Flight Testing
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16.0 - Chapter Preface

16.0.1 - Parts List
This chapter requires no parts.

16.0.2 - Tools List
This chapter requires no tools.

16.0.3 - Supplies List
This chapter requires no supplies.

16.0.4 - Glass List
This chapter requires no glass.

16.0.5 - Process Overview
This chapter has no processes.
16.1 - Final Preparation

16.1.1 - Placarding and Markings

Now that you have done everything in the preceding sections and chapters, sometimes at least twice, it is time to get into the fun part, taxi and flight testing your aircraft! It is very important that everything in Chapter 14 has been done, and has been rechecked by another person.

A recommended reference for this phase in your project is the Custom Built Sport Aircraft Handbook. This is an E.A.A. publication dealing with safety and design and the licensing process. There is a nice safety checklist to guide the builder through the pre-first flight inspections. The FAA has a book called Amateur Built Aircraft Reference Material that is most of the FAA publications that would be useful to a builder. Also check out AC90-89A Amateur-Built Aircraft & Ultralight Flight Testing Handbook.

The necessary inspections by the F.A.A. must be done before going into flight testing, and the federal regulations pertaining to the aircraft must have been complied with.

- Final inspection air worthiness certificate issued and displayed.
- Operating Limitations (Issued by FAA Inspector.)
- N numbers properly displayed.
- All warning and identification plates must be properly displayed.
- Accurate weight and balance completed and analyzed.

The following are a few hints concerning the inspection of the aircraft and how to deal with F.A.A. inspectors:

1. N numbers must have characters at least 3" tall and a color contrasting with that of the fuselage. On our factory aircraft they are displayed horizontally on the lower winglets. (Don't use Duct Tape.)

2. Experimental passenger warning and ID plate displayed on the inside of the door just above the hinged side. These are 4" x 24", and should be clearly visible when the door is open.

The plates and placards are available at aircraft supply houses such as Wicks and Aircraft Spruce.

3. External ID plate is a small aluminum tab approximately .060" thick, 3/4" high, and 6" long. It contains the following information:
   - Aircraft Type - Velocity XLRG
   - N-number
   - Serial Number.

We rivet ours to the pilot side just forward of the cowling cut line.

4. An accurate weight and balance in the aircraft to show to the inspector. This is necessary to obtain a certificate of airworthiness.

16.1.2 - Inspections

It has been our experience that many federal inspectors lack in-depth knowledge of this type of aircraft construction and configuration. Therefore, they tend to overlook many things that are of critical importance to the airframe, and concentrate instead on areas where they are knowledgeable and experienced such as powerplant, hardware, and paperwork.
The inspector can be extremely helpful with fuel systems, wiring, and other systems common to production aircraft. They are also bound by their authorities to have the proper paperwork. When you call for your inspection, make sure that you have all the necessary paperwork completed and complied with. These guys are really good fellows, and can be very helpful but, help them by having everything ready when they get there.

Though not mandatory, it is advisable that you enlist the aid of a representative of your local E.A.A. chapter who is familiar with composite construction. Get him to come and inspect your aircraft during the various stages of construction, as well as just prior to first flight. This will give you some peace of mind, and you'll probably make a new friend.

Check with him to see if he knows of anyone locally operating a Rutan-type canard aircraft or Velocity that would be interested in giving you some pointers, or might be willing to assist you in your first flights. This might be accomplished by a couple of flights in his E-Z or Velocity.

Depending on if you are planning on getting insurance or not you may require an Insurance Inspection. Velocity has several inspectors around the country that are knowledgeable individuals who have built Velocities themselves. This inspection is a good idea even if you do not require it for your insurance company. It is a good idea to have a person experienced with Velocities to double check your work.

16.1.3 - Pilot Qualifications

We find that the total hours logged is not as important as the number of different aircraft flown when transitioning to the Velocity. A person who has been flying a Cessna 172 all his life, say with 10,000 hours, will have a harder time than a reasonably low time pilot who has experience in many different aircraft.

