Arctic Cat Z1 w/ larger Garrett GT2860 turbo, larger intercooler, and water/ methanol injection. Jim Czekala

D&D Powersports' Glenn Hall, Dale Roes and Scott "Scooter" Moser brought Glenn's stock Z1 w/ D&D's newest Z1 performance upgrades to DTR for independent testing/ tuning/ demonstration.

The yet-to-be-named Z1 upgrades include a HiJacker fuel/ boost controller, custom SS merge header fitted to a larger (larger than stock but still small enough for quick boost rise and throttle response) Garrett GT2860 ball bearing turbocharger, supplemental fuel system, larger intercooler, aluminum charge tube, straight through non-restrictive exhaust and a custom water/ methanol injection system.

As we observed in our previous Z1/ HiJacker dyno session, the stock turbo on race gas was seemingly tapped out in the mid 250's HP at 1000 ft altitude. But greedy lakeracers, hillclimbers and hotrodders are desiring more power. To create and support more HP, larger everything is required. The Z1's tiny stock turbo is ideal for trail use—building significant boost even at a fast idle. But to create more HP more airflow is required than the stock turbo is capable of. The Garrett GT2860 is often selected by Yamaha Apex/ SkiDoo 4Tek turbo kit builders who shoot for target HP in the mid 300HP range with decent trail manners. The GT2860 has a small turbine with a larger compressor which creates high airflow with quick spoolup. The Garrett turbo's ball bearings, lubricated and cooled with very minimal oil, create very low friction. This allows the GT2860 to achieve boost rise much more quickly than the same turbo, fitted with plain sleeve bearings.

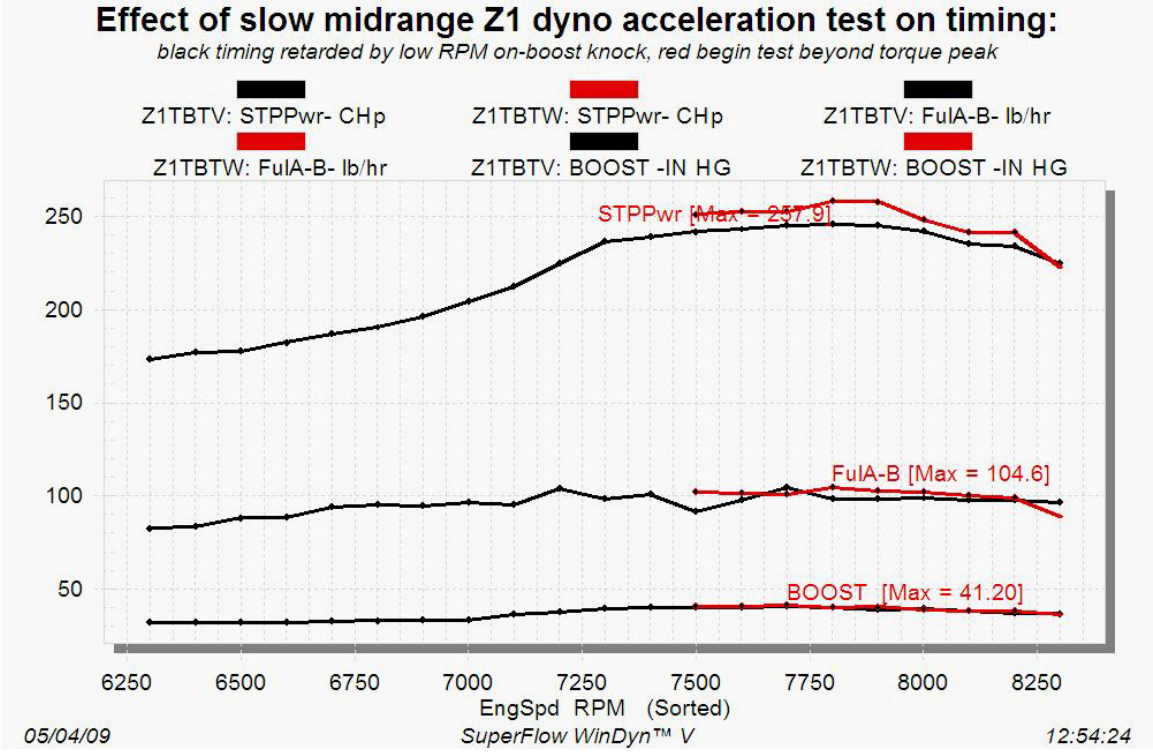
Additional fuel must be supplied to support HP in the mid 300's. D&D uses a supplemental fuel management system/ injector that feeds into the intake plenum when added fuel is required.

