Airmaster AP332 Propeller Upgrade from the Warp Drive to the Whirlwind Blades for Your Europa

By Bud Yerly and Jim Butcher

For years the Europa community has satisfactorily flown with the Airmaster using the tapered blade of 62 to 64 inches on the 912 powered Classic, and the 64 inch wide blade on the 912S and 914 powered aircraft. But there were the "my prop is better than yours crowd" who continually berated the Warp Drive blades as horribly inefficient. However, for the 914 turbo owners using an Airmaster AP332 hub with wide chord 64 inch blades, the Europa was hitting 160 knots true at 5500 RPM at 15,000 MSL. Yet this prop was still able to do a more comfortable cruise at 10,000 MSL at 150 knots true in the turbo Mono and 125 in the Trigear with 912S. Virtually the same performance as the "mine is better than yours crowd" when tested head-to-head on the same aircraft, without all the blade shedding and failure excitement of other brands.

What the Europa owners found was the Airmaster Propeller hub was so reliable and the blades were so tough it soon became the most popular constant speed propeller hub used on the Europa kit aircraft and a thousand other experimental kit owners.

Warp Drive Tapered 332

Sensenich 420

Whirlwind 64 inch 332

With the advent of light sport aircraft and European Ultralight Aircraft, many blade manufacturers began building ground adjustable propellers which were lighter and had better blade angles to take advantage of the slow prop turning Rotax 912S powerhouse. Some had unique twisting (flexible) blades, some were very light (shattered), and others were darned popular (cheap) but there was no empirical data on performance.

I spent four years looking into propeller design, programs and history to find out which blade type, twist, length and airfoil would enhance my Europa the most. I worked with both Warp Drive and Sensenich looking for a proper blade design that was optimized for our short 64 inch ground clearance. Soon Sensenich provided a reasonably efficient blade for the 912S. Airmaster was quick to design new hubs, the AP420 and AP430, to take advantage of the Sensenich and other manufacturers using larger diameter shanks on their two or three blades. Flight tests proved the 420 and the Sensenich were a good combination, they were slightly faster, lighter, but with more residual thrust on landing and more expensive. I soon found despite the longer landings, I preferred the noisier two blade prop for ease of cowl removal. However, who would buy a new prop to replace his perfectly good AP332 to save 7 pounds and gain a couple knots in speed just for easier cowl removal?

Whirlwind (WW) was looking into a line of ground adjustable propellers to add a new line to their hydraulic propellers. They used the latest design techniques and developed a blade similar to the Sensenich blade, but using a foam core rather than a hollow blade, which meant a smaller shank about the size of the Warp Drive could be used. Its root twist is still significant but its span loading is more gradual. Over a couple of years they developed a very good all-around prop which proved to be excellent in their ground adjustable hub. The shank size of the WW blade made it nearly small enough to fit the AP332, and they molded a 64 inch blade specifically for the Europa. Airmaster designed and built a heavier steel ferrule to take the stresses of the slightly larger shank yet be slim enough to fit the venerable AP332 hub. The ferrule and blade were about the same weight as the older aluminum ferrule with the Warp Drive (WD) blade, and

this meant the inertia at the tip was less, especially for longer props. Airmaster was quick to test this new combination.

Flight testing of the WW blade was easy. Screw out the WD blades and install the WW. The AP332 ground settings for fine and course pitch were slightly different and, of course, the prop would have to be re-balanced. Once balanced up, testing began using my Trigear and Jim Butcher's Mono as they were both using the AP332 WD blades and were reliable, clean stock aircraft that I know well.

Graphs and charts are boring, but it is what we do. Testing was done flying in similar temperatures and density altitudes. Swapping blades between flight tests was done overnight. I used the test procedure I have used for years which is on the Airmaster website, but is also on my website: www.customflightcreations.com. Three tests per blade set were made and the following discovered:

The Whirlwind climbs no better at 75 or 90 KIAS than the Sensenich or Warp Drive. It seems if you spin any of the blades faster, they all climbed about the same. We verified that a 90 knot vs 75 knot climb only yields about 100 FPM difference in rate, allows better cooling, and the nose is lower so you can see. Example of one set of test data:

