, and 55% at 11.8, 45% at 10.

Ff is gph. TC engine has reduced compression ratio and is not intercooled.

The Obvious

- True airspeed (TAS) increases with altitude.
- Indicated airspeed (IAS) decreases with altitude.
- Range is a function of IAS—not altitude.
- Normal aspiration (NA) is more efficient at low altitudes, turbocharging (TC) more so above 8,000 feet.
- TC doubles the available airspace.

Turbocharging and an oxygen system involve additional expense and weight. Whether it is worth depends on your operations, but it boils down to higher speed and more altitude capability, including climb rate. Oxygen is a minor bother, with conserving cannulas.

Range Performance

Most efficient flight is achieved with minimum drag. That's at Vbr, best range speed, the IAS where induced and parasite drags are equal.

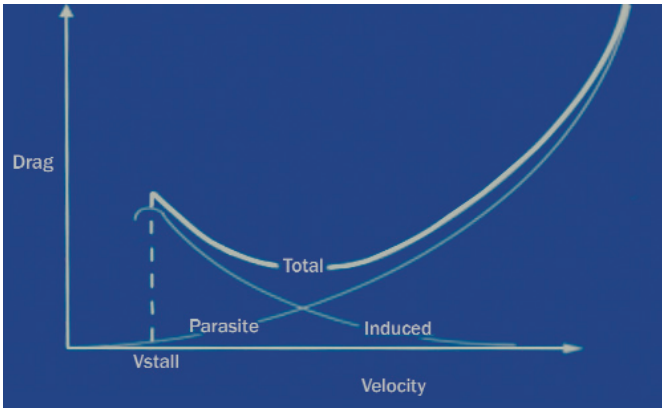

Figure 2: Indicated airspeed vs drag.

An IAS slower or faster than Vbr increases total drag and decreases range. On the Bonanza, Vbr seems somewhere in the 110-115 KIAS area at 3,400 pounds.

With altitude constant, adding power for more speed decreases range by raising IAS further above Vbr. But a higher altitude can reduce IAS and bring it closer to Vbr, increasing range while also increasing TAS. So, higher can mean faster, without a range penalty.

At 20,000 feet, 45 percent power was included because it shows IAS dropping to 104 KIAS, and range falling, because IAS is below Vbr.

TC Economy

Everyone once knew that turbocharged engines run hot, go through cylinders, and have lesser TBOs. But times have changed. Operating on the lean side of peak EGT is practical with tuned fuel injectors. LOP operations result in cleaner engines, lower cylinder head temperatures and lower peak combustion pressures. Some operators have had prolonged service life with TC engines run LOP. Fuel savings are significant. LOP operators can get power with lower fuel flow than the factory numbers in Figure 1.

The transition from ROP to LOP operations causes about a 10 percent power loss, easily compensated with an increase of manifold pressure. That extra boost is available with the TC engine beyond 14,000 feet, but the NA engine operating full throttle at 7,000 feet has nothing left to give, and the flight must slow down if going LOP. So turbocharging expands the use of LOP operations, and LOP operations protect the TC engine.

Safety

The ability to climb out of icing into clear skies or colder air can be a huge asset. A normally aspirated aircraft at 12,000 feet with a little ice has minimal climb ability, where the turbo aircraft has the advantage. Also, choosing an altitude 4 or 5,000 feet above the freezing level becomes a more practical tool for icing avoidance.

Over mountains or at night, single engine, it's reassuring to know the engine has been operated in a manner that keeps it clean, cool and healthy. Cruising at higher altitudes with direct routing simplifies planning and operations, reducing fatigue. Setting power, LOP, it's just about fuel flow: more simplification.

The Competition

There is nothing like a Bonanza, but the turbo adds a lot. I feel the V35TC was a dog before LOP operations, but it does very well with tuned fuel injectors. Newer 36TCs seem to have problems operating LOP, and they commonly have high fuel flows and short cylinder life. The intercooled turbo aftermarket conversions, especially with the Continental 550, are wonderful airplanes, but in a much higher price range.

If the V35TC were not available, as much as I love Bonanzas, I would be in the market for a Cessna T210. (I'd just avoid looking at it.) But if I were really flush, I'd go for the turbonormalized 550 Bonanza.