Building a Next Generation Airship

In Pursuit of the Perfect Personal Aircraft

story by Dan Nachbar

My adventure in LTA began about five years ago, November 2001 to be more precise. I was flying myself from Massachusetts to Texas, and back, in a Cessna Skyhawk. It takes a while, 30 hours or so, to make such a trip in such an aircraft. One of the benefits of the journey was that it provided me with a fair bit of time to muse. Mostly what I mused about was how darn noisy it was in that little airplane. Of course, small airplane rides have their good parts. The view is often awe inspiring. I decided to figure out some way to enjoy the view without the noise.

To be fair, my goal evolved fairly quickly beyond "nice-view/no-racket ". I wanted to find (or build if necessary) a true pleasure craft. I specifically had in mind an aircraft that both presented an enjoyable experience for the senses and was not a great challenge to fly. My goal was leisurely, serene (OK - lazy) flight. To put it another way, I wanted to maximize the joy-to-work ratio.

There are other types of aircraft that might seem to do pretty well on this score. For instance, gliders are certainly much quieter than airplanes. However, piloting a glider can –not generally be described as leisurely or serene. Except for very rare occasions, glider pilots are constantly on the hunt for updrafts in order to stay aloft. This hunt for lift can be a wonderful challenge. Serene it is not.

Balloons are also a pleasure to fly. Like gliders, they provide lovely views with a lot less noise. At the risk of uttering heresy, I have to admit that the end of every balloon flight feels to me like a de facto emergency. Not a life-threatening sort of emergency to be sure, but landing a balloon is fundamentally different than landing other types of aircraft. Rationally, I know that thousands of hot air balloons fly and land safely all the time. (Heck, I have a balloon rating and haven't yet bent or broken anything. I know that landing isn't all that difficult a trick.) Still, on every flight, a balloon pilot must use a combination of wits, skill, and experience to locate and reach a safe place to land. Sometimes it's easy, sometimes not. For other types of aircraft, that sort of decision-making is only required in emergencies. It's simply a

matter of taste as to whether the challenge presented in making such decisions adds to the enjoyment of the experience. For me, it does not.

Given that neither balloons nor gliders fit my goal, I concluded that maximally serene, low-effort flight would require a powered aircraft. This conclusion was unsettling because it is the propulsion system that creates the vast majority of the noise and vibration. Fortunately, there are other types of propulsion systems, such as electric motors with large-diameter low-speed props, that make far less noise than the typical internal combustion engine. I thought maybe I should look into airplanes with electric motors.

Unfortunately, a few conversations with people who are actually involved with developing electric airplanes persuaded me to seek serenity elsewhere. The problem is the power supply. Systems that produce enough power to propel an airplane weigh too much to get off the ground. Fuel cells offer great promise, but to date, they are not yet practical. The other alternative is high-tech batteries. But spending $100,000 on a lithium-ion battery pack (to obtain a 30-minute flight) was definitely not in the realm of what I was considering.

That led me to the question: What aircraft can carry more weight and requires less power? The answer: a blimp. I started looking into electrically propelled blimps or airships. (Airship is the broader and more technically correct name for LTA aircraft that can be propelled and steered. Sometimes these aircraft are also informally referred to as "ships.")

Here again, it took only a few telephone conversations with builders and owners of small Helium blimps to give me grave doubts. These conversations were mostly a sequence of woeful tales. They ranged from complaints about needing to have a large hangar (usually located far from home in order to be affordable) to rustling up a half-dozen helpers for every flight to handle the craft on the ground. Helium blimp owners also talked about how Helium constantly leaks (typically about 1% per day) whether the craft is flown or not. Helium ships "bleed cash" even when not being used. Then there was the story of the time one of these craft was being taken out for a ride and tore its envelope on the hangar door. Away floated $3,000 worth of Helium. Not inspiring.

In contrast to the Helium pilots' river of sorrow, I noticed that hot air worked pretty well as a lifting gas. In fact, the hot air balloon pilots I knew seemed to be pretty happy bunch. Why not use hot air rather than Helium for lift? Certainly, a hot air blimp would be significantly larger in volume than a Helium blimp with the same amount of lift. However, a larger volume with its commensurately lower airspeed struck me as a small price to pay in order to escape the endless hassles that invariably plague Helium blimps.

Not surprisingly, I was hardly the first person to have this bright idea. There are several companies, and individuals, building and selling hot air blimps. I did some shopping around for an existing hot air blimp and I didn't like what I found. A variety of performance limitations made them unappealing and, given the limited success of hot air blimps in the marketplace, I was clearly not alone in my reaction.

After thinking about the problem for a while, I concluded that a different type of structural design for the envelope was needed in order to make hot air blimps viable. I posed this design problem to a friend and neighbor, John Fabel. John has many years of experience designing backpacks, tents, and other fabric-based products. The very next day, he came up with the idea of building a blimp envelope as a tension membrane structure.

Tension membrane structures have been in use for centuries. They are the basis of everyday products such as umbrellas and tents. Their excellent strength-to-weight qualities make them well suited to aircraft. Yet as far as I, or anybody else I asked, knew they had never before been tried in an LTA envelope. (I'll describe the envelope design and the other technologies that we use in detail in Part II in the next issue of Ballooning. If you can't wait, feel free to take a look at www.personalblimp.com.)

Building Lots of Models

Many ideas seem good until you actually try to build them. Given the uniqueness of John's design, I wasn't going to build a full-sized version right off the bat (although, first time builders using conventional designs successfully build full-scale aircraft all the time) . I decided to build some models first. I also wanted to get some practice sewing before trying to build a real aircraft. The model building period gave me time to seek advice from such experienced LTA builders as Brian Boland, Don Piccard, and Paul Stumpf.

