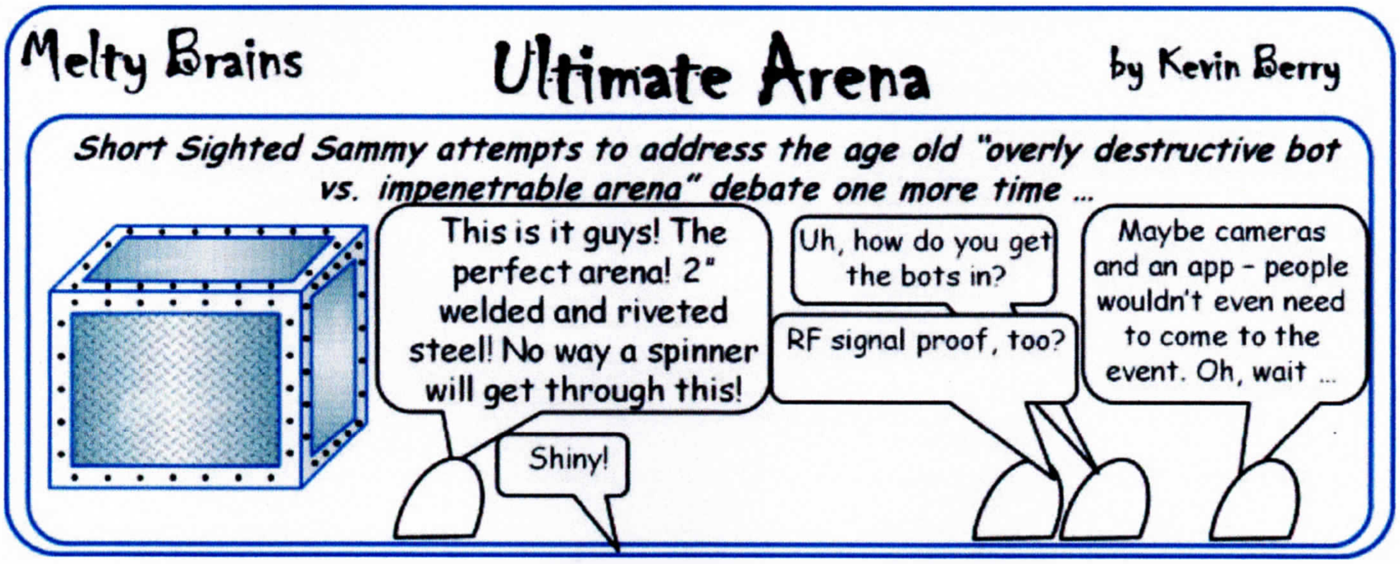
first into the wall. Taking the time and learning how to use the full range of travel (either using linear or exponential settings) will result in being able to drive much more smoothly. Smooth driving is controlled driving, and controlled driving gives you an advantage.

I prefer fast bots. The bots I run at events are usually some of the fastest machines in the class. Most of the time, I'm not using nearly all of that speed. I spend most of my time in matches below 50% throttle, only going to the limits of the travel when I'm lined up for or trying to avoid an attack. That being said, when fights I'm in go to the judges, I tend to score highly on aggression.

So, why would the bot that's driving slower and in a more controlled manner score high on aggression? It's simple: Aggression isn't the fastest bot. It's not the bot that's constantly charging in the general direction of their opponent. Aggression is the bot making successful attacks on their opponent. Blasting past your opponent and into the wall just gives them a free shot.

Speed is great. Accuracy is better. **SV**



Quality Versus Quantity — Or, Why One Axle is Sometimes Better Than Two

● by Pete Smith

The drums on my Saifu kits have worked pretty well, but when they lose it's usually been the same problem: bent axles. The drum uses a shoulder screw as a live axle at one end and the shaft of the Outrunner itself at the other (**Figure 1**). Initially, I used a 3/16" shoulder screw and that would be the failure point. I fixed that by moving to a 1/4" shoulder screw, but then the weak point was the 1/8" diameter axle in the Outrunner. A big hit would bend that small shaft and the motor would then seize up.

The existing design was simple to build as the entire motor would be glued into the drum, but it was clear that a tougher solution was required. First thoughts were to replace the motor shaft with a tougher one. A customer tried a titanium shaft, but that did no better; my next thought was to use a custom hardened steel one. This may have worked, but hardening steel is a complex subject and getting the right blend of hardness and toughness could have been tricky. I had also been considering another solution for some time.

