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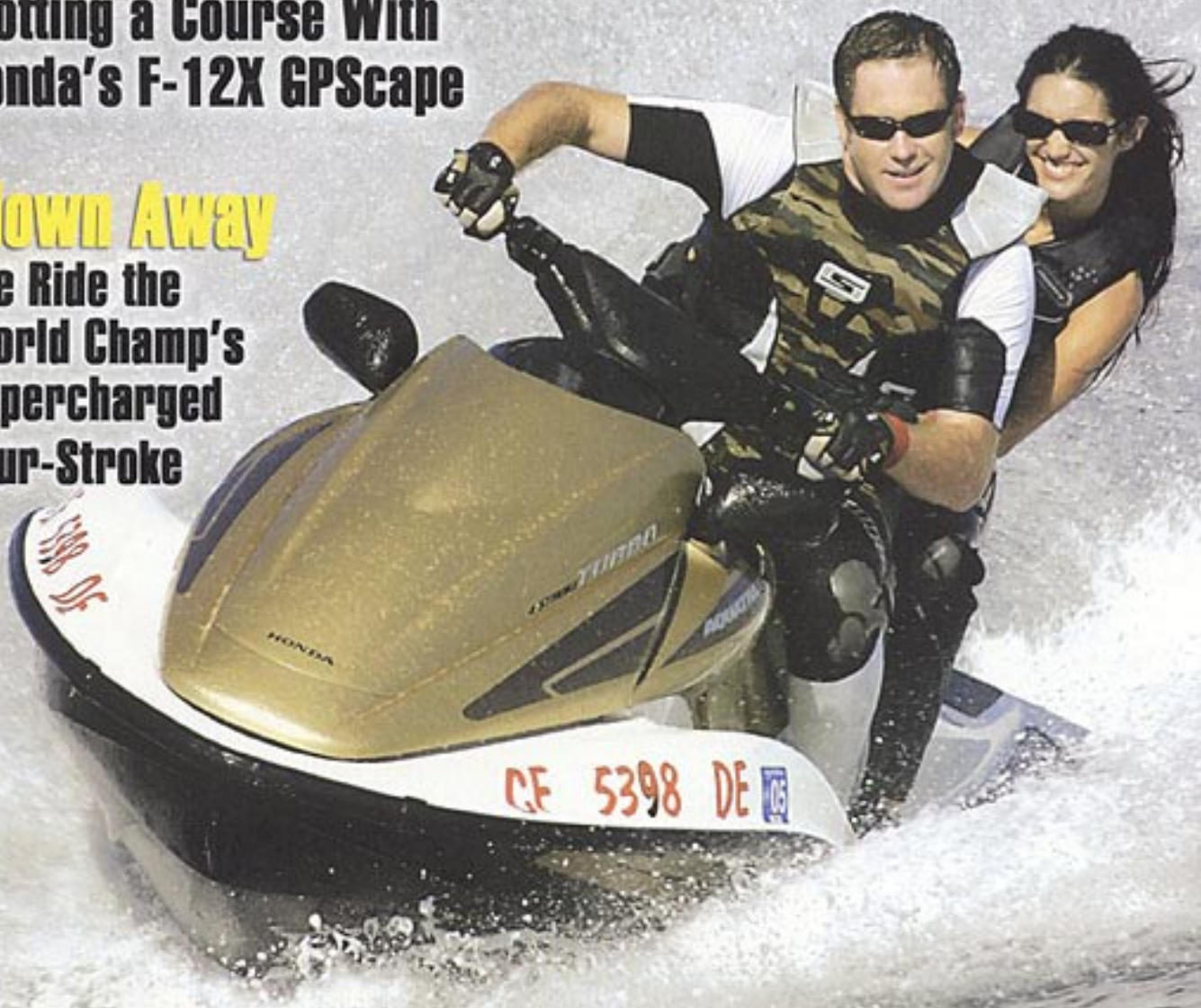

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FEAR FACTOR

WE RIDE CHRIS MACCLUGAGE'S WORLD CHAMPIONSHIP FOUR-STROKE RUNABOUT... AND HOLD ON FOR OUR LIVES

STORY BY JOSH BURNS
PHOTOS BY JOSH BURNS AND MIKE TELLERIA

(Right) U.M.I. steering, a carbon-fiber seat and some serious traction help MacClugage muscle the craft around the racecourse.
(Below) MacClugage's STX-15F racecraft looks similar to his two-stroke STX-R, but Kawasaki says the four-stroke weighs about 120 pounds more.

