Flight Testing of Your Europa Equipped with the Airmaster Propeller
By Bud Yerly
Custom Flight Creations, Inc.

Once you've selected the desired blade and hub for your Airmaster constant speed propeller, fight testing begins. You selected your Airmaster Propeller for reduced takeoff roll, better rate of climb, increased cruise speed, and a higher cruise ceiling, so you will be testing all these areas. A definite plan must be followed to verify your performance and organize your data. Each test area may be accomplished on the same sortie, however for consistent data, each test point area must be flown at least three times at or near the same pressure altitude, temperature, power settings, and gross weight to assure repeatable performance data that can be included later in the Pilots Operating Handbook (POH).

The fine and course pitch stops must be set properly. The static RPMs I use are 5650 RPM at full power, and the course limit set to 4800 RPM at full power. These two settings normally prevent an over speed on go arounds, and allow maximum cruise at altitude and does not allow over speed of the engine at Vne at altitudes below 10,000 MSL.

The flight test phase must only be attempted after the airframe is completely safe and the pitot static system calibrated. The propeller must be thoroughly checked out on the ground, dynamically balanced and the engine and fuel system must be in perfect operating condition. If there are any problems with the engine, propeller or air frame, do not attempt testing until the aircraft is completely airworthy and dependable.

Planning begins with research. Numerous books and articles have been written on flight testing, FAA AC90-89a is a good start.

However, performance testing for normal operations is just glossed over in most of these documents. Engine manufacturers produce very limited power curves or tables for the power output vs altitude, OAT, RPM, and fuel consumption. Because of their limited information, performance testing is essential for the experimental aircraft owner who wishes to take his aircraft on long trips to strange fields. Flight testing for performance is not glamorous, it is all about smooth, stabilized, well trimmed flying at precise throttle (manifold pressure) and RPM in smooth air. To assure repeatable data, a checklist of planned power settings and altitudes is essential. Takeoff and landing performance data must be planned just as carefully. Flap settings, rotation speed, and takeoff techniques must be well thought out and consistently followed.

The short field approach and landing is a concern to many pilots operating off of small airstrips. Short field operations require maximum performance of your aircraft in both landing and takeoff. Short field landings will be discussed later.

First, review the POH for the recommended configuration, rotation speeds and minimum takeoff speeds and expand them as required.

CAUTION! The Airmaster will produce a large amount of thrust and can cause a mono or conventional aircraft to tip up on its nose possibly (destroying the propeller) and loss of tail wheel control and a sudden and violent left turn without the pilot holding full aft stick or securely tying the tail down.

Climb angles will also be much higher. Ensure the fuel system is capable of operating at extreme pitch attitudes of 20 to 25 degrees, or the engine may fail due to fuel starvation (especially at low fuel levels). At hi angles of climb near the ground an engine failure will require a very large and very aggressive pushover from 10-20 degrees nose high to nearly 20 degrees nose low to be able to preserve sufficient airspeed to round out and flare.

In absence of detailed manufacturer's recommended minimum roll takeoff and best angle of climb procedure, it is best that the aircraft be fully flight tested in the air using normal takeoff techniques until safe max climb airspeeds can be ascertained. It is always best to start three mistakes high (about 3000 AGL) for airspeed and stall tests. To establish the minimum takeoff speed, slow to near stall speed for the configuration and then apply full power and rotate to the test climb speed. Record the climb rates when stabilized at each test speed.

Recording the data for the testing is not easy. The best “hands off test recorder” is an inflight camera and intercom recorder system mounted in the cockpit such as GO PRO or CONTOUR to allow the test pilot to fly, video his flight and record comments. Prepare simple spreadsheets to record your data as the videos are reviewed.

Post flight review of the video will reveal instrument readings, but also the running video time will verify climb rate and the test point accuracies.

During video review, the data points can be entered on a simple spreadsheet similar to the ones in the text below.

With video all instruments are visible and your comments with a running clock is availble.