This would have been to take the motor apart and use a much bigger

Figure 1. Old style drum.

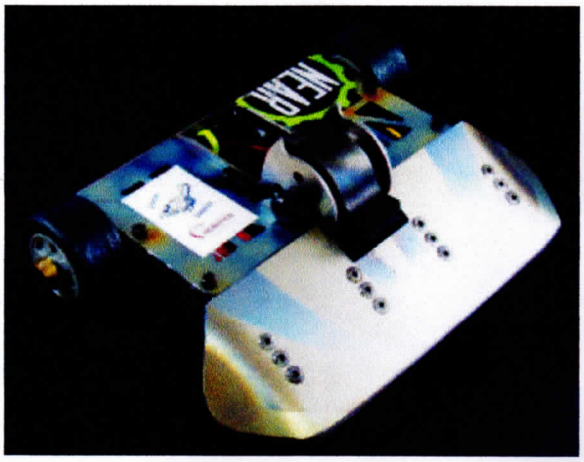


Figure 2. Algos.

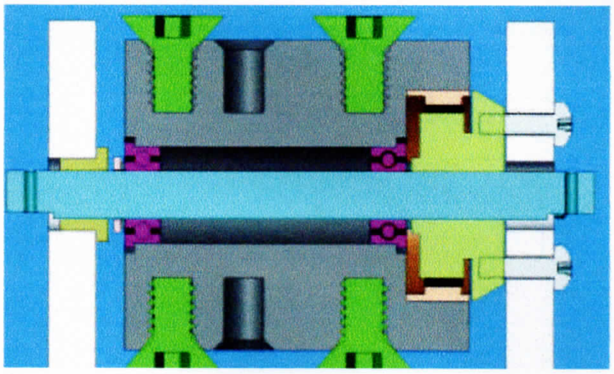


Figure 3. Cross-section.

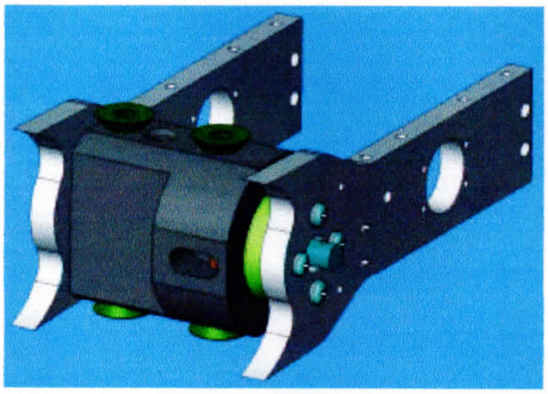


Figure 4. CAD version of the drum assembly.

Figure 5. Bearing.

Figure 6. Mangled motors.

diameter dead axle and separate — much bigger — ball bearings to mount the drum and the rotor (the part of the motor that has the permanent magnets). The stator (the part with the electromagnets) would remain mounted to the chassis. The tricky part would be to ensure that the rotor remained concentric with the stator, and that the permanent and electro magnets were still aligned correctly.

What finally spurred me into action was Mike Jeffries' successful implementation of a very similar design in his Antweight, Algos (**Figure 2**) which took first place at Motorama this year.

I used SolidWorks 2005 to design the various parts. A cross-section of the final design can be seen in **Figure 3**. The axle (in light blue) is located in the chassis by the stator (in light green) on the right and a flanged bushing on the left.

It should be noted that this is a "dead" axle; it does not rotate with the drum. The bushing on the left is only required to locate the 1/4" grade 5 titanium axle in an existing larger hole in the chassis. Two flanged ball bearings (in pink) allow the drum to spin freely on the shaft, and shims and washers keep the drum axially positioned relative to the stator.

The rotor (In beige) is glued into one end of the drum. Otherwise, the drum is much as before (**Figure 4**), with two teeth on each side and slots milled to allow easy removal and replacement of the rotor if necessary. One advantage of the new design is that because no clearance is required for the bell housing on the motor, the teeth can be a little further apart — 1" rather than 0.7".

My first task was to dismantle the Turnigy 28-22 Outrunner motor. The bell housing and shaft are secured to the stator with a tiny circlip on the shaft.