Sometimes the best game plan is to fly by the seat of your pants. Kawasaki didn't intend for that to be the plan of attack for the 2004 World Finals, but somehow it all worked out in the end.

Although Team Kawasaki's Minoru Kanamori was planning to ride a suped-up four-stroke in Pro Runabout at the 2004 IJSBA World Finals, the team was planning on putting its two World Championship hopefuls, Chris MacClugage and Dustin Farthing, on its proven two-stroke STX-R craft for the class.

MacClugage and Farthing would, however, be riding four-strokes in the Pro-Am Modified to try them out, considering this was really the first time either could really put these new four-stroke racecraft to the test in a race.

It was in the first of two 180-degree turns near the finish line during the first lap of the Modified race qualifier when MacClugage came into the turn on the inside with a little more speed than he wanted to, and he basically ran teammate Farthing off the course. MacClugage attacked the turn as he would on his two-stroke, but he was forced to take the turn wider when he realized the craft wouldn't slow down enough to make a sharp turn.

Chris MacClugage is the first person to win a World Championship on a four-stroke-powered craft.

It seemed "two-stroke" turning logic didn't apply.

Fast forward to later in the weekend. MacClugage hung up the four-stroke in the Modified class to focus on Pro Ski and Pro Runabout. Unfortunately, MacClugage's stand-up broke in the first heat of Pro Ski, and his chances of a title were shot.

This plague of bad luck seemed to follow MacClugage, because in the qualifying heat for Pro Runabout, he and teammate Farthing both missed a buoy. Farthing finished just in front of MacClugage and took the final qualifying spot, which meant MacClugage missed making the final. He had one last shot to do so - the last chance qualifier.

What many didn't know at the time is that MacClugage was having trouble with his two-stroke STX-R racecraft, so he was faced with the decision to either race his backup two-stroke or try his luck on the four-stroke in the qualifying heat - a craft that he was not very familiar with and one that didn't quite have the same predictable handling characteristics as his two-stroke. MacClugage decided to race the four-stroke in that LCQ, and the rest is history.

A four-stroke World title may have a come a little earlier than most people thought, maybe even Team Kawasaki. It's interesting to look at exactly how this occurred, because even the racers themselves weren't quite confident in the craft yet. Regardless, MacClugage's win showed that four-stroke performance - even if it isn't widely available yet - has definitely proven itself.

There are quite a few differences about Team Kawasaki's supercharged STX-15F compared to its two-stroke STX-R race craft. While the hull and deck are almost identical, the different engines - aside from the obvious two-stroke/four-stroke thing - really make a considerable difference in the handling abilities of each craft. The four-stroke is a bit more of a handful in many respects, which is why MacClugage and Farthing weren't planning on racing in the main classes just yet.

Kawasaki has been working on a four-stroke race craft for a few years now, and much of it stems from the work of Team Kawasaki and its technician/racer Minoru Kanamori, who began tinkering with an STX-12F (which features an 1199cc 125-horsepower four-stroke engine) last year. For last year's World Finals, Kawasaki

(Left) Chris MacClugage's STX-15F racecraft is rated to produce 320 horsepower at 8500 rpm - quite a jump from the 15F's stock rating of 160 horsepower.

installed a supercharger and a few other goodies on a 12F, and Kanamori, along with a few racers from Honda, raced the first four-stroke craft in a pro-level World Finals class.