	CLIMB SPD IAS	CLIMB SPD TAS knots	CLIMB SPD TAS fpm	RATE OF CLIMB fpm	Approx. angle of climb
	55	57	5774	900	8.5
NO FLAP	65	67	6787	1100	9.2
DATA	70	73	7395	1000	7.6
	75	78	7901	700	5
FULL FLAP	50	52	5267	800	8.5
DATA	55	57	5774	700	6.8
	60	62	6280	700	6.3
	65	68	6888	500	4.1
	70	73	7395	400	3

Normally the Airmaster propeller at best rate of climb speeds will cause the nose to be quite high.   A cruise climb is often preferred, which allows the nose to be lower giving the pilot a better view and promotes better engine cooling. A simple test comparison chart profile for determining the difference in rates of climb is shown below.

	Climb Speed 75					Climb Speed 90		
Altitude	Time on Tape	Delta	Rate		Altitude	Time on Tape	Delta	Rate
1000	10:37				1000	48:38:00		
2000	11:41	1.05	952		2000	50:50:00	1.2	833
3000	12:44	1.05	952		3000	52:15:00	1.4	714
4000	13:52	1.20	833		4000	53:33:00	1.3	769
5000	14:48	0.97	1030		5000	54:47:00	1.3	769
6000	15:57	1.15	869		6000	55:57:00	1.16	862
7000	17:02	1.10	909		7000	57:05:00	1.13	884
8000	18:04	1.02	980		8000	58:07:00	1.03	970
9000	19:19	1.25	800		9000	59:30:00	1.38	724
10000	20:30	1.20	833		10000	1:01:57	1.45	689
			8158					7214
			AVG 905fpm				AVG 801fpm	

In our testing, we perform cruise performance checks at 1000 feet, 2500, 5000, and every 2500 feet there on until the operational ceiling of the engine or airframe is reached. For the Rotax 914 that is approximately 15,000 feet at full gross weight (however flight to 25,000 is possible), and for a normally aspirated Rotax such as the 912 or 912S, maximum operational altitude is 10,000 to 15,000 feet. Above that altitude, the rate of climb will diminish significantly unless at very light weight.

Cruise speeds are tested at the engine's maximum continuous operating RPM and manifold pressure (MP), then at the manufacturer's recommended cruise RPM and MP. Manifold pressure for max continuous for the Rotax 912S is normally 26 inches near sea level and for the 914 it is 34 or 35 inches depending on the year group of the engine to 15,000 feet.

Other settings may be chosen based on the smoothness of the Airframe/Rotax engine and Airmaster propeller combination which yield desired range/endurance numbers. For the Rotax, 5200RPM/32" works well for headwind penetration, 5000/31 is recommended cruise, and 4800/28 is a smooth economical cruise for the aircraft tested.

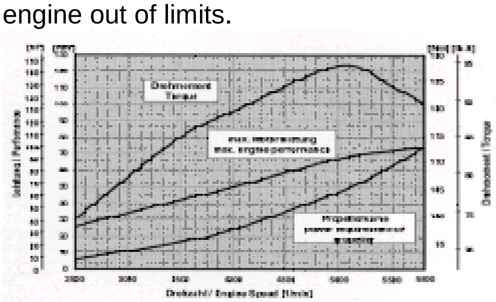
Selecting the power setting other than CLIMB or CRUISE is a simple matter of setting the MP with the throttle then selecting HOLD on the AC200 and adjusting the FINE/COURSE switch to attain the desired RPM.

See the example spreadsheet below to see how to organize your cruise data:

Pressure Altitude	RPM	MAP	Fuel Flow	IAS	TAS	Milage NM/Gal	OAT
1000	5500	35	6.8	141	146	21.47	27
	5200	32	5.8	131	135	23.27	
	5000	31	5.2	122	126	24.23	
	4800	28	3.8	114	117	30.78	
2500	5500	35	6.8	138	146	21.47	25
	5200	32	6	134	141	23.5	
	5000	31	5.5	122	130	23.64	24
	4800	28	4.6	113	120	26.09	
5000	5500	35	7	135	149	21.29	20
	5200	32	6.3	128	141	22.38	
	5000	31	5.7	123	135	23.68	
	4800	28	4.6	112	123	26.74	
7500	5500	35	6.8	133	154	22.64	15
	5200	32	6.3	128	147	23.33	
	5000	31	5.8	123	142	24.48	15
	4800	28	4.9	114	131	26.73	
10000	5500	35	7.3	131	156	21.37	11
	5200	32	6.7	124	148	22.09	
	5000	31	6.2	119	141	22.74	
	4800	28	5.4	112	134	24.81	

Propeller operations must be planned with regard to the engine power charts. Those charts are not as complete as we would like. The operator must maintain RPM and Manifold pressure between a certain range mandated by the engine manufacturer. In the case of the Rotax 91X series engines operation must be maintained between the HP available and propeller power requirement lines is depicted. Operation outside of these lines may cause the engine to lug causing piston slap or detonation.

