Cat 660 turbo performance upgrades

Jeff and Dave from JD Powersports in nearby Rochester NY (585-458-0620) have spent this past winter figuring out how to override the computer protection of the Cat turbo four-stroke. Recalling my own experience trying to mess with the first Cat 660 turbo dyno'd here (every trick I tried resulted in lowered HP), AC has figured out what us turbo hackers will try, and their turbo ECUs have been programmed accordingly. After experiencing similar results to their conventional attempts for extra HP on their 660 turbo, Jeff and Dave found these excellent results by working with an electronics engineering firm to produce an ECU piggy-back program override system. This high-boost high-HP pump gas tuning was finalized on the DTR dyno, using the dyno to hold the engine steady-state at various throttle positions while Jeff and Dave tweaked the fuel flow, timing, and boost pressure on their laptops (with umbilical cords attached) to create a powerful but safe for pump gas higher boost, high performance map.

93 octane pump gas was used for this tuning session, expecting that Cat's deto protection would help if deto was experienced.

Baseline HP numbers from our first 660 turbo stocker are included below (this was Dave's then-new sled).

2004 Arctic Cat 660 Turbo

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	Air 2 scfm	Fuel P psig	ManPrs inHg
4200	77.4	61.9	90	54.3	26.8
4300	76.8	62.9	91	54.5	26.9
4400	77.2	64.7	92	54.6	27.2
4500	77.9	66.8	95	54.8	27.8
4600	80.4	70.4	99	55.4	28.9
4700	81.2	72.6	103	55.8	29.9
4800	82.9	75.8	108	56.5	31.3
4900	85.1	79.3	113	57.3	32.9
5000	86.7	82.6	117	57.7	34.1
5100	87.4	84.9	120	58.1	34.7
5200	88.2	87.3	124	58.1	35.6
5300	88.5	89.3	128	59.1	36.7
5400	89.6	92.2	133	59.6	37.7
5500	91.2	95.5	139	60.2	38.8
5600	93.1	99.3	145	60.6	39.4
5700	93.4	101.3	146	60.5	39.7
5800	93.9	103.7	150	60.5	39.7
5900	92.9	104.4	152	60.4	39.4
6000	91.2	104.2	154	60.1	39.1
6100	90.1	104.7	156	60.2	39.1
6200	90.5	106.9	159	60.3	39.2
6300	90.5	108.6	162	60.3	39.2

6400	89.5	109.1	163	60.2	39.1
6500	88.7	109.7	165	60.3	39.1
6600	88.3	111.1	167	60.2	39.1
6700	86.7	110.6	170	59.9	39.1
6800	85.9	111.2	171	60.1	39.1
6900	85.3	112.1	174	59.9	38.8
7000	84.6	112.8	177	59.9	38.7
7100	84.1	113.6	180	59.9	38.7
7200	83.6	114.6	179	59.5	37.8
7300	81.1	112.6	177	58.6	36.2
7400	79.6	112.2	177	58.4	35.6
7500	78.5	112.1	178	58.2	35.2
7600	75.2	108.7	177	57.9	34.8
7700	72.7	106.6	175	57.2	33.4
7800	69.9	103.8	170	56.4	31.5

Note that while boost and airflow are increased 20% and 12% respectively on JD Powersports' sled, HP is up an incredible 30% due to JD's ability to fine tune the boost pressure, fuel flow and ignition timing as desired.A/F readings in our boosted test data were created from the new LM-1 A/F ratio O2 sensor on the dyno which we didn't have available when our first stocker was tested last year. Though seemingly slower reacting than our mechanical meters, LM-1 readings are very useful in situations like this. This test data shows 150 plus HP, but sweep tests as high as 154 were achieved with leaner fuel flow and a bit more boost.