Then, a larger intercooler is fitted to the sled to drop charge temperature as low as possible. This reduces the likelihood of detonation, as well as increases charge density allowing more SCFM and HP per pound of boost. But a sled chassis can only fit so much intercooler—similarly powered turbo pickups have stock intercoolers the size of two side by side non-carry-on Samsonite suitcases!

Finally, a water/ methanol injection pump is used to pump a charge-cooling mist into the engine's charge tube during high boost operation. In production, a tank is planned to fit in the bellypan below the intercooler. A 50/50 mix of methanol and water is said to provide the best combination of charge cooling/ octane boost/ detonation suppression (methanol adds fuel and octane, and water has the highest heat of vaporization). During this dyno test session, we used blue windshield washer fluid bought locally which is about 30% methanol and 70% water—the same stuff I've injected into my 5.3 liter twin GT25 turbo Silverado to avoid detonation even with 440 lb/ft of torque at the wheels (nearly double stock) trouble-free for 120,000 miles.

We began our test session with C14+ race gas without H2O injection. With the larger turbo, we went through the HiJacker settings from 240 on up. Glenn Hall monitored engine operation with his Cat EFI diagnostic software, and he could see that even with good gas the long, slow WOT acceleration of the dyno from low revs was creating long periods of time at very high cylinder pressures and light deto was causing timing to be reduced by the ECU, and power to be lower than expected. In the field, very little time is spent in the vulnerable midrange at these high boost levels compared to the slow acceleration of the dyno test.

So we changed out test procedure, loading the engine gradually at just beyond the torque peak. This way, the very protective ECU would leave timing full-in and best power could be achieved. *This may explain the very slightly lower-than-expected HP on our previous Z1HiJacker test session.* Here is a graph comparing our usual test procedure with our Z1-tailored acceleration test:



Now, with our testing procedure altered to fit the Z1 we ran through all the current HiJacker settings w/ C14+ race gas, using the "button" to add even more boost and HP to each setting above 240. Once we got above 280 + 20 on the button (24 psi boost), Glenn manually increased boost pressure to about max the GT2860's airflow at 30+ psi (60 + inches of mercury as shown on the dyno tests), and he manually added fuel numbers to create optimal fuel flow as indicated by the LM1 wideband.

Once those 20 or so tests were recorded, we drained the fuel tank, switched to 93 octane pump gas and connected the water/ methanol injection (windshield washer fluid that I

had purchased for my truck for $2.30/ gallon). Immediately, Glenn noticed about a 100 degree F decrease in charge air temp to a temperature even lower than the air coming into the turbo compressor! No knock and perfect power at 240. Then we gradually increased HiJacker power settings all the way to max and beyond. With the turbo maxed out at 30 psi, we made 340 HP at 11/1 A/F ratio with zero clicks of deto. Then, Glenn leaned out the fuel one full point and we made 350 HP on pump gas!

Here is a synopsis of the many dyno tests we did on pump gas with H2O/ methanol injection, without a click of deto, in order of the HP/ boost levels:

Z1 Pump gas, H2O, HJ 240 + 10 button

EngSpd	STPTrq	STPPwr	FulA-B	BSFA-B	LAMAF1	FuelP	BOOST
RPM	Clb-ft	CHp	lb/hr	lb/hph	Ratio	psig	IN HG
7500	175.8	251.0	101.9	0.43	11.5	62.1	40.6
7600	174.4	252.4	101.6	0.43	11.5	61.9	40.7
7700	172.3	252.6	100.9	0.42	11.4	62.0	41.2
7800	173.6	257.9	104.6	0.43	11.5	61.9	39.9
7900	171.4	257.8	102.7	0.42	11.6	61.6	40.4
8000	162.9	248.2	101.8	0.44	11.6	61.4	38.8
8100	156.7	241.6	100.3	0.44	11.8	61.1	38.4
8200	154.8	241.7	98.8	0.43	11.8	61.0	38.3
8300	141.1	222.9	89.1	0.42	12.0	60.0	36.2