While it might be possible to get a special set of pliers to remove this clip in one piece, it's not needed in the final assembly. So, I bent it apart with a small flat blade screwdriver and removed the remains with a pair of fine-nosed pliers.

The stator has two small ball bearings pressed into it (**Figure 5**) which need to be removed. I practiced this on an older slightly different motor first and they popped out right away, but the ones on my chosen motor proved unwilling to come out so easily. I used a small hammer and a blunt nosed punch. That got the bigger one out, but I had to (carefully) use my drill press to get out the other one. It's easy to damage the soft aluminum of the stator housing, and I mangled two motors before finally succeeding (**Figure 6**).

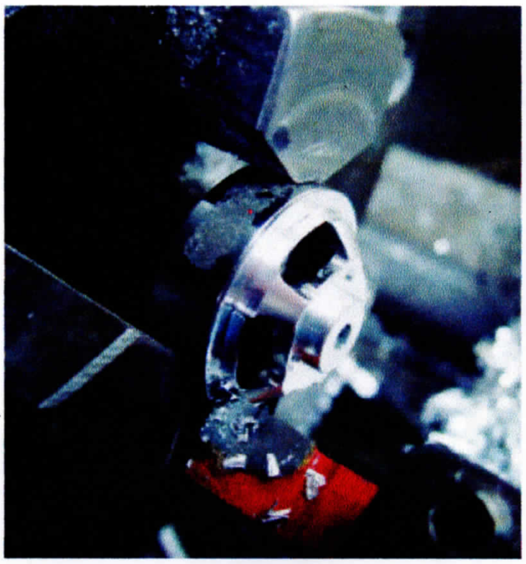


Figure 7. Removing the bell housing.

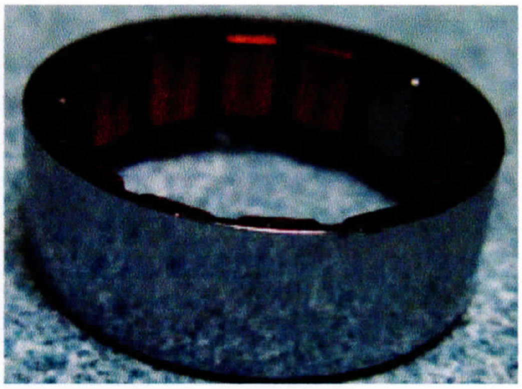


Figure 8. Rotor.

The bore left between the two bearings was almost exactly 1/4" in the trial motor but slightly less in the one I finally used. I drilled it out to 1/4" in steps to ensure it would be a nice close — but sliding — fit on the axle. Too loose and the stator and rotor would no longer be concentric; too tight and the axle would be hard to fit and remove for servicing.

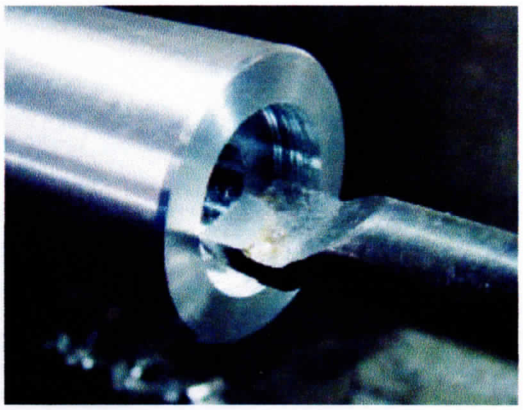


Figure 9. Machining a recess for the rotor.

I removed the bell housing and the old 1/8" axle from the rotor by lightly clamping it in the jaws on my lathe and machining it carefully (**Figure 7**) until the two parts separated, leaving the rotor as a separate ring (**Figure 8**).

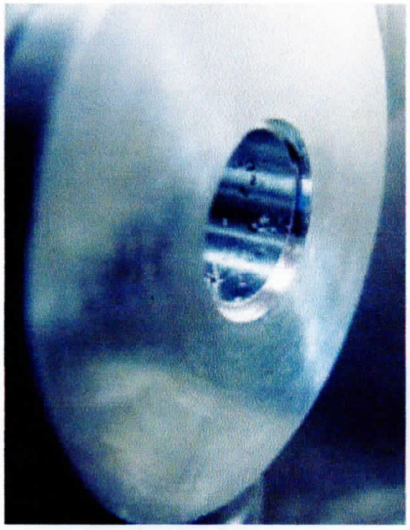


Figure 10. Counter bore for the bearing flange.

