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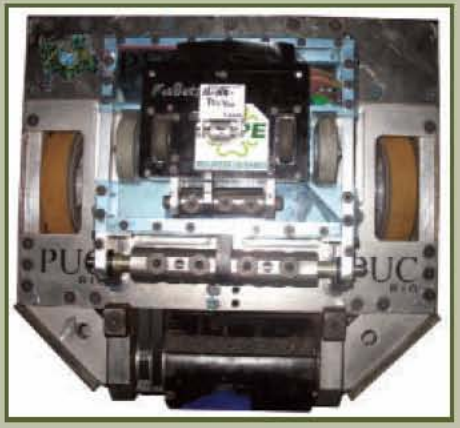
MANUFACTURING: RioBotz Combot Tutorial Summarized: Design Fundamentals

● Original text by Professor Marco Antonio Meggiolaro; Summarized by Kevin M. Berry

Professor Meggiolaro of the Pontifical Catholic University of Rio De Janeiro, Brazil, recently translated his popular book, *The RioBotz Combot Tutorial*, into English. In the process, he greatly expanded it and solicited input from a wide range of robot builders. The updated version – 367 pages long with an incredible 895 figures, graphs, and photographs – is available free for download at **www.riobotz.com.br/en/tutorial.html**. *SERVO Magazine*, as a service to the building community, is summarizing the tutorial in a series of articles beginning with part of Chapter 2, "Design Fundamentals." Look for the rest of Chapter 2 and additional chapters in the future. All information here is provided courtesy of Professor Meggiolaro and RioBotz.

Weight Classes

Combat robots range in size from the unnamed one ounce miniatures, through 50 or 75 gram fleaweights, up to 390 pound megaweights. **Table 1** summarizes current weight classes.



Middleweight, Hobby-weight, Beetleweight, and Fleaweight versions of the same "Touro" drumbot design, stacked to illustrate scaling factors.

Scale Factor

One important thing to keep in mind during the design phase is the scale factor. If the physical dimensions (length, weight, height) of a bot are doubled, the volume cubes. However, the cross sectional area of a structural member just doubles, so its strength doesn't keep up with the weight/volume. What does this have to do with combat robots? Everything.

If you want to take your 12 pound hobbyweight design and scale it up to a 120 pound middleweight, you'd need to multiply the weight by 10. You'd do this by multiplying all the dimensions by the cube root of 10, or 2.15. If you were going to double a 60 pound bot's weight, you'd be building a 120 pound middleweight with a scale factor of the cube root of two, or 1.26, so all dimensions should be increased by 26%.

Obviously, there is a lot more to this. Volume doesn't automatically equal weight unless the density is the same, which means precise scaling of components. Using commercial parts with standard sizes, this won't exactly happen. Also, stress and strength aren't linear factors. The tutorial recommends raising the scaling factor to a power of 1.5 in critical components like weapon shafts to account for

TABLE 2

WEIGHT CLASS	DIAMETER
• 60 pound Lightweight	0.5"
• 120 pound Middleweight	0.75"
• 220 pound Heavyweight	1.0"
• 340 pound Super-Heavyweight	1.25"

TABLE 1

NAME	WEIGHT
• Unnamed	1 ounce
• Fleaweights, Nanoweights, UK Fairyweights	50 or 75 grams
• US Fairyweights, UK Antweights	150 grams
• US Antweight	1 pound
• Beetleweight	3 pounds
• Kilobots	1 kilogram
• Mantisweight	6 pounds
• Featherweight (full combat & Sportsman)	12 pounds
• BotsIQ (small class)	15 pounds
• Hobbyweight (full combat & Sportsman)	30 pounds
• Lightweight	60 pounds
• Middleweight	120 pounds
• Heavyweight	220 pounds
• Super-heavyweight	340 pounds (US); 320 pounds (UK)
• Megaweight	390 pounds

Playing the "Who Can Beat Who" game is an integral part of the design process.

the weight of a multibot must be incapacitated to win a round, often three bots are used. This means three 120 pound middleweights (with one losing 20 pounds on a diet) would fight a 340 pound super-heavyweight. The odds of a 120 pound weapon inflicting damage on super-heavyweight armor are slim. Another technique using one "90%" bot and two smaller "door stops" hasn't worked well in practice, either.

Cost

Cost is variable, depending on creativity, resourcefulness, and design. However, a survey of typical costs for bots built with high quality parts reveals these numbers (including R/C equipment and spare batteries). See **Table 3**.