It is very important to be current and fly frequently in the few months prior to your first flight in your Velocity. Many builders concentrate on the construction of their aircraft and let their piloting skills deteriorate. Keep flying, even if it means putting down the sandpaper for a few hours a week.

Velocity offers a flight training program at the Factory for its builders. We will take you through two to three hours of ground school. After familiarizing the builder with the flying characteristics of the Velocity on the ground it is time to do some flying. We start off with basic air work then transition to takeoffs and landings. After a pilot has mastered landing the Velocity we will go through emergency procedures and first flight procedures.

We at Velocity want every builder who is finishing up their Velocity to get a factory check-out. A month or less before you are ready to fly your Velocity is when you should get a check out. This will keep the training fresh in your mind while you are making your first flights. Most insurance companies have now also made factory checkouts part of their requirements as well. We require a few things for a pilot to come to Velocity for training.

* Own a Velocity (We get many requests for training from pilots without airplanes.)
* Have a current biannual flight review.
* Flown 10 hours in the last 3 months (preferably in a high performance airplane.)
* High performance checkout (This is not required if you own a Standard body fixed gear with a fixed pitch propeller.)

It is unfortunate, but the first flight record for experimental aircraft is not that great. It usually is not the fault of the aircraft involved, but rather points to the fact that many of the pilots involved in these incidents let their flying skills deteriorate while constructing the aircraft. In many cases, the pilot was unaware of what to expect when the airplane took to the air. So practice and don’t feel compelled to fly the aircraft until you and it are completely ready. The next section is a true account of what happened when taxi testing the first Velocity.
16.1.4 - True Story

Written by Dan Maher

After spending seven months building the prototype Velocity, I was a very low time pilot with perhaps 120 hours, and had been doing very little flying while working on the prototype. I had the cards stacked against me in the piloting department, not to mention that many of the self-proclaimed authorities on canard aircraft warned me that the Velocity would not fly, and if it did, it would certainly crash.

Being a level headed fellow, I purchased a parachute and hired a professional test pilot to perform the initial flight testing in the aircraft. One day, when the weather was good, I decided to taxi test the plane to check the brakes, elevators, rudders, etc. for the test pilot. The test went something like this ... first run down the strip, 45 knots, everything OK.

Second run down the strip, 55 knots, oops, flying. Gotta get down, pull the throttle back, engine idling too fast, speed building, runway ending, go around! First pass on final, airspeed is 90 knots and accelerating, engine idling, go around again.

Finally, third pass, mile final, mags off, beautiful landing. “Where’s the bathroom?” First flight. Parachute is safe and sound at home in the closet. Test pilot is 200 miles away. What am I doing here? Boy, am I lucky. Since that first flight, the aircraft has flown beautifully, and I have enjoyed over 300 hours in it since without experiencing a problem. Talk about a lucky fool.

This stuff does happen, but don’t let it happen to you. You might not be as lucky as I was. Be prepared, and if there is any doubt, swallow the big ego and let a competent professional perform the initial flight testing. I find that these guys enjoy this work, and excel at it.

* * *
16.2 - Testing

16.2.1 - Taxi Testing

Make sure that all your inspections have been done and the airplane is ready for flight. Make sure you have adequate braking before you get too fast with the airplane. Watch your engine temperatures and pressures. It is not a good idea to do prolonged ground running on a new or rebuilt engine that hasn’t been broke in yet. If an engine is run for too long a period of time on the ground before it is broke in you can glaze the cylinders which will lead to high oil consumption. Keep this in mind and keep your ground run short.

_All taxi testing and early test flights are done with wheel pants removed._ This helps prevent overheating of the brakes and therefore the main gear adjacent to the brake disk. This testing should be done at speeds of less than 40 knots on a good, hard, smooth surface, free of loose gravel, etc.

Select a day with minimal wind and light traffic, if possible. Make sure that brakes and rudders are working correctly, and that your seat is in such a position that you have optimum visibility yet can work the brakes without any problem.