The drum itself is 7075 aluminum. I turned the exterior down to a diameter of 1.7", drilled out the center with a 15/32" drill, and then reamed it out to 0.500" (the size of the outside diameter of the ball bearings).

The next step was to machine the recess for the rotor using a boring bar (**Figure 9**).

This needs to be a close sliding fit for the rotor. A small recess (**Figure 10**) for the flanges on the bearings was then added to each end of the 1/2". To ensure the features on the outside of the drum are all correctly oriented on top of each other, I machined a flat on one side of the drum (**Figure 11**), and then flipped the part over and used that flat to orient the drum to allow a matching flat to be machined opposite it. The part is then turned 90°, and the two flats align the part in the vise so that flats can be added at 90° to the first set.

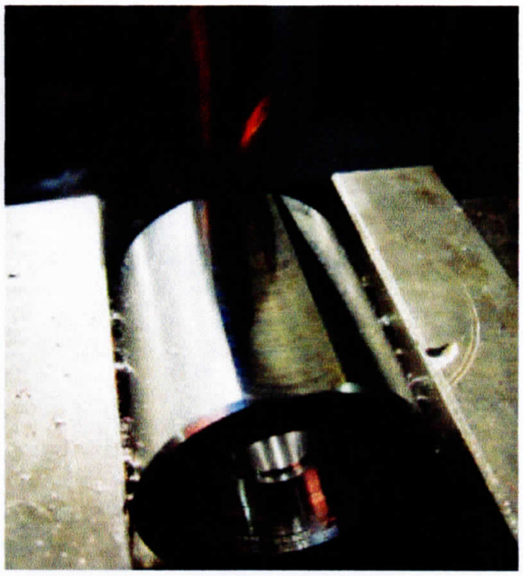


Figure 11. Machining flats.

A vise stop and edge finder (**Figure 12**) together with the DRO on my mill made positioning and milling out the teeth mounting holes and the slots to allow the rotor to be levered out a quick and easy task. The last major machining job was to remove enough material from the drum to get the weight down to about 4 oz (**Figure 13**).

I chose flanged bearings (**Figure 14**; McMaster part# 57155K323) to make it easy to limit how far they get pressed into the bore. I then chose

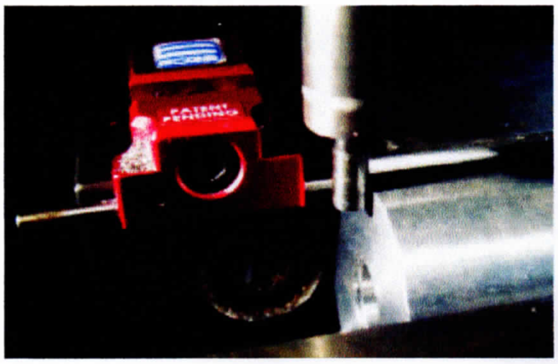


Figure 12. Use a vise stop and edge finder.

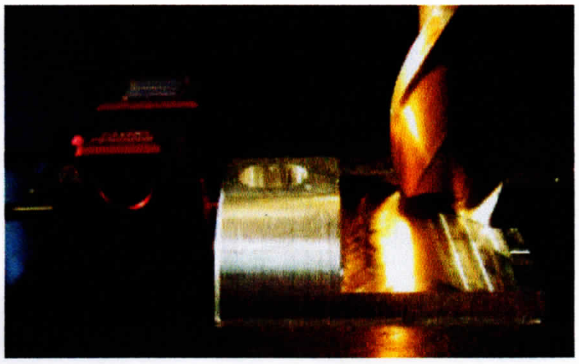


Figure 13. Losing weight.

Figure 14. Flanged ball bearing.

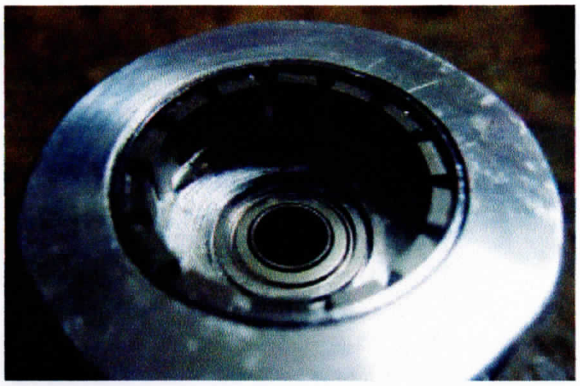


Figure 15. Pressed-in bearing and glued rotor.