While Kanamori rode the four-stroke race craft well in the qualifying heat of the 2003 World Finals, he finished 14th overall in the finals. The craft looked to be off to a good start, but it wasn't quite there yet.

This year, Kawasaki made some changes. First off, Kawasaki started with the new STX-15F engine platform, which produces 160 horsepower and has a 1498cc displacement. But this year, aside from just Kanamori racing a craft (one that is purported to produce 330 horsepower), Kawasaki also had craft for Farthing and MacClugage to race.

What may be the most interesting aspect of this craft is the fact that its horsepower output is doubled over stock with basically the addition of a supercharger. While Kanamori's craft is rated at roughly 330 horsepower, the craft MacClugage rode (the same one we saddled up on) is rated at 320 horsepower. This performance jump comes mostly from the Vortech supercharger installed on the craft, because while other parts have changed from stock, most of them are basically to assist the supercharger or to make the engine strong enough to handle the extra power.

Producing horsepower wasn't necessarily the greatest stumbling block for Team Kawasaki - finding the right pump configuration was where it got difficult. While there are multiple ways to produce more horsepower, it's worthless without a pump that can process the power efficiently. Kawasaki worked closely with Skat-Trak on different pump configurations, and eventually they found a good match - but it's not where they would've ever thought to start.

"The combination of what we found to get the pump to work with the horsepower and weight of the craft, it's not where you'd start if you were trying to make this configuration work," Kawasaki PWC racing manager Joe Heim says. "We found a good match after quite a few attempts at different setups. The cavitation is such a problem with that much horsepower and weight."

So while they found a pump to work with the added horsepower, the next issue was to get the riders onto the craft. While the engine is obviously different now, the craft is said to weigh about 120 pounds more than the STX-R two-stroke racecraft, and this additional weight has a huge impact on the handling of the craft.

"It seems as though it might have a higher center of gravity, so it wants to chine walk with the weight, and in turns it will want to roll over," Heim says.

With limited time on the craft before World Finals, neither MacClugage nor Farthing were comfortable enough to place their hopes in a relatively untested craft - especially when it came to trading it in for a platform they both felt comfortable with. After all, both had won the World title on an STX-R in each of the last two years.

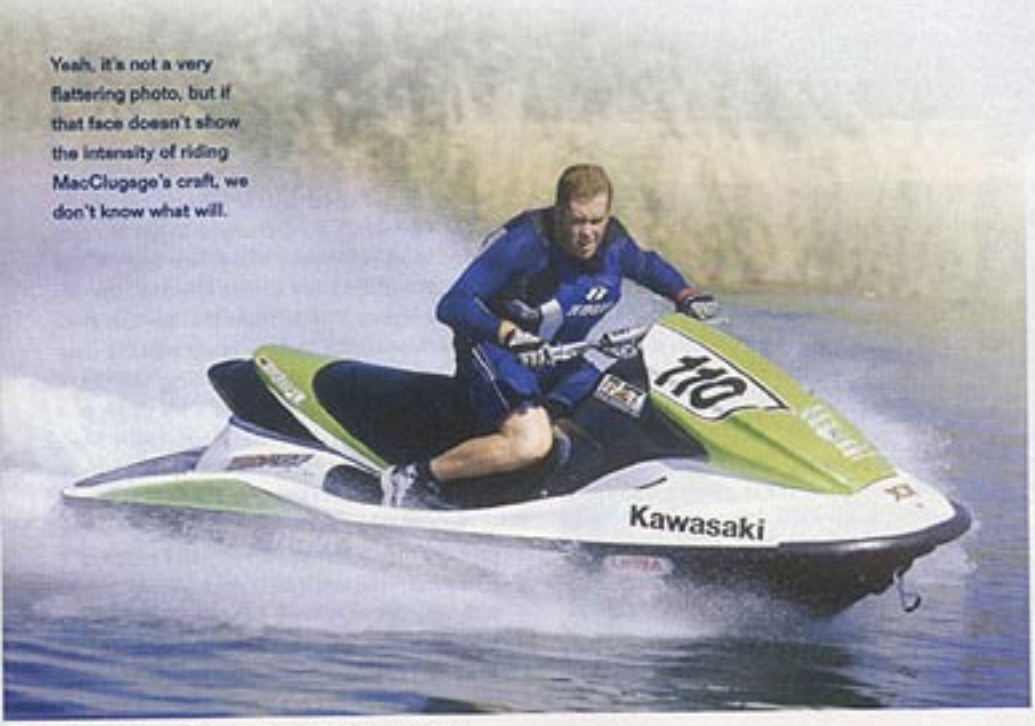
Having ridden Farthing and MacClugage's STX-R two-stroke racecraft the previous two years, we were also quite familiar with the platform. Since the STX-15F is roughly the same hull, it would be interesting to see how the new engine setup would change things.

