(cover letter to the 1985 Embry-Riddle Aeronautical University report on the LRI)

Dear Sir:

Enclosed is a complimentary copy of a research report on the Lift Reserve Indicator (LRI) completed by Mr. Wayne Stewart, a senior aeronautical engineering student, under my guidance. The highlights of the report on Mr. Morgan Huntington's invention are as follows:

> The LRI appears to measure q (dynamic or total pressure) times rho (angle of attack). Recalling that the lift equation can be written as L = CLrho rhoqS where CLrho is the lift curve slope and S is the wing area, it is clear that Mr. Huntington's invention **does indeed measure lift.**
>
> ...the LRI appears to be very repeatable and reliable and instantaneously responsive to changes in the flight conditions, irregardless of aircraft weight or flap settings.

Despite the fact that I don't completely understand the LRI, I like the system and I even trust it enough to use it as the primary traffic pattern indicator. In fact, I'm even installing one in my personal airplane, a Cherokee 140.

Sincerely,

Richard E. Neate

Associate Professor, Aeronautical Engineering Department, Embry-Riddle University, Daytona Beach

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Excerpts From:

EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

Investigation Of The Lift Reserve Indicator

Introduction

Each year numerous aircraft accidents occur while flying in the slow speed regime. It is this fact that has led to the development of the **Lift Reserve Indicator** (formerly called the Huntington Airspeed Director). A relatively simple device, the **Lift Reserve Indicator** (**LRI**) is designed to provide the pilot with accurate performance capabilities during slow flight conditions, including climb-outs, approaches and traffic patterns, at different wing loadings and flap settings...

This report is a follow-up to a research project that was conducted in the spring of 1983 by two former Embry-Riddle Aeronautical University (ERAU) students...The goal of the present project is to verify the results of the previous research and to further investigate some of the features of the **LRI**. As before, a Cessna 172 is the flight vehicle for conducting flight test on the **LRI**. This aircraft is fully instrumented and has served as the base of ERAU's flight test course since 1981...Through extensive flight testing and wind tunnel experimentation, a better understanding of the **Lift Reserve Indicator** shall be sought in this report.

Background

The **Lift Reserve Indicator** consists of two components, a rectangular probe and a display gauge. Adaptable to any aircraft, the **LRI** must be installed and calibrated for each individual aircraft.

...Mounted on the underside of the left wing of the C-172, it is located approximately 112 inches from the aircraft centerline, and at 19.55% of the wing chord. ..the probe [was] mounted at an angle of 69.5 degrees relative to the wing surface. Constructed of an aluminum alloy, the probe is 6 inches in length with two pressure ports located on perpendicular faces as shown in Figure 1...These two pressure ports are connected to the LRI display instrument by two sections of teflon tubing.

The **LRI** display instrument measure the pressure difference between the top and bottom surfaces...

...Once the **LRI** is installed on the aircraft, it must be calibrated before it can be used. As instructed by the inventor, proper calibration is reached when"...at the moment of flared touchdown with maximum elevator deflection, the indicator needle reads one division (a gauge reading of 0.4 in. H20) into the red sector of the **LRI** display. This is accomplished by changing the angle the probe makes to the wing surface after each landing until the proper reading is obtained.

...This investigation into the theory and operation of the **LRI** has been conducted under the supervision of Professor Richard Neate. Under this context, the investigation has served as an individual senior research project. The inventor of the LRI, Morgan G. Huntington, was informed of the investigation and he offered full cooperation with any requests submitted to him...The research philosophy is based upon standard experimental practices and is no way funded by [the inventor or the inventor's company]. The entire scope and objectives of the investigation have been established by Professor Neate and the writer.

Wind Tunnel Investigation

The fundamental concept behind the LRI is that each pressure port on the probe measures the dynamic pressure (q) of the relative wind. From this assumption, the inventor of the LRI states that the differential pressure (lift reserve) can be predicted by the equation DP=q (SIN T - SIN B) where:

DP = Differential pressure on the two probe surfaces

q = Dynamic pressure of the relative wind

SIN T = Sine of the angle between the relative wind and the top surface of the probe

SIN B = Sine of the angle between the relative wind and the bottom of the probe.

Results and Analysis

From the data obtained in the wind tunnel testing, plots were made of the actual differential pressure (DPA) and DP=q (SIN T - SIN B), which is the theoretical differential pressure. These plots show that no direct linear relationship between the tow exists, thus not supporting the inventor's theoretical equation. At each angle of attack the theoretical value of DP is greater than the actual measured value. This reveals that the pressure sensed by the LRI is not the entire dynamic pressure of the relative wind. On the other hand, the value of DPA closely corresponds to the indicated value of DP from the LRI gauge, showing that the LRI display instrument accurately measures the differential pressure.

Flight Testing

The broad flight testing program that was accomplished in this investigation has led to a better understanding of the **LRI**'s performance. Some of the results...

> ...At speeds close to stall..the flap settings of 0, 20 and 40 degrees produce the same DP.
>
> At load factors greater than 1, the DP for a corresponding velocity during the one 'g' of level flight decreases.
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> The flight test data of DP/q versus q does not exhibit the linearity and abrupt change in slope as predicted by the inventor. The data reveals a definite parabolic shape...This indicates that the DP is a function of at least two variables, most likely the dynamic pressure and angle of attack.
>
> The LRI does produce repeatable readings during flight. Since the LRI is independent of the aircraft pitot-static system, it could be utilized by the pilot for approximate airspeed indications in the event of failure (clogging) of the pitot-static system...
>
> The LRI reacts slightly faster than the pitot-static system to changes in angle of attack.
>
> The effect of different wing loadings was found to be negligible during this investigation.

Qualitative Data on the LRI

The test pilot for this research, Professor Neate, provided the writer with qualitative insight into the use and capabilities of the **LRI**. The test pilot had considerable flying experience, with over 1,500 hours of flying time in jet aircraft with the U.S. Air Force. Most recently the test pilot has been involved in flight testing as a professor and pilot for the flight-test course at Embry-Riddle Aeronautical University since 1981.

The pilot felt that, once calibrated, the **LRI** produced repeatable readings, with immediate gauge response to changes in elevator deflection (changes in angle of attack). This observation supports the notion that the **LRI** probe is influenced by changes in AOA. The pilot also noted that the response by the **LRI** gauge to elevator deflection seemed to be correct in both sense and magnitude. (An increase in AOA would result in a decrease in lift.)