Bots can certainly be built for more or less than these numbers. But, it's best to remember, this is not a cheap sport. For the interested new builder, smaller bots like featherweights or insects (less than 12 pounds) are a good option.

TABLE 3

WEIGHT CLASS	COST (US$)
• 60 pound Lightweight	$3,000
• 120 pound Middleweight	$4,000
• 220 pound Heavyweight	$6,000
• 340 pound Super-heavyweight	$8,000

this. This is backed up by steel wheel shaft data from successful combat bots (see **Table 2**).

Comparing heavyweights and super-heavyweights with similar aspects, the theoretical scale factor would be (340 lb/220 lb)1/3 = 1.16, and the ratio between the shaft diameters is 1.25"/1" = 1.25 — a value reasonably close to 1.161.5 = 1.249.

The bottom line is that theory combined with common sense is a very powerful design tool in practice. Imagine how many shafts have been broken in combat to arrive at this optimized sizing. Using these calculations, the optimum design can be done up front.

Robot Types

There are basically 16 types of combots: rammers, wedges, lifters, launchers, thwackbots, overhead thwackbots, spearbots, horizontal spinners, sawbots, vertical spinners, drumbots, hammerbots, clampers, crushers, flamethrowers, and multibots. While there are infinite subtle differences, they can always be categorized into one of these 16 types. There are also bots with interchangeable weapons (chameleons). Bots known as "Swiss Army Knives" with two or more weapons are usually not very efficient or effective, with the exception of using a wedge as a secondary weapon. This is so common as to be almost a standard design technique.

There are also defensive items like bumpers or hold off sticks.

Multibots generally don't do well. To get around the rule that 50% of

The stunning craftsmanship of Buster, a Super-heavyweight milled from titanium. Photo courtesy of Hal Rucker.

Sponsorship

The Robot MarketPlace has some great tips about sponsorship. (**http://robotmarketplace.com/tips.html**). Basically, it's not easy to get a sponsor if you haven't built a bot before. The only exceptions are companies whose owners or directors already know you well. Most big companies don't sponsor robots. It's better to look at smaller local shops that might benefit from the exposure. Also, you have to call or visit in person. Email isn't likely to bring you sponsorships.

Bring or mail business cards with your team's information and logo. Prepare a presentation folder with lots of nice photos. Show the

potential sponsors how and where their name will be visible, such as on team T-shirts, websites, You-Tube videos, and of course, on the bot. Show examples of where newspapers, magazines (say *SERVO* three times, loudly), and TV news programs have covered events. Showing videos from fights is important. Make sure the videos show enthusiastic crowds.

Include your annual budget on your folder. Include the total cost of building, fighting, and repairing your bot, marketing items like T-shirts, travel costs, entry fees, etc. Don't be afraid to show the total cost. They can always fund part of the cost instead of the whole, but going back for more money later is difficult.

It will be difficult to get cash from sponsors without a proven track record. However, parts or machining time are much more likely. Don't give up after getting turned down a few times. Evaluate what you're doing and keep going; this takes a lot of effort.

What's Next?

The next installment of this summary will get into the nuts and bolts (literally!) of combot design: calculations, optimization, building and testing, structures, armor, and drive types. This short summary covered 16 pages of dense and fascinating material. SV

All material used with permission of RioBotz, Marco Antonio Meggiolaro.

A well designed brochure can elevate a team from "begger" to "sponsored."

EVENTS

Completed and Upcoming Events

Completed Results for March 16 to April 12, 2009

Ideas Festival: March 27 and 28, Brisbane, Queensland.

Upcoming Events for Jun-Jul 2009

RoboGames will be held June 12-14 in San Francisco, CA. Go to **www.robogames.net** for more details. SV

ROBOWARS

ROBOGAMES

PARTS IS PARTS: Banebots P60 1:16 Gearbox Review

● by Nick Martin

My P60 gearboxes have arrived and so far, they look very promising. The overall machining quality is vastly improved when compared to the Chinese produced versions. All the mounting holes on my gearboxes are in exactly the right spots where the CAD drawings say they will be.

Compared to the 42 mm gearboxes they replace, the P60 has a very similar 1/2" output shaft that reduces to 3/8" at the front bearing. The reduction point is

PHOTO 1. P60 (center) with the 36 and 42 mm gearboxes it replaces.