Let's get one thing straight - this craft is ferocious. It's a pure adrenaline rush. The two-stroke racecraft is amazing in terms of power and force, but the STX-15F is almost beyond description. At first, the four-stroke felt a little less punchy on the bottom compared to the two-stroke. You can hear the 15F purr as you accelerate, and it didn't seem to have the punch that the two-stroke has. This is deceiving.

Once the 15F gets moving, it's like a locomotive - it just keeps gaining speed. While it may not "jump" off the line quite the same way the two-stroke does, it pulls away at an incredible rate. It feels as though it just keeps accelerating and accelerating.

To put the power of this engine into perspective, let's look at the top speed of the two-stroke vs. the four-stroke. Dustin Farthing's STX-R racecraft had a top speed of 69.78 mph. This year, MacClugage's SXT-15F race craft went 77.56 mph, and Team Kawasaki members tell us that this number is a bit low, as they usually see about 80 mph on their private test lake. Besides, Kawasaki has proven that top speed isn't the key to winning races: The key is having a strong rider and a well-rounded engine package.

What was even more interesting is the fact that I thought the four-stroke felt a little slower on the bottom-end, but in fact it was



Yeah, it's not a very flattering photo, but if that face doesn't show the intensity of riding MacClugage's craft, we don't know what will.

(Left) The Vortech V5G supercharger provides a huge increase in horsepower for the 15F racecraft.

(Left) Team Kawasaki actually uses automotive high-pressure injectors to deliver fuel.

(Above) R&D flame arrestors feed air to the supercharger that it gets via slits in the rear of the carbon-fiber seat.

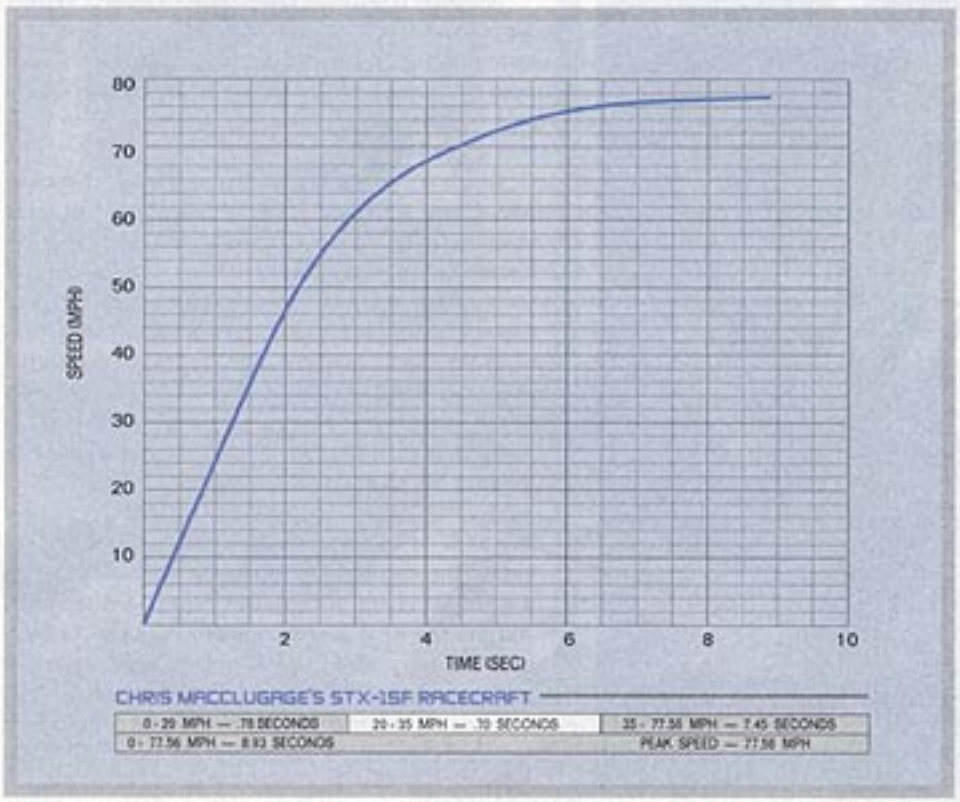
.06 of a second (.78 of a second) faster than Farthing's 2003 two-stroke racecraft in the 0- to 20-mph range at .84 of a second.