Z1 Pump gas, H2O, HJ 250 + 10 button

EngSpd	STPTrq	STPPwr	FulA-B	BSFA-B	LAMAF1	BOOST
RPM	Clb-ft	CHp	lb/hr	lb/hph	Ratio	IN HG
7500	172.9	246.9	105.6	0.46	12.0	39.2
7600	175.3	253.7	103.7	0.44	12.0	39.7
7700	181.3	265.8	105.8	0.43	11.8	41.9
7800	178.1	264.5	106.6	0.43	11.8	42.0
7900	173.3	260.7	103.8	0.43	12.2	40.8
8000	172.2	262.3	102.0	0.42	12.2	40.0
8100	167.7	258.7	100.5	0.42	12.2	39.1
8200	163.6	255.4	101.6	0.43	12.1	38.1
8300	151.2	238.9	97.8	0.44	12.2	38.0

Pump gas, H2O, HJ 260 + 10 button

EngSpd	STPTrq	STPPwr	FulA-B	BSFA-B	LAMAF1	BOOST
RPM	Clb-ft	CHp	lb/hr	lb/hph	Ratio	IN HG
7500	172.1	245.8	100.1	0.43	11.8	37.4
7600	174.7	252.7	104.0	0.44	11.9	38.6
7700	190.6	279.4	114.8	0.43	11.9	43.7
7800	188.8	280.4	115.8	0.44	12.0	44.5
7900	184.8	278.0	110.2	0.42	12.0	42.7
8000	181.4	276.3	109.0	0.42	12.0	42.4
8100	176.9	272.9	103.8	0.40	12.1	41.1
8200	172.1	268.8	106.5	0.42	12.1	40.7

Pump gas, H2O, HJ 280 + 10 button

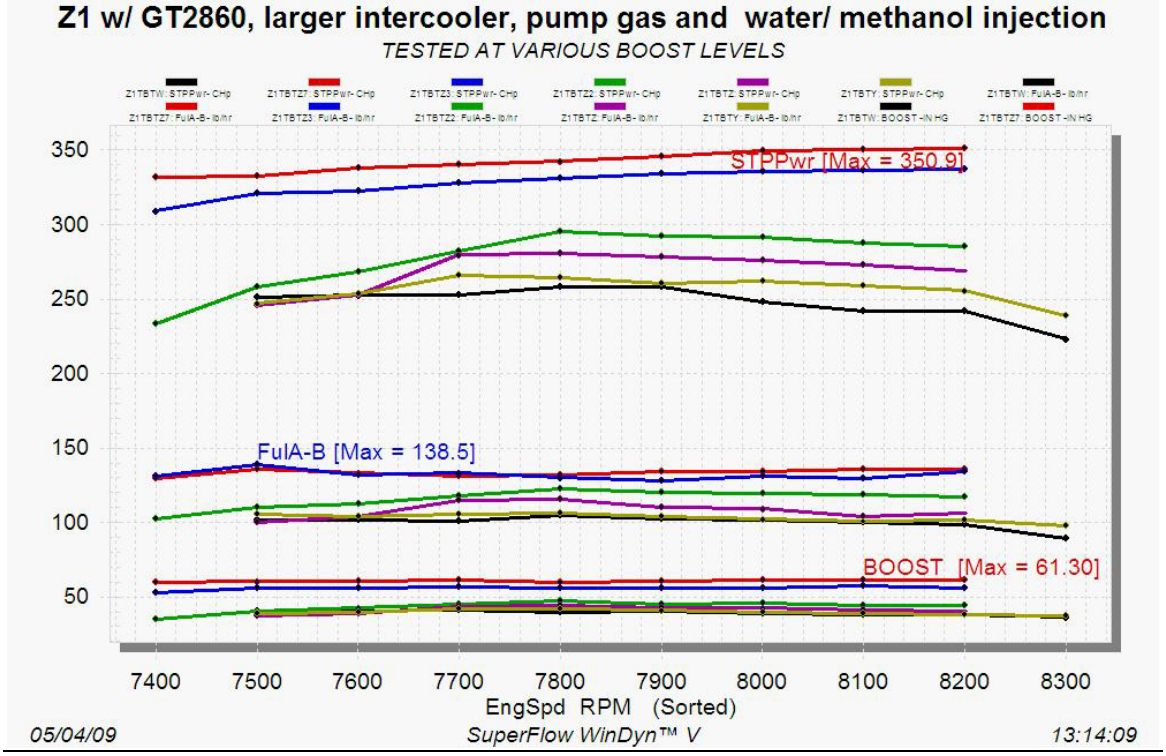
EngSpd	STPTrq	STPPwr	FulA-B	BSFA-B	LAMAF1	BOOST
RPM	Clb-ft	CHp	lb/hr	lb/hph	Ratio	IN HG
7400	165.5	233.2	102.1	0.47	10.9	35.2
7500	180.9	258.3	110.2	0.46	11.1	40.1
7600	185.3	268.2	112.8	0.45	11.1	42.4
7700	192.6	282.4	118.0	0.45	11.1	45.2
7800	199.1	295.6	122.9	0.44	11.1	47.7
7900	194.5	292.5	120.3	0.44	10.7	45.3
8000	191.5	291.7	119.5	0.44	10.6	45.7
8100	186.6	287.9	118.5	0.44	10.5	44.2
8200	182.7	285.3	117.0	0.44	10.4	44.0

