

Intro / Overview

For larger bots, wheel chair motors are a pretty standard choice for an off-the-shelf combination consisting of motor and gearbox. In the smaller bots, it's been mostly a do-it-yourself affair, often done by buying whole cordless drills and doing a lot of modification work.

But there are a few options for buying a nearly ready made drivetrain; this article will examine a few of them. As much as possible, these were chosen as items which could be purchased and bolted onto a base plate to provide the most complete drivetrain solution with the least amount of additional work.

The ones being compared in this writeup are as follows:

At the low end, cordless drill combos are available quite cheaply from places like Harbor Freight and Homier (homier.com). A whole 12V drill can be had for around \$15; this is carved up to extract just the motor and gearbox. Mounting can be a little tricky, and they usually require a creative solution for locking the slip clutch in place. Due to the additional work required, their unknown performance data and much lower reliability than the other entries, they have not been included in this analysis.

Team Delta buys motors and gearboxes from the 18V cordless drill directly from Dewalt, and machines an aluminum mount for them. Coupled with a matching output shaft, a whole drive solution including mounting can be purchased for \$145. These are reported to handle overvolting to 24V quite well

DC Waterjet gets motors from the 24V Dewalt Hammerdrill, and modifies them to handle higher heat by replacing the brush holder with a phenolic endcap. The gearbox is modified to accept a shaft with two flats, and mounts are made for the whole assembly. These are available for \$320 (plus \$15 for the output shaft) through Robotcombat.com. This combination is also commonly overvolted to 36 volts.

Another option is the high performance motors from Astroflight. These are available with integrated planetary gearboxes, however mounting is still up to the user. Originally made for electric hobby aircraft, they are small and powerful, high quality motors. These motors do not handle excess voltage, so the nameplate specifications are used.

Team Whyachi has machined some custom gearboxes for both the Astroflight motors and the Magmotors. The smallest magmotor gearbox comes in on the large side, but is still small enough to be included in this comparison.

In addition to the 'wheelchair' style motors, NPC offers a kit for smaller robots. This consists off a motor, gearing, output shaft, mounted wheel and support plates. It makes a bolt together drivetrain, and also finds a place in the analysis.

Specifications:

Drive System	Cost	Voltage	Speed, rpm	Stall Torque, Inch-pounds	Weight, Pounds	Notes
Team Delta 18V Dewalt	\$145	18	450 1450	400 124	1.7	Low gear High gear
Team Delta 18V Dewalt		24V	600 1930	533 165	1.7	Overvolted
Dustin 24V Dewalt	\$335 \$320	24	250 2000	550 123	3.7	Low gear High gear
Dustin 24V Dewalt		36V	675 3000	825 185	3.7	Overvolted
NPC K24	\$160	24	900	34	7	Includes Wheel
NPC K24		36	1350	51	7	Overvolted
Astro940P	\$360	24	1080	187	1.6	No mounting included
Astro 960P	\$450	36	830	338	2.25	
Astro 990P	\$500	48	960	463	4	
Whyachi TWA 40	\$365	24	2100	97	1.8	Including Astro motor, shaft and wheel
Whyachi TWA69 w/ Astro 960	\$550?	36	1500	175	2.8?	New product – Prices estimated
Whyachi TWA69 w/ Astro 990	\$600?	48	1475	258	3.5?	Weight estimated too
Whyachi TWM3M	\$620	24	840	878	9.5	Smallest Magmotor

From these specifications, a number of calculations were made. First the peak horsepower was calculated using the formula $HP = (\text{No load speed}) \times (\text{stall torque}) / 252,100$. Then the specific ratings were calculated to derive a value for peak horsepower per pound, and peak horse power per dollar (times 1000). Additionally, the speed was calculated assuming the output shaft was directly coupled to a 4" wheel.

