In holography, one is able to get shape information since you are dealing with an image of the particle field, and the velocity field of the particles can also be obtained. A big advantage of holography is that there has been a lot of experience with it and one is quite confident when employing holography that you will get quality data that is useful. The big disadvantage in one area is data reduction. If you get a lot of data, it is difficult to extract out of that information the subset of information which is important to you. I might point out, however, that there are programs underway at a number of centers focusing on automating the process of getting the desired information out of holographic images. The advent of computer technology, of course, is making that possible. When one makes a hologram of an object field, he then reconstructs the image field for a three-dimensional image on which the photography work can be done.

Recent applications of holography include spray characterization, coal combustion, and much work in wind tunnels. One of the early applications of holography for particle field studies was at AEDC here in Tullahoma, where it was used to characterize a particle environment in a tunnel that was laden with particulate for purposes of erosion studies. That was more than 10 years ago. There is a great deal of experience with use of this technique in wind tunnels. Rocket engines and various industrial processes are other applications.

The advantages of the single particle techniques are size and velocity information, good spatial resolution, and a big advantage is real-time data acquisition. This is based on light scattering which goes into a photo-multiplier tube, then eventually into a computer where the data is virtually all handled in real-time and managed by the computer. All of these optical techniques, of course, are nonintrusive. It is a single particle inferred LWC which can be either a disadvantage or an advantage depending on what the real mission or objective is. Quantities of interest for icing studies like LWC have to be inferred from the measurement of particle size and velocity.

Let me just summarize with a few words on ensemble measurements. Ensemble measurements are those on which one projects light into the particle field of interest and collect the scattered light off of the ensemble of particles. There are systems of that kind available and improvements are underway for them. The advantage is that those systems are inherently quite simple; the data, however, is not of as high a resolution as one can obtain by other means. They are very useful, though, depending upon the mission of the instrument.

In closing, I would again say that I think we need to clearly establish what the measurement requirements are on the various ground and flight test programs. Then, based on the voids that exist in the measurement requirements compared to what we are using today, some of the advanced methods that are underway and available may be appropriate for implementation on those programs.

"DEVELOPMENT OF A WIND SHEAR PERFORMANCE ENVELOPE"

John H. Bliss

Flying into an airmass which is moving in a new direction and/or at a different velocity may produce a large airspeed change. An increase is incidental. A significant loss, well below the bug speed in use, will severly alter the flight path and produce a large descent rate.

If there is no continuing headwind loss after such an airspeed loss, you can apply maximum power, pull the nose up, and go-around. However, a continuing headwind loss equal to or exceeding accelerative capability will prevent a successful go-around.

In a simple downdraft, altitude can be held in air which is descending as fast as the airplane can climb. Consequently, some think altitude can also be held when a headwind is diminishing at the same rate as the airplane can be accelerated.

It is quite important that the airplane performance during a continuing headwind loss be understood. This presentation is offered in recognition of this importance, and to present an aspect of performance not normally considered. Lack of consideration of this characteristic can result in assuming almost twice the performance than that which the airplane actually has during severe wind shear at high descent rates. The example data relates to the Boeing 727-200, but the characteristics are applicable to any airplane. Figure 1 portrays the characteristic of an airplane in the landing configuration, gear down, flaps 30, 100%, power, standard sea-level day, and 140,000 lbs. gross weight.

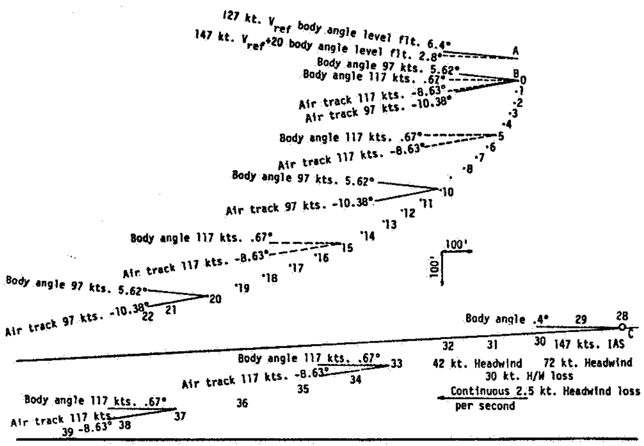

Figure 1.