Note: Manifold pressure will decrease with altitude in normally aspirated engines. The normally aspirated engines are best run at wide open throttle at altitude and at RPMs recommended by Rotax. That said, it is not always economical. Follow the chart and note the manifold pressure/fuel flow and RPM desired by the propeller curve. This gives ideal specific fuel consumption in most cases. This is a result of the Bing carb needle dropping lower in the throat, leaning the mixture. However, EGT must now be carefully monitored to prevent operating the engine out of limits.



With the turbo charged engines, manifold pressure can be maintained up to the operational ceiling on a standard day. It is very important to know the temperature and density altitude for testing. On a day at 15 degrees hotter than standard, even a turbocharged engine will lose MP near the operational ceiling. When the propeller RPM is decreased from CLIMB to CRUISE you will note the manifold pressure fall off as the turbo can no longer get sufficient exhaust flow to turn fast enough to keep the boost at its recommended settings. Record the information and attempt to test fly at or near the same takeoff temperatures and pressure altitudes in subsequent tests.

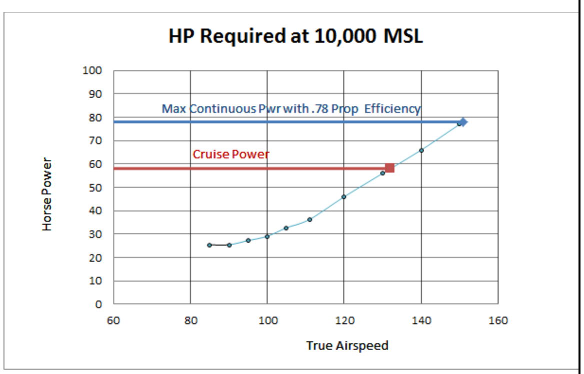
The Europa is a relatively fast aircraft. As speed increases, if the propeller is not able to hold your desired RPM at high power settings (prop speed increases beyond the setting), your course setting is too fine. Increase your course stop setting on the ground by two degrees (about 34 degrees). However, be sure to check that if the prop is stuck at the course limit, it can still spin up to 5000 RPM for go round capability. As a technique, we dive to Vne in cruise to check the controller will maintain 5000 without hitting the stop.

For maximum endurance simply follow the recommended maximum Lift over Drag (L/D max) airspeed provided by the airframe manufacturer, which is also your best engine out glide speed. To test, slow the aircraft to that air speed and note the manifold pressure and rpm required to maintain un-accelerated flight. Keep in mind the constant speed propeller with 914 engine will not be able to hold 5000 rpm at cruise when the manifold pressure is pulled well below 28 inches of manifold pressure.

Example: Let's say the best glide speed (L/D max) is 75 knots. Consider testing at 70, 75 and 80 knots to see which gave the lowest power setting to maintain level flight. This airspeed will be the maximum endurance airspeed. If 70 knots requires less power than the recommended 75 knots, do not be confused, your deck angle and propeller are actually contributing to the lift of the aircraft. As a result one may obtain better performance than your manufacturer's normal fixed pitch propeller numbers in the POH.

During deceleration or descent conditions, the Airmaster constant speed propeller will move to its fine stop limit when the throttle is pulled back below normal cruise manifold pressure. The braking from the propeller wind milling can cause some airframe vibration. The Rotax gearbox has a small amount of gear lash and when the wind milling propeller and engine speeds are nearly the same, the gear box prop shaft begins to unload. This is felt as a vibration. To test, climb back to altitude and reduce power to at or near L/D max. Continue to reduce power until the vibration is felt. Select MANUAL and move the propeller FINE/COURSE switch to a course setting. The increased coarse prop setting should stop this type of vibration.