Pump gas, H2O, HJ 280 + 20 button

EngSpd	STPTrq	STPPwr	FulA-B	BSFA-B	LAMAF1	BOOST
RPM	Clb-ft	CHp	lb/hr	lb/hph	Ratio	IN HG
7400	219.3	309.0	131.2	0.45	11.2	52.8
7500	224.8	321.0	138.5	0.46	11.4	56.0
7600	222.9	322.6	131.6	0.44	11.5	55.7
7700	223.6	327.8	133.0	0.43	11.5	56.5
7800	222.7	330.8	129.9	0.42	11.6	56.2
7900	222.2	334.3	128.2	0.41	11.6	56.0
8000	220.3	335.6	131.1	0.42	11.7	56.2
8100	218.3	336.7	129.6	0.41	11.8	57.3
8200	216.0	337.2	134.2	0.43	11.7	56.2

Pump gas, H2O, HJ wfo plus manual fuel adjustment

EngSpd	STPTrq	STPPwr	FulA-B	BSFA-B	LAMAF1	BOOST
RPM	Clb-ft	CHp	lb/hr	lb/hph	Ratio	IN HG
7400	235.4	331.7	129.8	0.42	11.6	60.0
7500	233.0	332.7	136.0	0.43	11.6	60.2
7600	233.5	337.8	133.0	0.42	11.6	60.5
7700	231.9	340.0	130.9	0.41	11.7	61.2
7800	230.4	342.2	131.9	0.41	11.7	59.9
7900	229.7	345.5	134.3	0.41	11.9	60.4
8000	229.6	349.7	134.0	0.41	12.0	61.2
8100	227.1	350.2	135.4	0.41	12.1	61.3
8200	224.8	350.9	136.0	0.41	12.1	61.2


Z1 w/ GT2860, larger intercooler, pump gas and water/ methanol injection
TESTED AT VARIOUS BOOST LEVELS
Z1TBTW: STPPwr- CHp
Z1TBTZ7: STPPwr- CHp
Z1TBTZ3: STPPwr- CHp
Z1TBTZ2: STPPwr- CHp
Z1TBTZ: STPPwr- CHp
Z1TBTY: STPPwr- CHp
Z1TBTW: FulA-B- lb/hr
Z1TBTZ7: FulA-B- lb/hr
Z1TBTZ3: FulA-B- lb/hr
Z1TBTZ2: FulA-B- lb/hr
Z1TBTZ: FulA-B- lb/hr
Z1TBTY: FulA-B- lb/hr
Z1TBTW: BOOST -IN HG
Z1TBTZ7: BOOST -IN HG
STPPwr [Max = 350.9]
FulA-B [Max = 138.5]
BOOST [Max = 61.30]
350
300
250
200
150
100
50
7400
7500
7600
7700
7800
7900
8000
8100
8200
8300
EngSpd RPM (Sorted)
05/04/09
SuperFlow WinDyn™ V
13:14:09