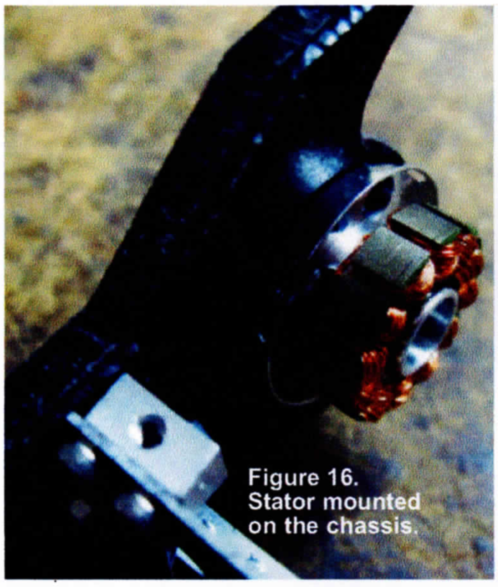


Figure 16. Stator mounted on the chassis.

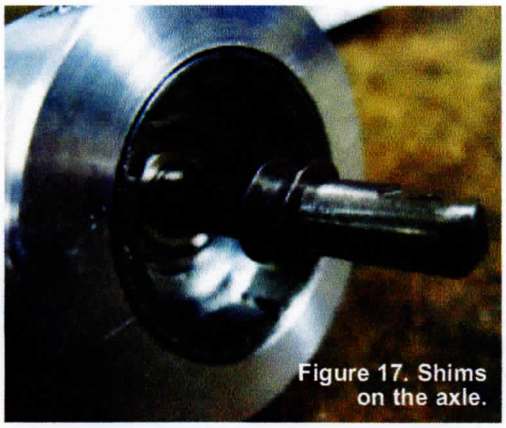


Figure 17. Shims on the axle.

shielded bearings since they protect against dust, etc., getting into the bearings without the drag of a fully sealed bearing. I also checked that the speed rating exceeded the likely max RPM of the drum.

The dynamic load rating of 243 lbs seems adequate, but our applications are so outside normal use that establishing a relationship between dynamic load ratings and actual effectiveness for any weight class in combat robotics would be very difficult.

The first bearing I tried did not fit onto the 1/4" titanium shaft, and it was still a press-fit on the shaft even after I de-burred the shaft and gave it a quick sanding on the lathe.

Given that the ground titanium shaft was supposed to be just under 1/4" (and the bearing just over) and should have been an easy sliding fit, I decided to try another of the bearings and it slid right on!

I had bought four bearings, and all the rest fit the shaft without problems. The lesson to learn is do not assume that if a bearing won't fit, that all similar bearings won't fit. I measured the shaft and it was not oversized, so I should have guessed earlier that the problem was with that particular bearing and not the shaft.

The bearings were a light press-fit in the bore, and the rotor was secured in place using a smear of "Goop" adhesive (**Figure 15**). The stator side of the motor is screwed to the side wall of the chassis (**Figure 16**). It is important to ensure that none of the screws hit the wires going into the motor or the coils on the magnets themselves.

I used small nylon washers to space the screws out to accomplish this, adding two washers under two of the screws and one under the other two.

I assembled the drum onto the axle and added a number of shims (**Figure 17**) to maintain the correct axial position of the rotor relative to the stator. I found that two shims resulted in a gap between the stator and rotor similar to that of the original motor.

The next task was to balance the drum assembly. I mounted it on the axle and supported the axle on two sockets of the same height. The shielded bearings allow the drum to rotate freely, and the heavy side will always settle at the bottom. I must have made a machining error when I was lightening it as it took drilling a large "divot" out of that heavy side to get it to balance properly and not settle repeatedly at any one point (**Figure 18**).

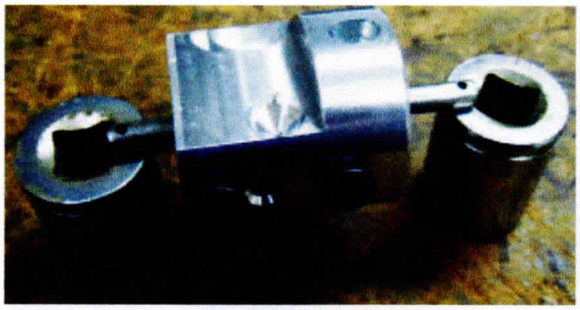


Figure 18. Balancing the drum.