All taxi testing must be done within the first flight CG box. Put approximately 10 gallons of fuel in each main tank, and allow the fuel to settle into the sump. Park the aircraft on a level surface so that the fuel will distribute itself evenly.

During low speed taxi maneuvers, you should get used to the feel of your aircraft on the ground. Pay attention to how the brakes work, how the nose wheel responds, when the rudders take effect, etc. We have found that during low speed taxiing, it is better to jab the brake to turn the nose wheel, rather than riding the brake and inducing break wear and heat buildup. Spend a couple of hours, and get familiar with the effects that crosswinds or variations in runway / taxiway surfaces will have on your Velocity. Once you are satisfied:

- Remove your cowl and check for leaks or other problems.
- Check your brakes again. Bleed again if necessary.

16.2.2 - High Speed Taxiing

When you begin high speed taxi testing, you should have at least 4000’ of good, smooth, clear runway to work with. Weather conditions should be calm, no crosswind, and there should be little or no traffic. Early morning is a preferable time for these operations.

Remember, _no wheel pants_ during taxi testing.

Other canard aircraft designers suggest that you do the tests we recommend in two other aircraft first. We think this is an excellent idea. You are provided with the opportunity to experience a few strange, new maneuvers in an aircraft that you are familiar with and feel comfortable in.

You will need a lot of runway to accelerate to speed, maintain that speed, then decelerate. Set your pitch trim to neutral and the roll trim to neutral.

Run your taxi tests in increments of 5 knots, beginning with 30 knots and ending at 50 knots. At 50 knots, the Velocity might rotate if full aft stick is applied, but the aircraft will not lift off. Do not rotate at this time, just make numerous runs by accelerating to desired speed, then reducing power to idle, and then feel the aircraft out.

Allow sufficient time between runs to cool brakes and landing gear. It is a good idea to get under one of the wings and lift the airplane until the wheel is off the ground. This will help remedy the tendency of the gear to creep. You also want to keep an eye on your engine temperatures. You do not want to do prolonged ground running because the engine does not get the cooling air it needs at these low speeds.

Operate the ailerons, rudders, elevator (slightly), and the brakes. Practice reaching the desired speed and maintaining it with small throttle adjustments. You will be surprised at how little power is necessary to maintain speed in a Velocity.
Caution: Be sure that the engine is idling below 900 RPM.

This is a good time for you to establish a visual reference of where 0 degree attitude is in relationship to the horizon, as well as the elevation of the pilot and the aircraft from the runway surface. This will be very useful in determining flare height when doing landings. Don’t short change yourself, spend a day performing these exercises. It will be time well spent.

16.2.3 - High Speed Taxi Nose Wheel Liftoffs

To proceed into this phase, you must master the technique of reaching a speed and maintaining it until braking. Nose wheel liftoff speeds will vary from one aircraft to another, depending on gross weight and CG placement. Make sure that your CG is in proper position at this point.

To find your rotation speed, accelerate to approximately 45 knots, pull the power back to maintain speed and slowly pull the stick back. If rotation is achieved, slowly relax the stick and let the nose wheel settle. Do not force the stick forward quickly. If rotation is not achieved, go back around and repeat this procedure approximately 3 knots faster. Repeat the procedure until rotation is achieved.

The Velocity will fly shortly after rotation. Some canard aircraft will rotate 10-15 knots before flight. The Velocity, however, flies a lot sooner. The placement of the main gear makes it possible for the Velocity to fly approximately 5 knots past rotation speed, unless the aircraft is very heavily loaded.

Be sure the power is back when you try to rotate. Once rotation speed is determined, practice holding the nose gear just a couple of inches off the ground, maintaining power, then letting the nose wheel settle gently to the ground while relaxing back pressure and reducing power.

Do not over rotate. If you do, reduce power and let the nose down gently. Practicing the art of holding the nosewheel slightly off the ground will give you a good hand on controlling the pitch of the aircraft.