Riding the craft wide open in a straight line takes a bit of nerve. Having ridden a handful of 80-plus mph modified craft, riding this roughly 80-mph racecraft is completely different - it's night and day.

And turning the craft doesn't get any more relaxing. It pulls so hard in the corners that it feels like it could toss you off like an angry bull. It takes all the strength you can muster just to hold on.

Plain and simple, unless you're MacClugage or Farthing (or a handful of other elite racers), you have no business even trying to ride this craft. I got a small taste of the boat's potential, and it was enough to make me realize that the four-stroke's potential as a racecraft has just begun. We'll just have to see where it goes from here. *PWI*

(Left) The Skat-Trak pump and impeller configuration is a key component to this craft, since it processes the added horsepower of the engine.



CHRIS MACCLUGAGE'S STX-15F RACECRAFT

0 - 20 MPH — .78 SECONDS	20 - 35 MPH — .70 SECONDS	35 - 77.56 MPH — 7.45 SECONDS
0 - 77.56 MPH — 8.93 SECONDS		PEAK SPEED — 77.56 MPH

CHRIS MacCLUGAGE'S STX-15F

HULL

- **U.M.I. Racing steering system:** Puts handlebar in a more vertical position, allowing it to pivot more like a motorcycle than a car. Also lowers handlebar position to bring down center of gravity.
- **Beach House sponsons:** A key modification, since they allow the rider to carve turns more predictably and make the craft more stable in rough water.
- **R&D Racing ride plate:** This plate is more efficient than stock and can aid in top speed and/or handling by dropping or raising craft's nose to help control the planing attitude, even while turning. Kawasaki actually removes some of the rocker from the R&D plate to drop the center tunnel about 12mm. They will use small shims to fine-tune the craft's handling according to the conditions.
- **R&D Racing scoop grate:** Single-wing design and extra-deep channel rails eliminate cavitation and allow for quicker acceleration with improved speed and handling.
- **3DR seat base:** Made from carbon fiber, this unit is stronger than stock and much lighter.
- **AP Designs seat cover:** The seat is built up higher than stock to allow rider to grip it with his thighs.
- **AP Designs footwell mats:** These traction mats provide strong grip for the racer's boots, while they also provide lifters in the footwells for the rider to hook his feet.
- **Jet Ski Unlimited Bumpers:** Much smaller cross section improves handling and is of a lighter weight.
- **UMI Racing bypass fittings:** Additional fittings required for cooling.

