Lift Reserve Indicator

Written by Robbie Culver, Sonex 1517
June 11, 2013

One of the goals in organizing the Sonex Builders and Pilots Foundation was as a safety initiative to address the NTSB's recommendation that, to paraphrase, the EAB cleans up its collective act and stops killing themselves in homebuilts.

In our initial discussions with Sonex Aircraft, LLC while creating this foundation, the subject of Angle of Attack (AOA) indicators and Lift Reserve Indicators (LRI) came up. Sonex Aircraft LLC expressed strong support for the installation and use of these safety devices. This discussion will focus on LRI's, as they are relatively easy to fabricate from scratch, install, and calibrate. An Angle of Attack indicator is not the same as an LRI, and is not discussed here.

As the founder and current President of the Sonex Builders and Pilots Foundation, and a Sonex kit builder, I wanted to document some available sources for scratch building an LRI, and explain what an LRI is, and why I chose to create one for installation in Sonex 1517.

As always, this discussion must include the statement that this device is not designed by the Sonex Builders and Pilots Foundation, nor is it endorsed as an official modification to the Sonex line of aircraft by the Sonex Builders and Pilots Foundation nor Sonex Aircraft, LLC. However, if a builder is looking for a common sense addition to their aircraft that enhances safety in a very affordable manner, the LRI offers a very big enhancement for very little investment in time, effort, and money.

Much of this article is based on a document written and drawn by Jim Mantyla of Barrie Ont for the AirSoob list. In fact, the original text, and PDF files of the probe, mounting plates, and brackets is found in the files section of the Yahoo group SonexTalk for free to members (and signing up is also free). The author built an entire LRI probe with hose, connectors, mounting plates, and brackets for less than $50. That cost does not cover the gauge.

There is extensive information on LRI's on the Internet, and the files used in reference here are found on SonexTalk and Wikipedia, as well as the links shown at the end of the article.

Why Install an LRI?

Installation and use of these devices is subject to the individual builder or pilots implementation and use of the LRI. When taking off, landing, or maneuvering, an LRI provides visual indication of the lift being produced by the wing, regardless of angle of attack or bank. It simply measures differential pressure and provides feedback to the pilot about the lift being produced. As such, the system enhances safety as a visual aid to provide additional information to the pilot other than airspeed or visual angle of attack.

I chose to install one since, when built strictly to plans, the Sonex line of aircraft does not have an audible or visual stall indication. I wanted one in my aircraft, and after extensive research and discussion, I found that an AOA or LRI system is used widely in military aircraft. In fact, the LRI/AOA theory is widely viewed as one of the best safety devices a builder or owner can add to their aircraft (subject to widely varying opinion, of course). I chose an LRI because it is mechanically simple, very reliable, and relatively easy to make.

What is an LRI?

An LRI is a system used to measure the amount of lift being produced by a wing in any given situation, by comparing the static pressure to the dynamic pressure in a probe mounted in a fixed position under the wing. The device is used to maintain a safe margin from a stalling condition, and may be used in takeoff, landing and while maneuvering at any attitude or angle.

When displayed on a simple pressure differential gauge with a modified face, the pilot knows the amount of lift reserve available at any given instant. The gauge is frequently mounted either on top of or near the top of the instrument panel, where it remains in the visual scan of the pilot. More sophisticated LRI systems and AOA systems may also be connected to an EFIS.