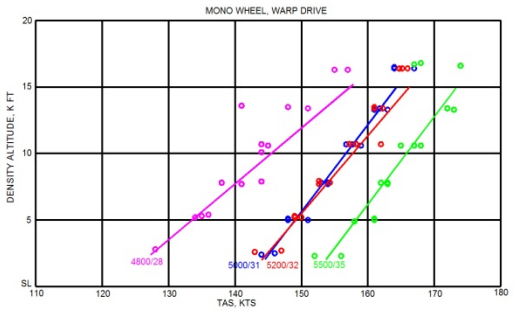
		AP332 WD			
Cruise Data based on power setting: Typical 914 engine					
	TO Temp: 30C		1-Jul-15		
Pressure Altitude	RPM	MAP	Fuel Flow	IAS	TAS
1000	5500	35	6.7	139	144
	5200	32	5.9	132	136
	5000	31	5.4	124	128
	4800	28	3.5	110	114
2500	5500	35	6.7	139	147
	5200	32	5.9	132	139
	5000	31	5.5	128	134
	4800	28	4.1	114	120
5000	5500	35	6.7	134	149
	5200	32	5.9	130	144
	5000	31	5.4	125	138
	4800	28	4.3	118	129
7500	5500	35	6.5	134	154
	5200	32	5.8	129	147
	5000	31	5.5	123	141
	4800	28	4.4	112	128
10000	5500	35	6.4	131	156
	5200	32	5.9	125	149
	5000	31	5.5	120	143
	4800	28	4.3	115	137
12500	5500	34	6.3	127	157
	5200	32	5.9	119	149
	5000	31	5.9	119	148
	4800	28	4.3	111	130
15000	5500	31	6.1	119	154
	5200	29	7.5	118	152
	5000	27.5	5.4	109	141
	4800	26	5	108	141

		AP332 WW			
Cruise Data based on power setting: Typical 914 engine					
	TO Temp: 30C		9-Jul-15		
Pressure Altitude	RPM	MAP	Fuel Flow	IAS	TAS
1000	5500	35	6.7	142	147
	5200	32	6	132	137
	5000	31	5.3	122	126
	4800	28	3.8	113	117
2500	5500	35	6.8	140	148
	5200	32	5.9	134	143
	5000	31	5.5	126	133
	4800	28	4.3	112	119
5000	5500	35	6.7	140	154
	5200	32	6	129	143
	5000	31	5.7	128	141
	4800	28	4.6	122	134
7500	5500	35	6.7	137	157
	5200	32	6.2	127	146
	5000	31	5.8	123	141
	4800	28	4.6	115	133
10000	5500	35	6.8	136	163
	5200	32	6.3	130	155
	5000	31	5.8	123	146
	4800	28	5	111	132
12500	5500	33.5	7	129	160
	5200	32	6.6	124	154
	5000	30	6.3	117	145
	4800	28	5.9	112	140
15000	5500	30.5	6.9	120	156
	5200	28.5	6.7	116	151
	5000	27.5	6.3	112	145
	4800	25	5.6	105	137

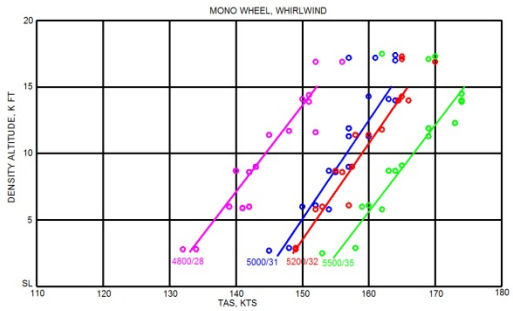
Cruise testing was done at four settings of 28 inches of manifold pressure/4800 Tach RPM, 31/5000, 32/5200 and 35/5500. I used a spreadsheet to keep track of my results as in the databases shown above.

I gave Jim my data and had him do the same basic tests on his Mono. His charts and raw data indicated a small increase in speed also. The prop prefers the higher altitudes as we expected. The course setting in degrees will have to be increased slightly (one turn) as you will be going faster. Interesting to note was the decrease in average fuel flow for the same power setting. This was odd as the same manifold pressure and same RPM should use the same amount of fuel. Granted, it is only a small amount on the average and I attribute it to inaccuracies in the MP gauge and RPM gauges and calibrations of the fuel flow senders. However, the WWs did require less fuel overall and a bit less throttle over the WDs. Another unintentional variation was the dead band of the prop, which is about 30 RPM so although it looked like 5000 RPM was set sometimes we had 5030 RPM which made a bit of a difference also. Jim charted out his and my data by hand because neither of us wanted to configure Excel. See the charts below:

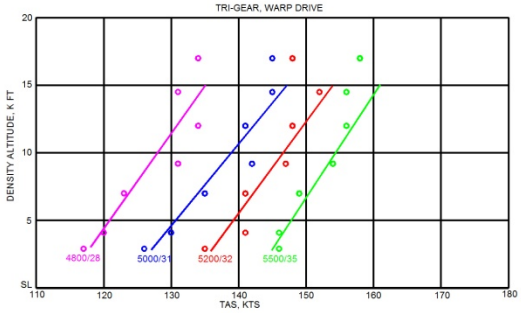
Warp Drive on Mono Chart



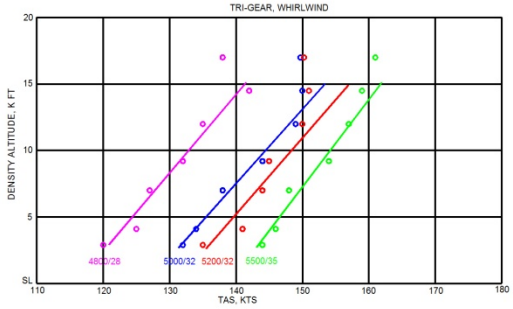
Whirlwind on Mono Chart



Warp Drive on Trigear Chart



Whirlwind on Trigear Chart



Our impressions and performance increases were similar. Overall, the WW blades were slightly faster at altitude, slightly more efficient and have less residual thrust in the flare making airspeed on final and float distance a bit easier to control. The charts may be hard to see in a magazine article so let's summarize. The scatter data points are interesting in that the power settings differ slightly based on the equipment and instrumentation differences in our two aircraft. With 914 engines one would expect the engines to be similar but, of course, they are not, and fuel flows may be slightly higher or lower but the trend data across the board indicates that the flow rates and relative speed differences in the blades are consistent.