ENGINE

- **Extrude-hone stock exhaust manifold:** Removes slight imperfections to help improve flow.
- **Intake Manifold:** Kawasaki relies on the stock intake manifold on its race craft.
- **Vortech V5G Supercharger:** Provides huge rise in horsepower to the 15F engine.
- **Vortech Intercooler:** The hot air coming from the supercharger is cooled by this intercooler before being sent to the engine.
- **Vortech bypass valve:** This high-flow valve is more responsive in a race application to bypass compressed air away from the engine when the throttle plates are closed.
- **Automotive high-flow fuel injectors:** Kawasaki actually uses fuel injectors from a Subaru car.
- **Programable Mitsubishi ECU:** This is responsible for changing rev limiter, ignition timing and fuel mapping of the engine. Note: Kawasaki suggests using Motec's Engine Management System, since the Mitsubishi unit is not available to the public.
- **Megacycle adjustable cam sprockets:** Change the cam timing (lobe center). Note: Team Kawasaki's Dustin Farthing is running a stock camshaft, and Kawasaki feels there is a 4- to 5-horsepower difference without it.
- **Stock fuel tap:** While Kawasaki retains the stock fuel tap, it does install a high-pressure Walboro fuel pump. Team Kawasaki uses an automotive fuel pressure regulator to keep pressure at 60 psi.
- **Stock Cylinder Head:** While Kawasaki retains the stock head, it does install a thicker head gasket to lower compression.
- **MTC forged pistons:** These forged pistons are based on the stock design but are a stronger, denser metal to withstand the added stress on the engine from the additional horsepower.
- **Modified stock waterbox:** Although there are two waterboxes on the stock STX-15F, Kawasaki removes one entirely and then modifies the remaining one to reduce backpressure. By removing one of the waterboxes, Kawasaki reroutes the exhaust outlet to the starboard side from the port side.
- **R&D Racing flame arrestors:** Located under the rear of the carbon-fiber seat, these flame arrestors feed air into the supercharger.
- **Stock crank:** The one-piece crank stays stock on STX-15F race craft.
- **VP Jet X Fuel (MS109)**
- **Maxima 0-30W synthetic motor oil**

PUMP

- **Skat-Trak 160mm 12-vane set-back Magnum pump:** This Skat-Trak pump is crucial in turning the horsepower into thrust. As Heim said, "None of this would be possible without Skat-Trak."
- **Skat-Trak extended driveshaft:** This driveshaft is about 30mm longer than stock to accommodate the set-back pump.
- **Skat-Trak 84/90mm steering nozzles**
- **Skat-Trak 10/18" swirl impeller**

By Kevin Cameron

EXPLORING KAWASAKI'S SUPERCHARGED FOUR-STROKE RACE CRAFT

PROFESSOR PWC

WATER

Chris McCluggage won the IJSBA World Finals Pro Runabout class at the controls of a 320-horsepower supercharged Kawasaki STX-15F. I love this kind of too-much-ness - it's like showing up at the quarter-mile drags with a Sprint ABM on wheels and running a sub-one-second E.T. (small problem - the driver would be crushed by the 100G acceleration).

Not so long ago, we were privately drooling over our favorite crazies down in Louisiana who crammed a 300-plus-horsepower helicopter engine into a watercraft. Now that same power is within reach of any determined person, using parts that are (with one exception) available over-the-counter.

Based on what has already been achieved elsewhere, there are hundreds more horsepower instantly available if there were any way to put them to work.

The basic ingredients of power are Kawasaki's robust 1500cc four-cylinder engine, a V5 Vortech tooth-belt-driven centrifugal supercharger, and a specially programmed engine control computer loaded with the instructions it needs to provide safe operation at exactly double the stock horsepower.

How does this work? The supercharger impeller, spinning at a very moderate 45,000 rpm (there's lots to come - just gear up the blower), doubles the intake pressure of the engine. This doubles the number of hot little molecules beating against the piston crowns. Why doesn't the engine go straight into detonation and become a pile of hot, twisted parts? It does not because the compression ratio is reduced enough to keep combustion chamber temperatures below the level that produces deto. What makes the power is not higher temperature but instead higher pressure, and that the engine can tolerate quite well.