Building an LRI

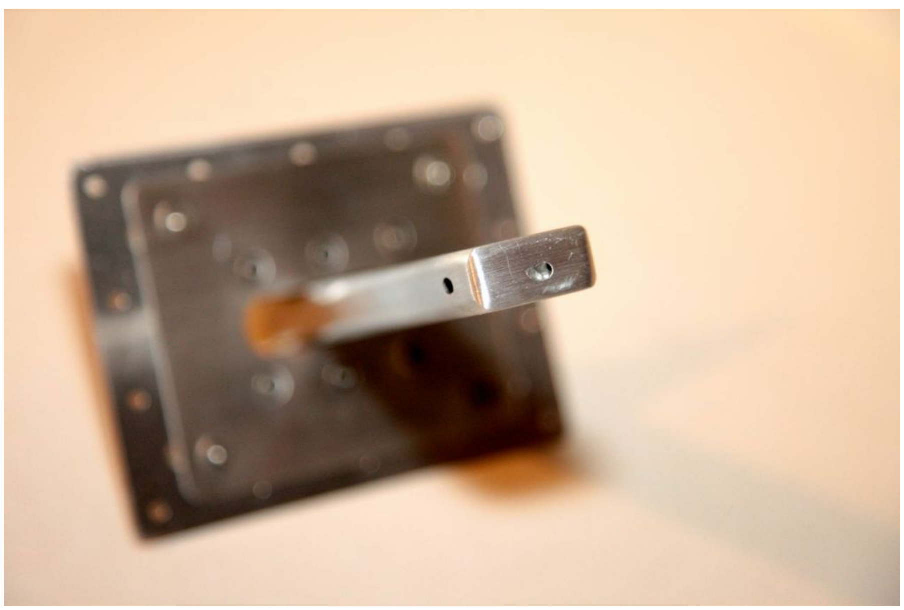
I am not the most skilled builder, nor a true craftsman in the most literal sense. But I was able to create from aluminum bar stock and some sheet stock, plus several affordable fittings, a usable LRI probe over the course of one weekend's work. When connected to a modified "DWYER MINIHELIC II" pressure gauge, this affordable solution addresses one challenge of flying an experimental aircraft with different flight characteristics than certified aircraft – maintaining a safe amount of lift in maneuvers, takeoff, and landing.

Certified aircraft have audible and/or visual stall indicators. Experimental aircraft have whatever the builder installs, and quite frequently this involves customizing a system built from scratch. While some builders may wish to design their own system, existing drawings are available at http://groups.yahoo.com/group/sonextalk/files/AOA/

I used the drawings from SonexTalk to create the probe, and did so using a drill press with 6" bits, a bandsaw, and tap and die set. The probe itself is made from 1" by 1/2" by 6" aluminum bar stock. I bought mine from McMaster Carr. I also purchased several 3/16" barbed fittings, as well some vinyl tubing from a hardware store.

I cut the bar stock to rough length, smoothed the ends and edges a bit, then clamped it up in the drill press and – being careful to make the face parallel to the bit – began drilling slowly. I used a 6" long 1/8" drill bit for the initial holes, then updrilled to 3/16".

I then flipped the bar stock and drilled the two 1/8" holes in the end at a 45 degree angle. Finally, I used an 11/32" drill bit to enlarge the openings at the end of the bar for the barbed fittings, and used a tap to make the threads for the barbs. When I was done, I carefully smoothed the bar on the scotchbrite belt and slightly rounded the edges.



For the mounting plates and brackets, I used aluminum sheet stock, a band saw, a vise, mallet, and forming blocks, my disc sander and scotch brite belt, and a drill press. I also used a hand squeeze riveting tool with dimple dies to create the dimples for the flush mounting screws.

While I was lucky enough to receive the pressure gauge for a Christmas present, builders can search online for sellers using the “DWYER MINIHELIC II” pressure gauge, part number 2-5002. This gauge reads 0-2” of water column as manufactured, but the gauge face is removable and is modified to show 3 separate colored zones.

The first zone, marked as a “red zone” is set from 0 to .5” on the stock gauge. The second zone, marked as white or yellow is set from .5” to 1.0” on the stock gauge. The third zone, marked with green is set from 1.0” to 2.0” on the stock gauge.

When properly installed and calibrated, the red zone tells a pilot that the wing is no longer generating enough lift to sustain level flight. The top of the red sector and the bottom of the white or yellow sector is the point that wing is generating "just" enough lift to support the aircraft in flight.

During takeoff, a properly calibrated and installed system shows the needle clearing the red sector and moving into the yellow sector just as the plane has enough lift for takeoff. On landing, the goal is to get the tires to just touch the runway when the needle is one mark from the top of the red sector, at about 0.4" on the stock gauge.

During initial testing, rotate the probe from its initial setting and repeat landings until the needle is at about 0.4". Once properly established, the probe position should be permanently marked so that any change in position may be seen during a preflight.

The white or yellow sector indicates the slow speed region of the wing's lift. The ideal final approach to landing is flown with the needle centered in the white or yellow sector, and the turn to final should be done with the needle no lower than the transition area of the white or yellow to green zone.

The green zone is the region where there is enough lift being produced by the wing, and the needle will most probably pegged at 2.0" on the stock gauge.