Note: Do not allow the aircraft to exceed 60 knots during the preceding exercise. Be sure that you do not rotate the nose too high or you will be flying.

When you feel that you have things under control, set your elevator trim to the position where it will assist you in holding the nose slightly off the ground, but will not add enough correction to cause the aircraft to over rotate. It will be necessary for you to assist the trim to induce rotation, but once rotation is achieved, the trim should hold its own. At this point, stop the aircraft and note the position of the elevators and the stick. Set the trim at this position for the first flight.

16.2.4 Runway Hops

If you have sufficient runway you can do a runway hop after you have mastered the high speed taxi skills. A Velocity can rotate as slow as 50 knots if the power is pulled back so we have to be ready to fly at any speed over this. You have to understand as the pilot in command that if you get into a situation where you are airborne and running out of room you may have to add power and fly the airplane.

As you are doing your high speed taxi tests you will reach a speed where the airplane will start to feel light and want to try to lift off the ground. The Velocity will rotate at a slower speed with the power pulled off than with the power on. This is because the thrust line of the aircraft is slightly higher that the centerline of the airplane.
As you did with your high speed taxi tests accelerate down the runway until you reach between 55-60 knots reduce the power to idle and increase back pressure. After the nose has lifted off the ground it does not take much more angle of attack to get the mains off the ground. Be careful not to over rotate. With the power at idle you should have enough momentum to hop into the air for no more than 5 feet. When you are in the air pay attention to the roll and yaw characteristics of the airplane with the stick centered and no rudder input. If you notice the airplane roll or yaws you can shim a rudder or a wing to correct this now. I find it better to experience a problem at 5 feet off the ground and correct it rather than on my first flight when I am hundreds of feet in the air.

### 16.2.4 - First Flight

The wheel pants should be off for your first flight in the Velocity. Check your tires, brakes and shimmy damper. Are you ready? If not, get some rest, wait for good weather, and keep reminding yourself that you spent a lot of time and effort getting to this point - don’t rush into it! If there are any squawks or nagging problems in the aircraft, fix them now.

There are many things that a pilot should think about before flying an airplane for the first time.

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Evaluate your airport. Make sure you use the longest largest airport that is available to you. If you have to take the wings off the airplane and trailer it to a better airport than do it. An ounce of prevention may keep you from pulling your airplane out of the weeds.

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Know the surrounding area. If you have a runway that on one side faces a town and the other end faces a field take off towards the field. I make sure I know the area around the airport and before I fly I have figured out what I will do if I run into a problem at any altitude and any point around the airport.

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You want to make sure you have the right weather for the first flight. You want a no wind condition. If you have a lot of wind it is hard to evaluate if an airplane is rolling or yawing because the airframe isn’t straight or because the wind or turbulence is moving you.

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I find it best to just have a small support crew with me as I perform a first flight. If you have alot of people watching a first flight it puts more pressure on the pilot. You will have enough pressure and things to worry about already.

The following will brief you on what to expect in the way of differences between the Velocity and conventional aircraft.

- **Rudder / Brake** - both rudders can be deployed at the same time in the Velocity, so take care not to do so in flight. It is advisable to remove your feet from the pedals during flight in order to resist unintentional yawing of the aircraft. Remember to relieve the pressure on the rudder pedals at point of touchdown so that you don’t inadvertently land with the brakes on.

- All aircraft fly differently. Some are loose and sloppy while others are tight and precise. The Velocity responds to pitch and roll inputs immediately and the smallest increment of input will be felt. Be sure to avoid overcontrol of the aircraft, especially when dealing with pitch. Use your trim to stabilize the aircraft. We have found that over rotation is a mistake that beginning pilots tend to make. Once the aircraft rotates, relax slightly on the stick pressure and let the aircraft fly itself off. Keep the canard well below the horizon.

Your first liftoff should be very conservative. Climb out at 100-110 knots, stay very close to the airport and do not do anything foolish.

Limit your airspeeds to 140-150 knots. Trim your aircraft for hands off flight. There is very little trim change when power is applied or reduced.