T660 Cat turbo--fuel, spark and boost tuned by JD Powersports
23.5 psi peak boost pressure

EngSpd RPM	STPTrq Clb-ft	STPPwr CHp	VolEff %	A/F1 Ratio	BMEP psi	AirTmp degF	Air1+2 scfm	ManPrs inHg	TsTim2 second
5500	114.6	120.1	216.4	11.9	410.8	49	138	45.8	0
5600	113.2	120.7	214.7	11.6	406.1	49	139	45.5	0.8
5700	113.6	123.3	216.9	11.5	407.8	48	143	45.3	1.7
5800	113.6	125.5	217.1	11.4	407.4	49	146	45.3	2.2
5900	114.1	128.1	218.5	11.3	408.6	50	149	45.4	2.9
6000	114.5	131.1	218.6	11.3	410.8	50	151	45.7	3.6
6100	114.5	133.1	220.7	11.2	410.4	50	155	46.2	4.3
6200	113.3	133.8	217.3	11.2	406.1	50	156	46.1	4.8
6300	113.2	135.7	216.9	11.1	405.2	50	158	45.9	5.5
6400	112.9	137.6	219.9	11.1	404.5	50	163	46.6	6.2
6500	113.1	140.1	218.9	11.1	405.2	50	164	47.9	6.7
6600	112.1	140.9	220.3	11.2	401.2	51	168	47.1	7.6
6700	112.2	143.2	221.8	11.2	401.2	52	171	47.6	8.3
6800	109.1	141.3	220.9	11.1	390.4	51	173	46.9	9.3
6900	108.9	143.1	218.6	11.1	389.7	51	174	47.1	9.7
7000	109.8	146.3	220.3	11.1	392.6	51	178	47.5	10.3
7100	107.3	145.1	216.1	11.1	383.8	51	177	46.5	10.9

7200	107.8	147.8	217.9	10.9	385.6	51	181	46.9	11.5
7300	107.1	148.8	217.9	11.2	383.1	51	183	47.2	12.1
7400	106.7	150.3	218.6	12.4	381.5	51	186	47.5	12.7
7500	105.2	150.3	217.8	12.1	376.4	51	188	47.4	13.4
7600	103.3	149.4	214.7	11.3	369.3	51	188	47.2	13.9
7700	101.4	148.7	214.1	11.1	362.7	51	190	47.4	14.5

Since our sweep test here is fairly long in duration, intercooler temp is fairly high at HP peak, even with 80 mph cold air aimed at it from our dyno blower. To appreciate the benefit of a cold intercooler we did one stab test--set the dyno computer to hold engine just below 7500 regardless of load and whacked the throttle with chilled intercooler, just like it would be after cruising on the trail. As you can see here, HP is incredible at 165 then gradually drops as intercooler builds heat, boost drops, airflow drops, and A/F ratio goes richer and safer (fuel flow appears to stay constant as airflow drops). This data shows that at these high HP levels a more efficient intercooler would be a good investment (either thicker air/air or some sort of air/liquid/snow system). Jeff and Dave will contact my pal Gerhard at Bellintercoolers.com to see what options they may have to create better charge air cooling with the limited space available.

JD powersports' plan is to integrate fixed tuning into a plug-in computer module to sell to cat turbo owners to give them added HP in various stages. They have factory style connectors being tooled up, and will surely be back when they have final production kits. And they are hoping that the 660 electrical connectors are the same as the connectors on the new 1100 four-stroke (turbo?) twin that will very liklely benefit from tuning like this.

JD Powersports' T660, WOT stab on dyno at just below 7500 rpm, begin w/ cold intercooler, WOT for seven seconds

EngSpd	STPTrq	STPPwr	TsTim2	A/F1	BMEP	AirTmp	Air1+2	ManPrs	VolEff
RPM	Clb-ft	CHp	second	Ratio	psi	degF	scfm	inHg	%
7476	115.2	164.1	0	12.9	410.8	53	203	50.3	236.4
7472	116.2	165.4	0.6	12.4	414.5	53	203	50.3	236.6
7475	114.5	163.1	1.3	12.1	408.6	52	201	49.9	234.6
7476	114.1	162.5	2.1	11.9	407.4	52	199	49.7	232.2
7476	112.7	160.5	2.8	11.7	402.3	52	197	49.1	229.4
7479	112.2	159.7	3.7	11.7	399.3	54	196	49.2	229.4
7485	111.7	159.2	4.5	11.7	397.8	54	195	49.1	228.1
7488	111.1	158.2	5.3	11.7	395.2	54	195	49.1	227.1
7482	110.8	157.8	6.1	11.6	395.2	52	195	48.9	226.5
7481	109.9	156.6	6.9	11.6	392.3	52	194	48.8	226.2

For tech data aficionados I have included some extra dyno computer-generated data including incredibly high BMEP and VE% readings. I assume they are correct.