GO LOW, WATCH FLOW

Fast as you can isn't always the best idea

BY NEIL SINGER PHOTOGRAPHY BY MIKE FIZER

WHEN MOST PILOTS THINK of the benefits of upgrading to jet power, speed usually tops the list. The slowest of light jets can cruise faster than nearly every turboprop in production, even those with a reputation for speed. Airframe manufacturers are all too happy to boast of the top cruise speed of their slick machines, so pilots come to think of airplane X as a 400-knot cruiser, and airplane Y as a 450-knot screamer. And while these aircraft certainly are capable of meeting the stated speed numbers, the hard truths of aerodynamics and operating economics dictate that, in practice, they are often flown significantly slower than the top cruise numbers boasted about in the slick ads.

For example, let's look at the case of a popular light jet with a top speed of just more than 450 knots. To reach that speed, the aircraft must be flown at an altitude at or near 30,000 feet, and with the engine thrust set at the maximum allowable cruise setting, or max cruise. Modern light jet engines are controlled by computers called FADECs (full authority digital electronic control), so to set max cruise thrust, the pilot needs only click the thrust levers into the proper detent, or line them up with the appropriate markings that indicate cruise thrust.

CRUISE 29,000 FEET

ANTI-ICE SYSTEMS OFF — **TWO ENGINES**

WT LBS	TEMP	RAT °C	FAN PERCENT RPM	FUEL FLOW LBS/HR	KIAS	IND MACH	KTAS	NAUTICAL MILES/100 LBS FUEL: HEADWIND			ZERO WIND	TAILWIND		
								100 kt	50 kt	25 kt		25 kt	50 kt	100 kt
7500	ISA+20°C -22°C	-10	(1) 89.3	610	188	.50	309	34.3	42.5	46.6	50.7	54.8	58.9	67.1
		-10	88.5	594	184	.490	304	34.3	42.7	46.9	51.1	55.3	59.5	67.9
		-11	(2) 87.5	573	179	.48	296	34.2	42.9	47.3	51.6	56.0	60.4	69.1
	ISA+10°C -32°C	-18	**(1) 91.7**	697	208	.55	334	**33.5**	40.7	44.3	47.9	51.4	55.0	62.2
		-19	**90.0**	654	200	.530	322	**33.9**	41.5	45.4	49.2	53.0	56.8	64.5
		-20	**88.4**	614	192	.510	310	**34.1**	42.3	46.3	50.4	54.5	58.6	66.7
		-21	**86.8**	578	184	.490	298	**34.2**	42.8	47.1	51.4	55.8	60.1	68.7
		-21	**(2) 85.8**	558	179	.48	290	**34.0**	43.0	47.5	52.0	56.4	60.9	69.9
	ISA+0°C -42°C	-27	(1) 92.3	737	218	.58	342	32.8	39.6	43.0	46.4	49.8	53.2	60.0
		-28	89.9	678	208	.550	327	33.4	40.8	44.5	48.2	51.9	55.5	62.9
		-29	88.2	636	200	.530	315	33.8	41.6	45.6	49.5	53.4	57.4	65.2
		-30	86.6	598	192	.510	303	34.0	42.4	46.5	50.7	54.9	59.1	67.5
		-32	(2) 83.9	543	179	.48	284	33.9	43.1	47.7	52.3	56.9	61.5	70.7

(1) MAXIMUM CRUISE THRUST (2) THRUST FOR MAXIMUM RANGE (APPROXIMATE)

THIS CESSNA MUSTANG cruise chart shows that in situations with strong headwinds aloft, setting lower than max cruise thrust may result in little or no efficiency gain.

The FADEC will do the rest of the work, metering fuel to the engine as appropriate for altitude and temperature.

As the airplane reaches 450 knots, the total fuel flow to both engines will be settling down to about 1,600 pounds of fuel per hour, or about 240 gallons per hour. The aircraft will be traveling 0.28 nm per pound of fuel burned, a measurement of efficiency called the specific range. Let's contrast these numbers with what the pilot would experience if he cruised at the aircraft's ceiling of 45,000 feet.

As indicated airspeed is essentially a function of fuel flow, and the ratio of true airspeed to indicated airspeed gets larger as altitude increases, an airplane can fly faster for a given fuel flow the higher it cruises. This means the best specific range is usually found at the highest altitude the aircraft can fly. The aircraft at 45,000 feet is now cruising at 416 KTAS, but fuel flow is down to under 900 pph, for a specific range of 0.47 nm/pound—a 68 percent increase in efficiency. For this efficiency increase, the aircraft is flying 8 percent slower, and for a 1,000-nm trip might arrive 10 minutes later, but with more than 200 gallons more fuel left in the tanks—not a bad trade off.

Flight at higher altitude is nearly always significantly less expensive, as well as necessary for meeting the maximum range numbers published for aircraft. But what if higher altitude is not possible? In congested airspace, ATC constraints often force jets to fly at much lower altitudes than would be preferred. Pilots in these situations who desire to minimize fuel burn have a tool—the long range cruise (LRC) information published in their aircraft operating manual.

LRC tables give information on the speed, fuel flow, and specific range that will result from setting thrust to a specified, lower than max cruise, value. This is calculated to give not the highest value of specific range, but one that trades a slight bit of efficiency, usually about 1 percent, for a significant improvement in cruise speed and margin above stall speed, as opposed to absolute max range speed.

If the pilot is unable to climb higher, and wishes to fly more efficiently than maximum cruise, he would enter the LRC table to find the proper engine thrust setting, or N_1. A measurement of how rapidly the forward-most compressor/fan of the engine is turning, N_1 is the primary thrust gauge in light jets. The LRC table would direct the pilot to set engine N_1 to 74.1 percent, significantly lower than the 87.3 percent N_1 that would result if the thrust levers were left in the max cruise setting. At this setting, the aircraft would cruise at only 320 KTAS, but fuel flow would decrease from 1,600 pph to 900 pph, and specific range would rise 29 percent to 0.36 nm/pound. As cruise altitude increases, the difference between max cruise and LRC thrust gets smaller, so much so that for many of the lightest jets being built, max cruise and LRC converge at the aircraft's ceiling. This means that when at the aircraft's ceiling, setting any power setting less than max cruise will result in a decrease in fuel efficiency, not always an intuitive concept. Do not to assume setting LRC will always result in maximum efficiency. Winds aloft must also be considered.

Consider a Citation Mustang flying on a warmer than average (ISA+10) day into a 100-knot headwind at FL290. Looking at the cruise performance table, as thrust is reduced from max cruise, initially the specific range increases slightly, from 0.335 nm/pound (per 100 pounds of fuel), to about 0.34 nm/pound. Further reductions of thrust make no appreciable difference in specific range, and the airplane's efficiency decreases slightly if thrust is reduced more to the LRC value of 85.8 percent N_1. For a difference in fuel burn across the trip of about 1 percent, a groundspeed of 224 knots could be realized at max cruise, versus 190 knots at LRC. This holds true for all aircraft—the efficiency benefit of setting LRC thrust decreases as headwind increases, and with strong enough winds is lost completely. **AOPA**

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