On a retractable gear airplane I prefer to retract the gear on the first flight. This allows me to fly fast enough to keep the engine cool. In order to have enough confidence in the RG system I will have done over 50 retracts with the airplane on jacks to make sure it works properly.
Spend your first flight feeling out your pitch, roll and yaw responses. Pay especially close attention to your engine RPM, temperatures, and pressures. If it looks like a potential problem is developing, land and check it out immediately.

A good approach speed is approximately 85-90 knots, and touchdown with a slight flare at 70-75 knots. We suggest that you fly the aircraft on to the runway on your first few landings, but take care not to put the nose wheel down first.

After your first flight, take a couple of hours to go over your aircraft thoroughly.

- It is advisable to flush your fuel system and clean all the fuel filters.
- Check for signs of leaking oil, chafing of wires or hoses, and any evidence of any type of overheating.
- If there is a problem with the aircraft trim, such as a tendency to roll or yaw, investigate and make the necessary adjustments before your second flight.

Aircraft are not like us, they do not heal themselves. Small problems seem to get worse with the passage of time, and sometimes lead to other problems.

Once all the bugs have been dealt with, it is time to do some more flying. Get used to the aircraft. Keep it within the CG box prescribed for the first flight for at least the first ten hours of flight. Do not exceed 150 knots indicated. Practice your approaches, departures, and pattern work. Get familiar with the effect that your speed brake has on your glide path.

Remember that you have 25-40 hours of restriction to fly off, so make good use of the time. Get familiar with all aspects of your Velocity. As you expand the flight envelope, document the performance limitations and restrictions that you personally place on your aircraft. Spaces are provided in the Owner’s Manual for such documentation. Remember - no operations outside the envelope established by Velocity Aircraft. Feel free to limit your aircraft within the box. First Flight

### 16.2.5 - Envelope Expansion

We suggest that you wear a parachute during all flight testing. Remember that you have approximately 40 hours of restricted flight time, so use it wisely.

40 hours is enough time in which to complete a very professional test flight program and acquaint yourself thoroughly with your aircraft without leaving the area of your home field. When you start adding or removing weight to the aircraft do so in small increments, and calculate your CG as you do so in order to avoid going outside of the flight envelope. If at any time you feel uncomfortable about the weight or CG be sure to limit your aircraft accordingly.

When attempting pitch bucks (canard stalls), maintain at least 6000 feet AGL. Approach the pitch buck while maintaining altitude. Slowly bring the stick back until minimum speed is achieved. Pitch buck speed will vary from approximately 55 - 63 knots (light load) to 65-70 knots at heavy load with a forward CG.

Your aircraft will exhibit different stall characteristics under different CG and weight combinations. Usually, when the load is light and the aircraft is in the middle CG range, it will just mush. As the weight increases and the CG moves forward, the stall should become a slight bucking action. This is a good thing to take note of as you do not want the aircraft to do this while landing.

Record the type of stall you encounter at a particular speed as well as the weight and CG position at which you were flying. Familiarize yourself with the various stall characteristics, it can be valuable in setting up your landing speeds.

As a rule, I use approximately 10 knots above liftoff speed for a touch down speed. We generally use 100 knots in the pattern and 90 knots on approach.
When you are flying with new weights and CG conditions, make a mental note of the liftoff speed and take it into consideration during approaches and landings. If you are operating in crosswinds or gusty conditions, carry approximately 10 knots extra speed.

Once you become more familiar with your aircraft, you can adjust your approach and landing speeds to whatever you feel comfortable with.

Check the CG location of the aircraft, and placard your aircraft to limit your CG box forward of this point. During our flight testing, we use 100 pound bags of sand wrapped in plastic and duct tape. They are held in place in the seats with the seat belts and some rope. The only problem is that sand does not sit in a seat, and its CG will be several inches forward than that of a human body.