This results in static balancing only, but because the part is symmetrical around the axis of the axle, it is usually good enough for our purposes.

The drum was assembled back into the chassis and the axle secured at each end with a washer and a cotter pin (**Figure 19**).

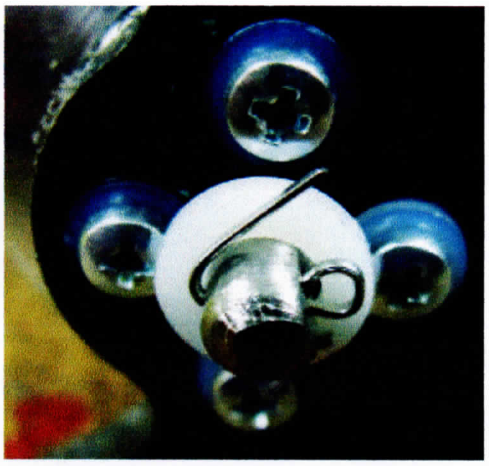


Figure 19. Washer and cotter pin.

I then tested the drum by hooking up the electronics of my wide version of Saifu to the stator in the new chassis (**Figure 20**) and it spun up smoothly with no problems at all.

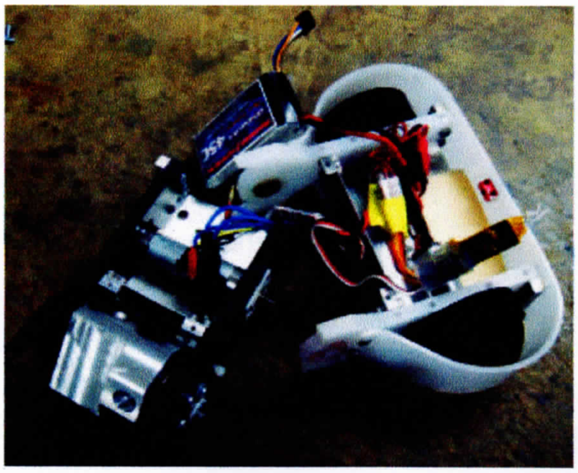


Figure 20. Testing the drum.

The assembled kit was shipped off to the customer and was built up as the Antweight, Hopeful Narwhal (**Figure 21**). It competed (winning at least one fight) at RoboGames in California at the time of this writing.

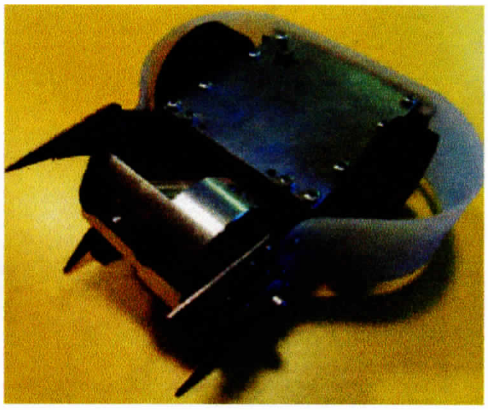


Figure 21. Hopeful Narwhal.

My next step is to rebuild my wide version of Saifu with a similar drum and compete at this summer's "Clash of the Bots." Then, if it works well, I'll make this design the basis of a new kit available to the public.

I think I will also build a 3 lb version of this drum and try it out in a modified Weta chassis ... lots to do! **SV**

ME LABS

PBP3

PICBASIC PRO™ Compiler 3.0

BASIC Compiler for Microchip PIC® microcontroller

FREE

Student - ~~$49.95~~

Silver Edition - $119.95

Gold Edition - $269.95

A world class BASIC Compiler for rapid development of Microchip PIC® microcontroller based projects.

- Lightning Fast
- Generates Optimized, Machine Ready Code
- Easy enough for the hobbyist, strong enough for a pro.
- This is a full-blown development tool that produces code in the same manner as a C compiler (without the pain of C).
- It is very easy to learn and understand.

Download a FREE Trial Now!

www.PBP3.com

PICBASIC and PICBASIC PRO are trademarks of Microchip Technology Inc. in the USA and other countries. PIC is a registered trademarks of Microchip Technology Inc. in the USA and other countries.