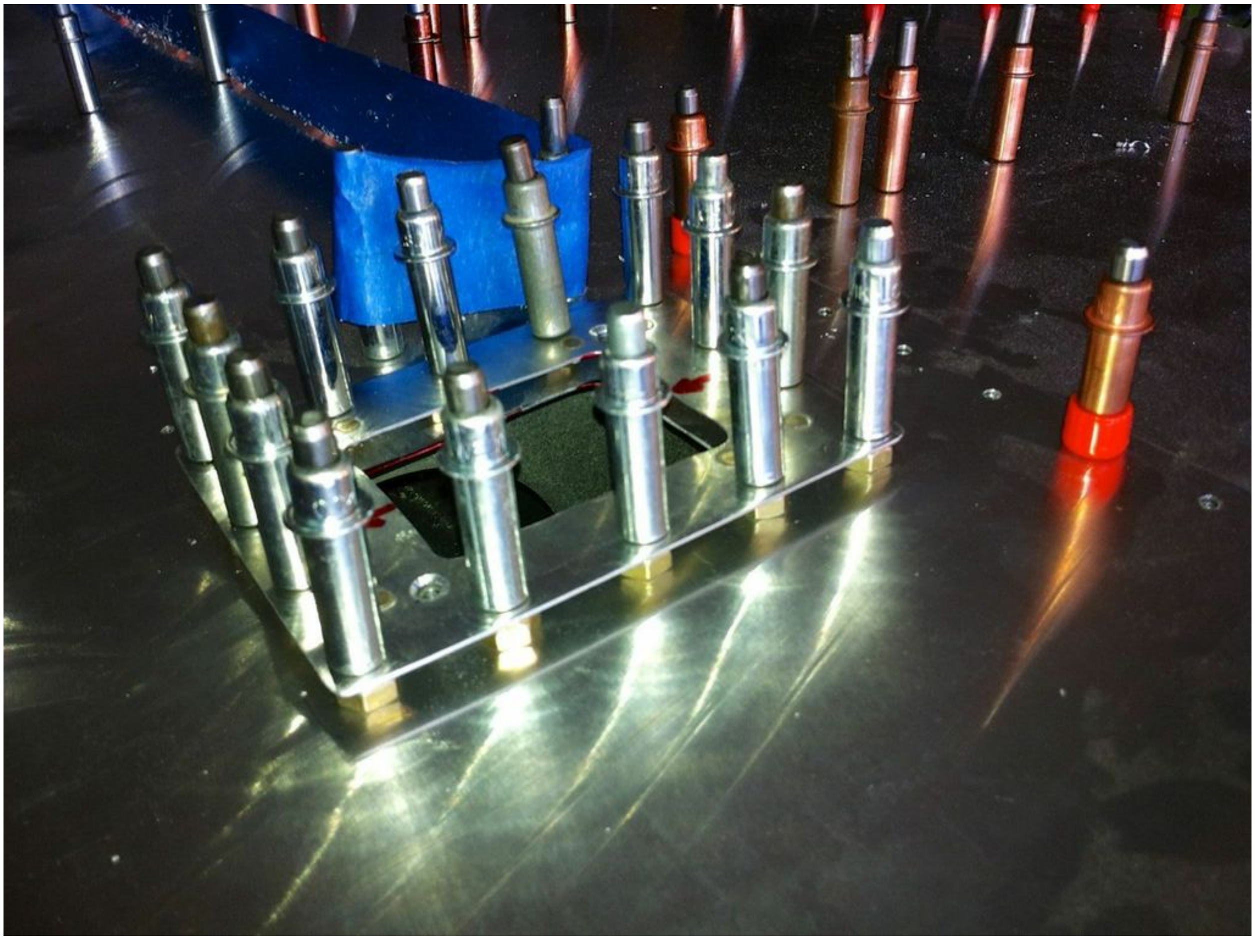
Installing the LRI

As written by Jim Mantyla in his original article, "The location of the probe should be out of the prop wash and located between 15% and 30% of the wing chord as measured from the leading edge. The angle to start is recommended to be about 50 degrees from the bottom of the wing. A Cessna 172, that was fitted with this device had the probe at 69.5 degrees from the bottom of the wing surface. You will have to determine this on your own plane."

On May 28th, 2013, in a post on the Yahoo group SonexTalk, Sonex builder/pilot Dale Williams set his LRI probe at 51º from the bottom of the wing. It should be noted that Dale's system is not identical to the system described on SonexTalk, and individual builders and aircraft should carefully test the system to ensure reliable indications.

I placed the LRI on the left wing in exactly the same location as the pitot tube assembly is mounted on the right wing. I built hose mounting plates identical to the pitot tube hose mounts, and put them in the leading edge ribs as those on the right side. I then ran the tubing out from the root rib, leaving a lot of extra tubing available to run inside the cockpit.