The best way to correct for this is to mark the center of the bag, weigh the bag, and measure its distance from a bulkhead, such as the instrument panel or the firewall. Add or subtract this dimension to find the arm of the sandbag. Multiply the arm by the weight to find the moment, then plug the moment into the formula to find the resultant CG of the aircraft. I find personally that the bags of sand don’t complain much.

During this phase of envelope expansion, it is very helpful to record things like rotation and liftoff speeds and distances, best rate of climb, best angle of climb, landing roll, distance over obstacles, etc. Because of differences in finish, construction, and engine and propeller combinations, each aircraft will perform differently. It is therefore very important to know and document your particular aircraft.

Specifications from our factory aircraft are listed to give you an idea as to what to expect. You will find that the propeller is usually the culprit when large changes become apparent in some performance areas. When choosing a propeller, decide what kind of conditions, weights, and distances the aircraft will experience most of the time.

16.2.6 - High Speed Flight Envelope Expansion

Flutter

Prior to this procedure ask yourself, “Did I balance those elevators and ailerons properly?” When flutter occurs, it usually begins in a control surface. We have never experienced any problems with our aircraft in this regard, but we do take great care when balancing our control surfaces. For this particular test, maintain at least 7500 feet AGL and wear a parachute.

There has never been a Vne established for the Velocity, since each aircraft will be built differently and will have its own Vne. We placard our aircraft at 200 knot redline. This will keep you within the design limitations of the aircraft.

When expanding your envelope, begin at 150 knots and kick the rudder, jab the stick left, right, forward, and aft. The controls and the aircraft should return immediately following each input. Any movement other than straight and level in the airframe should cease. Add 5 knots and repeat the procedure.

When entering speeds that your aircraft will not maintain on straight and level course, dive the Velocity, level her off, and repeat the control inputs. Keep a close watch on your engine’s RPM. When you reach a point that your controls begin to act differently, or do not damp out like the time before, STOP!

Don’t go any faster. Land the aircraft and check the suspicious control. Check the balance and solve the problem prior to progressing on to a test conducted at a higher speed. If you are satisfied with this speed, placard your aircraft for 5 knots below it. Do not expand the envelope beyond 200 knots indicated.
16.2.7 - Flying the Velocity

Once in the air, you will find that your Velocity will fly much like any conventional aircraft. One thing that you will notice is the absence of any adverse yaw. This allows you to operate your aircraft without the use of rudders. Approximately 95% of your flying will be without the use of rudders, which are mostly used for taxiing and for control of the yaw of the aircraft just prior to touchdown. The XL’s will use more rudder than a standard wing Velocity at pattern speeds to keep turns crisp.

16.2.8 - Crosswind Landings

In a crosswind landing, it is best to crab the aircraft down on final, and just before touchdown, use a little rudder input while in ground effect to straighten things out. It is all right to land the Velocity in a slight crab, as the aircraft will immediately straighten out once contact is made with the ground.

I feel quite comfortable in crosswinds in the 15-25 knot range, and have landed in crosswinds exceeding 30 knots. I do not slip or cross-control the aircraft. Velocities do not have as much side area as most conventional airplanes. You will pick up as much speed in a slip in a Velocity as you will pushing the airplane over in a dive that is of the same pitch attitude. We do not recommend slipping as a crosswind or descent procedure in the Velocity, it could turn into a potentially dangerous situation.

First, there is the possibility of stalling a winglet which could result in a departure. Secondly, when slipping an aircraft with swept wings, the wing opposite the direction that the aircraft is being slipped, or the forward rear wing, is more perpendicular to the relative wind. This gives the leading wing more leverage and lift than the trailing wing, thus allowing the possibility that the aircraft could be forced into a stall during exaggerated cross-control and slow flight. Thirdly, with the majority of the fuselage being forward of the wings, there is a chance that the fuselage could blank out the wind to the trailing wing.

If you insist on slipping or cross-controlling your Velocity, do it at a safe altitude. The best advice is do not do cross-controls or slips in a Velocity. Other than this, flying the Velocity is very conventional.

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