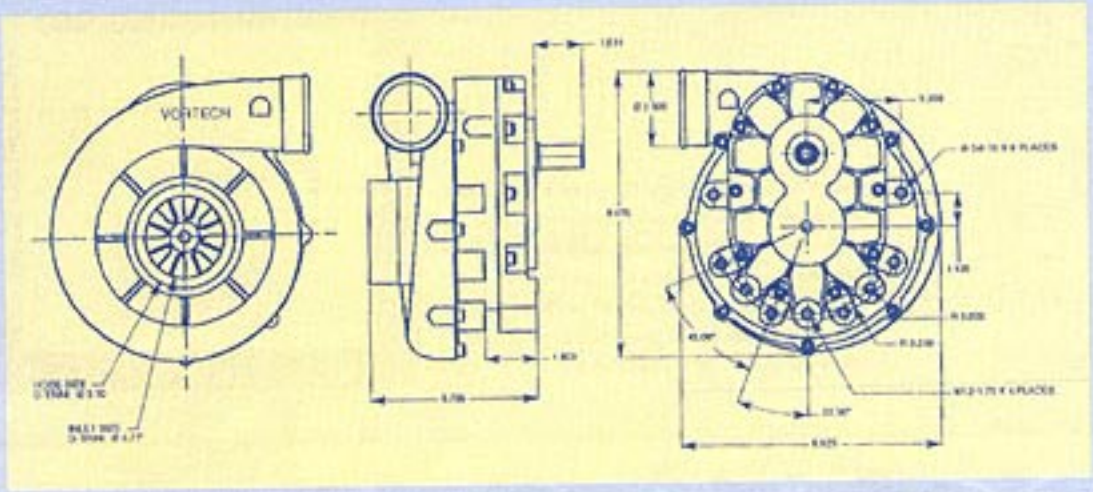
Besides supercharging, the other path to power is to push up rpm. This raises two big problems: (1) Available pumps usually like to turn in the range of 6000-7500 rpm, so higher engine rpm requires some kind of gear-reduction drive; and (2) Inertia stress on pistons and connecting-rods rises as the square of engine rpm. This means that if you boost power by raising the revs 25 percent (while keeping the engine breathing at its original level with bigger valves, longer-duration cams and larger throttle bodies, etc.), you are pushing the parts' stress upward by 1.25 X 1.25 = 1.56, or 56 percent. How far can you go with that? It's therefore much more relaxing to increase stress only during the power stroke, and in a way the engine can handle - by supercharging.

I spoke with Joe Heim, Team Kawasaki PWC race manager, who is soft-spoken to near-inaudibility. I immediately thought of "mild-mannered Clark Kent," not stepping into a phone booth to become Superman, but into a dyno cell.

"We've seen 400 hp on the dyno," he noted evenly. This is no surprise. Based on what has already been achieved elsewhere, there are hundreds more horsepower instantly available if there were any way to put them to work. Just change the drive ratio to the Vortech supercharger.

(Right) During testing and development, Kawasaki worked with Vortech Superchargers to find the right blower to compliment the engine package. What they came up with is a version of the V-5G. This supercharger can spin up to 65,000 rpm, but Kawasaki only spins its blower at 45,000 rpm - there's still untapped potential.

ROCKET



Right now, hulls are the problem.

"Watching Sea-Doos race in Europe - their pumps are spinning up in really sharp turns - four-stroke boats are heavier," Heim said. "They want to roll out in turns, or chine-walk a little bit. The problem is to find a pump that can handle the power; a lot of power cavitates the pump really badly."

What this means is that big horsepower can spin the pump so fast that it's all-important net positive suction head (NPSH) goes to zero - there isn't enough water pressure ahead of the pump to push water into it as fast as the engine is throwing it out the back. When you take a bigger number away from a smaller one this way, what you get is negative - a vacuum inside the pump. This is called cavitation.

The pump is a custom-sized 160mm 12-vane Skat-Trak Magnum, and without it, Kawasaki says none of this would be possible. Of its bulk, Heim said, "We're running out of room for a bigger pump (on this hull)."