Derived Data

Motor	Peak HP	Speed, mph 4"wheel	HP per \$1000	HP per Pound	Notes
Team Delta 18Vdewalt @ 18V	0.71	5.4 17.3	4.92	0.42	
Team Delta 18Vdewalt @ 24V	1.27	7.1 23.0	8.75	0.75	
Dustin 24V Dewalt @24V	0.98	5.4 23.8	2.93	0.26	
Dustin 24V Dewalt @36V	2.21	8.0 35.7	6.59	0.59	
NPC K24 @24V	0.32	10.7	1.98	0.05	
NPC K24 @36V	0.71	16.1	4.45	0.10	
Astro940P	0.80	12.9	2.23	0.51	
Astro 960P	1.11	9.9	2.46	0.49	
Astro 990P	1.76	11.4	3.52	0.44	
Whyachi TWA 40	0.80	25.0	2.05	0.41	14mph w/ std 2.25" wheel
Whyachi TWA69/960	1.04	17.9	1.90	0.37	
Whyachi TWA69/990	1.51	17.6	2.52	0.43	
Whyachi TWM3M	2.93	10	4.72	0.31	

Comments on the data

The Team Delta 18V setup run at 24V gives the best power per dollar and power per pound of any of the above. The Dustin motor at 36V comes in second in both categories

The Whyachi gearbox with the shortie mag produces the highest power, at nearly 3 horses. The Dustin Dewalt at 36V is not far behind at 2 and a quarter.

The two gear ratios on the TD Dewalt are different by about 3:1, while the two speeds of the 24V Dustin are almost 4.5 to 1. In high gear, the faster Dewalt needs very small wheels to get to a controllable speed.

General comments

The TD Dewalt and the Astroflight motors are a good match to an IFI Victor. Voltages above 24, such as the Dustin, NPC and higher Astro's require a larger motor controller; Vantec, RSG or OSMC.

Only the Whyachi gearboxes and the NPC system are really suitable for mounting and supporting a wheel. The Astros and Dewalts from TD and DCWJ both need an additional bearing support for the live axle. One is available from Team Delta in their part number RCM-200; for an additional \$25 (and ½ pound), this setup would be ready to attach a wheel.

Many of these combinations result in a ‘high strung’ application. The Astroflight motors are known for running very hot, and external cooling is strongly recommended. One of the major changes made to the Dustin motor involves replacing the brush holding plate with a higher temperature material, as these have been known to get so hot they melt in use.

Others are more robust; The NPC system seems to be more tolerant of heat loads, as do the magmotor powered Whyachi boxes. This is somewhat reflected in their lower power/ weight ratios.

NPC has offered their small drive package with a larger motor in the past, but this size is unavailable at this time. Using that motor, the nominal 24V numbers would be comparable to the 36 volt numbers listed in the table, and overvolting would have shown further gains. They have indicated they are working on making a newer, larger motor available.

There are substantial size differences between these arrangements as well; often this is as much a determining factor in motor selection as the power characteristics. The Astroflight motors are the smallest, followed by the Whyachi gearbox and TD Dewalt setup. The Dustin motor is substantially larger, are the NPC and Magmotor version Whyachi boxes largest of all.

All of the Dewalt setups run much higher torque loads than the manufacturer intended when they designed their portable drills. There have been shaft failures reported at the connection of the output ‘axle’ to the gearbox in both configurations. Both manufacturers have taken steps to remedy this – Team Delta has gone to a better material and zone hardens that end of the shaft. The Dustin sticks with plain steel, but uses a dual flat ‘double D’ connection by modifying the output coupling to accept it. Both of these are relatively new upgrades and don’t have enough combat experience to fully evaluate what works and what doesn’t.

Conclusions

Of the drive systems evaluated, the Team Delta 18V Dewalt setup is the clear performance leader. It provides the highest power per dollar, and power per pound. While the part number RCM515 isn’t a complete drive system, the addition of a few parts from the Team Delta catalog allows a builder to quickly assemble a whole robot.

The systems from Whyachi and NPC are also quite complete, performing the function of wheel mounting and including the drive wheels, but they do not match the ‘bang for the buck’ of the Team Delta systems, nor do they match them in ‘bang for the pound’.