While building the left wing, I used the mounting plate as a template to match-drill the holes used to hold the probe and brackets in place. I had to get creative when pilot drilling, and found that standard nuts, used as a standoff, allowed me to accurately drill the holes and cleco the plate in place.



It is my personal opinion that this probe and gauge provide a reasonably simple, mechanically reliable, and relatively maintenance free system that will add to the safety of each and every flight I make in my Sonex. While I am still building, and have obviously not tested the system in flight, other Sonex owners report the system is indeed reliable and useful.

Additional notes:

On May 28th, 2013, in a post on the Yahoo group SonexTalk, Sonex builder/pilot Dale Williams posted the following sage advice regarding the installation of an LRI.

As already noted the LRI is easy to install. I've put one in a finished Sonex and this one was put in during the build:

https://s3.amazonaws.com/expercraft/daleandee/5453769024bf752923a458.jpg https://s3.amazonaws.com/expercraft/daleandee/10684715724bf8962513938.jpg

The probe was set at 51° from the bottom of the wing. The instructions state that during a full stall landing the probe should read two notches into the red. Look at the video and note that the LRI is very close to being exactly where it should be:

http://www.youtube.com/watch?v=WjA7JDJVKeQ

.....

Dale Williams
N319WF @ 6J2
Myunn - 120 HP (3.0)
Tail Wheel - Center Stick
24:12 hours - Phase One
Status - Flying

For reference, the definition from the WIkipedia article is here:

http://en.wikipedia.org/wiki/Airspeed_indicator

The **Lift Reserve Indicator** (LRI) has been proposed as an alternative or backup to the Airspeed Indicator (ASI) during critical stages of flight. This is an elegant device but is rarely found in light aircraft or even transport jets. The conventional Airspeed Indicator is less sensitive and less accurate as airspeed diminishes, thus providing less reliable information to the pilot as the aircraft slows towards the stall. The actual stall speed of an aircraft also varies with flight conditions, particularly changes in gross weight and wing loading during maneuvers. The ASI does not show the pilot directly how the stall is being approached during these maneuvers, whereas the LRI does.

The LRI shows the pilot directly the Potential of Wing Lift (POWL) above the stall at all times and at any airspeed, so it is more descriptive and easier for the pilot to use. The LRI uses dynamic differential pressure and **Angle of Attack** to operate. It is very fast acting and extremely accurate at low airspeeds, thus providing more reliable information to the pilot as airspeed diminishes and becomes critical.

The LRI uses a three zone, red-white-green display. During flight, the green zone is well above the stall where flight controls are firm, angle of attack is low, and the unused POWL is high. The white zone is near the stall where flight controls soften, angle of attack is high, and the unused POWL is diminished. The top of the red zone defines the beginning of the stall. The severity of stall increases as the needle travels deeper into the red. During the takeoff, the LRI uses dynamic pressure to operate and will not lift the needle above the red zone until enough airspeed energy is available to fly.

The pilot adjusts the instrument to indicate the edge of the red-white zone during minimum airspeed practice at altitude, indicating the aircraft has zero POWL beyond that point. Since the wing will stall at the same angle of attack at any airspeed, once properly adjusted the LRI will indicate the red-white edge anytime the stall is approached. This includes landing stalls, climbing stalls, and accelerated stalls. After adjustment, the black line in the center of the white indicates maximum angle of climb and maximum angle of descent with enough reserve lift for the landing flare. With practice, the pilot can use the LRI to determine the exact moment for liftoff with minimum ground roll and maximum angle of climb combined.

The LRI has been well received by STOL pilots and pilots of experimental or home-built aircraft. The LRI is very useful for short field landings, short field takeoffs, and slow speed maneuvers such as steep turns, steep climbs, and steep descents, and also allows pilots of fast or "slippery" aircraft to land with little or no float very reliably. Since the LRI is so useful at the critical lower end of the flight envelope, most pilots will use the LRI as a complement to the ASI, using the LRI for slow speed work and the ASI for cruising and navigational work.

Additional discussion may be found at:

http://home.hiwaay.net/~sbuc/journal/liftreserve.htm

http://home.hiwaay.net/~sbuc/journal/liftreserve-pg2.htm

http://www.liftreserve.com/

http://sonex604.com/aoa.html

http://sonex604.com/misc/AirsoobLRI.pdf

The files used as reference by the author may be found at:

http://groups.yahoo.com/group/sonextalk/files/AOA/