The problem is to keep water flowing to this pump across a wide speed range. At high water speed, a scoop grate converts the water's velocity into lots of NPSH, and the pump does not cavitate. At lower speeds, this dynamic pressure drops, making cavitation more likely because all that remains to push water into the pump is the pressure resulting from how deep the pump intake is in the water and how well the rider is keeping that intake "buried."

I suspect this team chose a centrifugal supercharger to give the engine a torque curve with the same steeply rising shape as the pump's torque capacity - not too strong at the bottom, but steeply rising with engine rpm.

"I think we could be successful with either (type of supercharger)," Heim commented, referring to the roots-type blower that is the obvious alternative to the Vortech centrifugal blower. Some of the torque curve shaping could be done in the engine control computer, just as it is done in motorcycle racing, where the equivalent of pump cavitation is wheelspin. Ideally, the engine's output would be refined by development to make cavitation controllable by the operator.

Air enters the center of the impeller and its vanes accelerate the air to something near the speed of sound as it is flung off the impeller tips.

Heim noted that even with the 15F engine's low-speed torque reduced by the necessary drop in compression ratio, "it still has way more off the bottom than a two-stroke." A good reason for this is that the torque of a two-stroke engine depends mainly on the action of its exhaust pipes, which pump a lot of air over only a narrow rpm range up at the top of the rev range. Below the rpm of strong pipe action, only the engine's crankcase pumping is keeping it running, putting out much less than peak torque.

The big Kawasaki four-stroke makes power two ways: (1) Because it's a four-stroke, its separate strokes pump air with good efficiency over the whole range of engine rpm; and (2) adding the supercharger allows intake pressure to double as the engine nears its normal operating rpm. The result is the ability to "break loose" the pump almost any time the rider pushes a bit too hard. Making all this excess controllable is the real game here - making power is no problem. Hooking that power to the water is everything. This will be the central problem of going faster.

The Vortech supercharger has a radial-vaned impeller spinning inside a snail-shaped scroll housing. Air enters the center of the impeller and its vanes accelerate the air to something near the speed of sound as it is flung off the impeller tips. The scroll housing collects this air and smoothly decelerates it, converting velocity into pressure that is then piped into the engine's intakes. On the back of the scroll housing is a spur-gear step-up drive of 3.45:1 ratio, driven by a toothed belt at 60/35 from a cog pulley on the engine coupler. Compressing air raises its temperature, and temperature is what provokes detonation. To cool the compressed air coming from the blower, an air-to-water charge cooler is used. Two hoses are tapped from the waterjet pump - one circuit cools the charge cooler, and then the engine, in series. The other cools the exhaust plumbing (bilge explosions are worth avoiding - ask any old-timer at the marina about them) and then cools the engine as well. In this way, the engine is not overcooled, for it receives two sources of preheated water. Overcooling of marine engines is worth avoiding - it causes corrosion, power loss from increased oil viscosity, and mixture problems because fuel evaporation becomes incomplete.

The low-compression MTC forged pistons have smooth depressions milled in their domes. A conventional three-ring package is used and wristpins are retained in aircraft fashion by plugs rather than spring clips.

Vortech makes a series of various-sized blowers, and its literature identifies this V-S unit as suitable for "engines under four liters" displacement. Because the straight-cut spur gears and bearings in the unit's step-up drive are so busy, they are lubricated (as turbochargers usually are) by circulating engine oil. I suspect that this is done to limit the temperature rise of the drive.

Because supercharged engines need completely different ignition and fuel injection instructions, the ECU on this Kawasaki is custom-programmed and not available to the public. Out there on the free market are both programmable ECUs and all the dyno time you care to buy, so if you're bored with the sameness of cigarette boats, giant white Maybach limos and G5 biz-jets, here's something for the sports-minded enthusiast.

Might Kawasaki produce such a machine? Some say that an all-new boat is in the works. The only question is: What could it be? **PWI**