We engineers prefer to determine zero thrust drag polars. This is easily done by reducing power, turning off the ignition and feathering the propeller. Glide speeds and rates of descent for a specific altitude are recorded and calculations made to determine the HP required for the airframe. These drag polars allow a method to obtain the exact L/D, maximum range, etc. An example is seen below:



Note the chart above the engine HP available and required actually are very precise. This allows you to optimize your cruise. A line from Zero airspeed to the tangent of the line yields the exact max cruise speed for maximum range.

Short field landing techniques must be flown at safe approach speeds, precise flap settings and be flown from a stabilized approach at the same weight, with the same flare technique for proper testing. The POH is instrumental in setting techniques and procedures to begin your test planning.

The normal or short field landing pattern should be planned to enter at the speed identified in the POH. In absence of manufacturers guidance, use the flap limiting airspeed.

Final turn speeds should be planned to be at or near best glide speed for safety and a longer than normal final approach to be planned to stabilize the final approach speed and angle.

In the landing checklist, we recommend setting the propeller to either Climb or Take Off. Either of these settings are ideal for a potential go around situation. With the propeller in either of these settings, the propeller will drive to the fine pitch stop at low power settings. This will reduce the amount of thrust the propeller provides on final approach, allowing a slightly steeper approach, less float distance and a shorter landing roll. Airspeed bleed off in the flare may be slightly higher than with a fixed pitch cruise propeller.

Note that a small amount of power, even in fine pitch, will increase airspeed and RPM quickly as the RPM will build faster in fine pitch than an equivalent fixed pitch propeller set at cruise pitch. This effect may cause an undesirable increase in final approach airspeed on short final increasing float distance and landing roll out distances. This rapid rise in RPM in a go around or a planned touch and go landing may cause an engine over speed unless the fine pitch limit is set properly. Also a long float distance, *may eat up more runway than planned leaving insufficient stopping distance.*

Pilot workload is increased in the short field landing. Obstacle clearances (fences, trees, etc.) can distract from runway aim point and airspeed control. Testing must be conducted in a benign runway environment to properly learn the techniques, power settings and approach angles suitable for your aircraft. Some aircraft (especially those equipped with vortex generators for better slow speed handling) may develop slow speed approach angles that the pilot cannot arrest before impact.

Caution also must be exercised as failure to monitor your airspeed on final with full flaps and gear (Mono) may lead to sink rates which even full power will not quickly arrest.

Start the short field approach test at a normal approach speed of 65-70 KIAS, and 3 degree angle of approach and slowly decrease the approach speed to the minimum speed from which a safe flare can be accomplished. Then change the approach angle for the normal approach speed and test the round out and flare from the different approach glide path angles required by over obstacle approaches.

Plan to do low approaches and go arounds as trying to land out of a non-stabilized or non-standard practiced approach can end in a hard/short/long landing until proficiency improves.   My technique is to slowly adjust the final approach speed to achieve from 60-65 KIAS on final on a glide path to clear the obstacles then adjust the aim point to the threshold and allow the speed to bleed off to no lower than 55 KIAS so as to allow a safe round out for each approach angle. I hold power and round out to level flight in ground effect, inches above the landing surface at 50-55KIAS. Then pull off the remaining power and continue the flare to a tail wheel first landing about 45 KIAS in a Mono, and the same angle of touchdown speed in the Trigear.

Installing stall strips properly adjusted for a wings level buffet 5 knots prior to the full flap stall, keeps the pilot honest and out of trouble. One will feel the rumble rather than watching the airspeed which is impractical during the round out and touchdown.

The only way to make consistent short field approaches and landings is from a stabilized approach at a tested approach speed and angle that the pilot has practiced many times.

Earlier I stated that performance test flying is not glamorous, but it is rewarding. During this phase keep airframe modifications to a minimum to assure consistent test results. By flying consistent test procedures, you are properly testing your aircraft, increasing your proficiency and verifying your aircraft's flight characteristics. Once complete, modify the POH with your flight performance data and enjoy your aircraft. The work you do now and the new expanded data for your POH will make future flight planning and strange field landing a breeze.