All told, I ended up building a dozen or so models over the next two years. I started out on a borrowed home sewing machine and quickly moved to high-speed industrial machines. The first models had 8-foot ribs. After that, I built models with rib lengths of progressively larger sizes. The largest model was roughly half-scale with 50-foot ribs. None of these models got off the ground nor were they intended to. Their purpose was to work out the details of design and construction and the inflation/deflation processes.

Getting Moving

At this point, Fall of 2004, it was time to see how the envelope structure would stand up to the aerodynamic forces encountered when moving through the air. Large aerospace companies use wind tunnels and fancy computer programs to do such testing. Shoestring projects, such as this one, get the job done by bolting models on to the front of a car or truck to create a "poor man's wind tunnel."

At about this time, I teamed up with an experienced, and incredibly talented, aircraft mechanic named Michael Kuehlmuss. (Mike is actually an engineer disguised as a mechanic.) Mike and I designed and built a rig for mounting one of the larger models out in front of a pickup truck. We made our test runs along the runway of a very quiet airport near us. We left some folks scratching their heads and wondering what these crazy people were up to.

The "wind tunnel" tests went reasonably well. We obtained "airspeeds" that were comparable to what we wanted for a real aircraft without any significant deformation of the envelope. The tests were somewhat inconclusive due to some limits inherent in our design of the test rig, but we were happy enough with the results to take the next step.

Going Full-Scale

It was time to build our first full-sized ship. I did the fabric work on the envelope. A friend, Kevin Hirschman, gave me a hand with cutting the 1,600 yards of fabric. It took about 2.5 million stitches and 539.5 hours of sewing to finish the envelope. During this same period, Mike designed and built the non-fabric components. These included the 132-foot

Above: Given the large size of the envelope some unconventional sewing techniques were needed. The main body of fabric is piled up on a table set against the wall while the next gore and sewing machine were mounted on a rolling platform that moved down the length of the envelope. This minimized the physical labor of pulling the fabric to the sewing machine.

Below: The "poor man's Windtunnel" testing a model with 24 foot ribs.

long ribs (assembled from 12-foot segments), tail fins, nose/tail cones, and cabin. (The design and construction will be described in detail in Part II.)

The basic structural components of the aircraft were finished on Sept 30, 2005. The next day, October 1, marked the beginning of the rainiest October on record for our part of the world (New England.) In spite of the rain we did manage to get the ship inflated a few times before Winter set in. Usually, we kept the cabin on the ground. We did indulge in some brief 3-foot high tethered flights. It was tempting to think that the design and construction were nearly done. Wrong! It took another year of concentrated effort to go from tethered to free flight.

The unprecedented rains of Autumn 2005 were followed by two more months of record rainfall in the Spring of 2006. We did not get back into the field until June. We made numerous tethered inflations throughout the Summer and early Fall. At first, we used 8 tethering lines. As we gained confidence with the behavior of the aircraft on the ground, we reduced the number of tethers. Eventually, we could routinely inflate the aircraft and operate the engine on just a single tether. In parallel with the technical development, we were training our ground crew. We also brought a crew chief, Wayne Crouch, onto the project. With all of that in place, it was time to fly.

First Flight

The weather forecast for the morning of October 27, 2006 was promising. I sent out the word to folks who were following our project that the big day was here. One of them, David Tanzer, a balloon pilot from Vermont, came down to give us a hand.

A large high pressure system was settled over the area. The winds promised to be light and variable all day. Nonetheless, we arrived at the field an hour before sunrise to make sure we had enough time to be ready to lift off exactly at sunrise. We'd been working towards this day for nearly five years. We couldn't have been more ready.

Ready -- Hah! What followed, for the next four hours, looked more like a Three Stooges routine than preparation for a first flight. The number of things we'd overlooked was spectacular when it came down to the wire. One particularly charming pratfall was the realization that I had left our hard-won airworthiness certificate back in my office -- a good 20-minute drive from the field.

Nonetheless, with the retrieved FAA documents unceremoniously duct-taped to the cabin, we finally managed to get the ship ready for flight at 9:20 AM. Mercifully, the wind was still variable at less than a knot. We released the final tether, I hit the burners and revved the engine. The ship headed "upwind" at walking speed for a straight hop of 50 yards or so. I then did another short bounce before handing the ship over to Mike. He made a few longer hops and a 360 turn. (Video of the first turn is available on our website.) As Mike was flying, the wind came up to a few knots. Given our unfamiliarity with the aircraft, we decided to call it a day.

Where to from Here

Since that first flight, we've logged a bit more than 10 hours of flight time. Most of this was part of what the FAA calls Phase I flight testing with no passengers allowed.

In fact, passengers are probably not a good idea just yet. In addition to working through the inevitable peculiarities of a new type of aircraft, we need to accumulate some experience as airship pilots. Although Mike and I have both balloon and airplane ratings, we have had zero flight experience in airships. We are not alone in this. Today, there are fewer airship pilots than astronauts. But who knows? If this design approach works as well as I expect, that may well change.

As a brand new, rough-around-the-edges technology, setting up for each flight still requires a fair bit of running around and fiddling with things. Winter flying in snowy New England was not in the cards. As the weather turns warmer, we're looking forward to trying out some of the some minor improvements we made in the shop during the cold weather months.

In the next issue I'll describe the technologies we use and our plans for future development.

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