The difference between the Warp Drive and Whirlwind in performance may be due to the scimitar shape, but in my opinion, with analytics to verify, it is due to the change in pitch from root to tip and aspect ratio (length over chord) differences between the blades. Slightly less power is needed to generate the same RPM, and the blade pulls slightly better so there is a small speed increase and fuel flow decrease for the same conditions.

For example, on 12AY I see a slightly lower fuel flow, and about 5 more knots at my normal cruising altitude of 10,000 MSL. That works out to be about an increase of 3% in cruise. Not much you say, that is the difference between a polished aircraft and a dirty one, but for an airplane, if the fuel flow and speed are improved, by 3% each, now it makes a difference (no it is not really additive). Consider flying 400 miles at 147 vs 142 KTAS and 5.5 vs 5.7 GPH. That's 14.6 gallons used in my new 20 gallon tank (1.5gal/30 miles for start, taxi, take off, and climb to level off, a cruise for 2.2 hours for 330 NM at 147 KTAS using 12.1 gallons, and one gallon for a slow en route descent at 90 KIAS/45 NM at 2 GPH and a half gallon for the pattern.) That's about 400 NM in a lowly Trigear. Can you do that in a Europa for real? I just did 328 NM with a ten to twelve knot headwind. I counted on my fingers and toes for nearly three hours and landed burning 14.6 gallons. I effectively flew 370 NM. Truth be known, I actually slowed to 138 KTAS (128GS) at 5 GPM into the headwind as we were still well above max range cruise speed for my bird of 95 KTAS at 10,000 which is another article on how I figured that. I adjusted the throttle until the Time Until Empty less one hour on the fuel totalizer and Time en route on the EFIS read the same and just watched the time and gas go by. I could never have gone that far with my Warp Drive blades. It would have cost another gallon of gas cutting into my pucker factor reserve. I prefer to land with fuel still showing in the saddle (2.5 gallons on both the main and reserve side of the tank or 5 gallons). The Whirlwind doesn't give a large increase, but every little bit helps and is less of a payload drain by adding an extended range tank.

Here are the results in Jim's words:

Summary Conclusion:

- **Speed -**The Whirlwind blades are faster, especially at higher altitudes. The difference is small, 2-5 knots compared to Warp Drive blades with 3200 RPM coarse limit setting and 5-8 knots compared to Warp Drive blades with 4000 RPM coarse limit setting.
- **Climb -**There is little difference in the climb performance between the blades. Climb is a bit better with the Whirlwind at high altitude when compared to the Warp Drive with 4000 RPM coarse limit setting.
- **Landing -**We found the airplane easier to land with the Whirlwind blades, probably because they cause more drag or less thrust.
- **Weight -**The Whirlwind blades are slightly lighter than the Warp Drive but the steel ferrule makes the total prop weight basically the same. The starter spins the engine easier and faster for easier starting on a low battery. Any weight reduction is welcome on a Europa!
- **Cooling -**There does not appear to be any significant difference in oil or coolant temperatures. We have noted that with the Whirlwind blades, the access panel in the top center of the cowl (for checking / adding coolant) is flexing up as though the air pressure in the cowl is higher.
- **Appearance -**The Whirlwind blades have a high quality appearance. Our Warp Drive blades have some paint off just inboard of the metal protection strip, so we think the Whirlwind longer strip will be a plus. The shape of the Whirlwind blades (a bit of scimitar, not constant width) is more in line with what one sees on current high performance airplanes.

How do you get these blades? Airmaster has a blade swap program and the price is roughly $3200 US including shipping (exchange rate April 2016). Whirlwind molds a 64 inch for the Europa (WWs normal blades are 68, 70 and the super STOL 75 inches). The blades come clear-coated showing the black carbon fiber through a clear acrylic coat on the front and the back side of the blades are flat coated for glare reduction. The tips are painted white. No other colors are available. Order directly from me at Custom Flight Creations, Inc., the US Dealer, or direct from Airmaster Propellers.

Airmaster is currently working with the LAA for approvals in Britain and other countries which may have regulatory problems with change. We expect no problems as the reputation of the Airmaster is well known, and there are virtually no documented mechanical problems in AP332. If you cruise for long distances and

need just a bit more leg, this is a pretty cost-effective upgrade and doesn't require extensive down time, engine mods, work on cowl, gear, cooling, or paint to achieve.