We will begin with evidence of how forces are balanced during a maximum performance climb, at a Vref airspeed of 128 kts (see Figure 2). It is important to recognize that the airborne framework coincides with the inertial framework (no wind shear). I would like to draw your attention to the angles which apply. The angle, flight path to "G" direction, equals 97.31°.

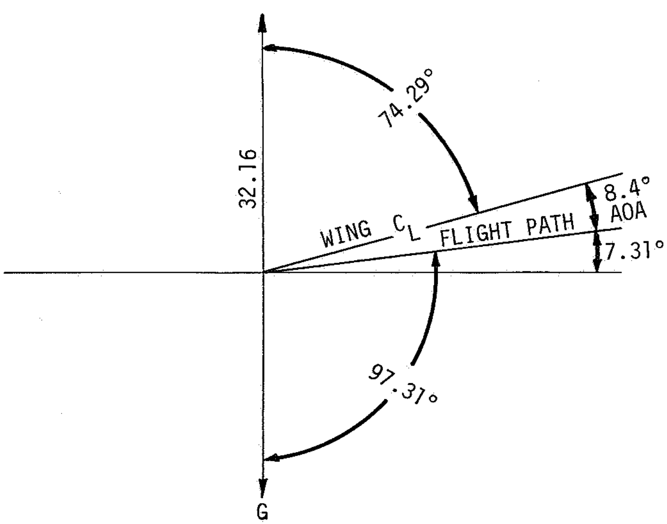

Figure 2.

A climb of 1650 fpm (27.5 fps) is achieved using maximum performance under stable air conditions. I would like to emphasize "using maximum performance".

Now consider Figure 3. We have the level flight condition, where there is an acceleration of 2.5 kps (4.222 fps). The angle between the flight path and "G" direction remains at 97.31°. Notice the rotation of lift by 7.31° results in a slight lift deficiency which can be ignored due to its fleeting 1-second existance. Altitude is then held and airspeed increases 2.5 kts/sec.

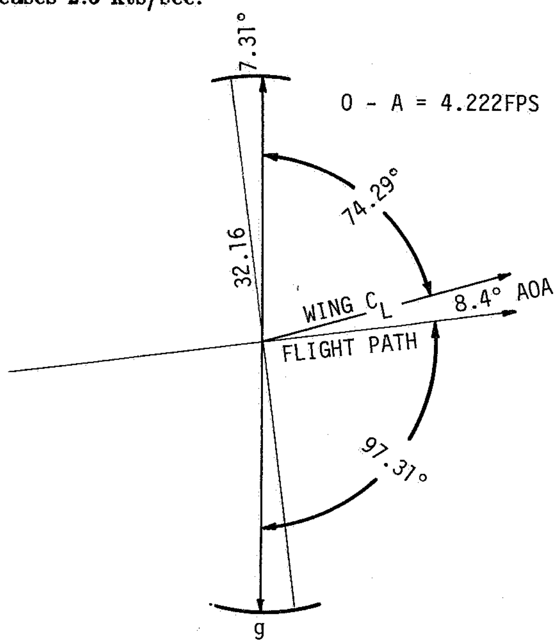

Figure 3.

Turning to Figure 4, we have the same condition as in Figure 3 except with a 2.5 kps constant headwind loss, the airspeed does not rise. The slight loss of lift in Figure 4 now becomes significant. The loss is constantly present due to no airspeed increase. The maximum flight path angle is now a tangent to the lift line represented in Figure 3, with the same airspeed. All is as balanced as the previous condition in Figure 2 as long as the 2.5 kt/sec. headwind loss endures.

Inspecting Figure 4 in comparison with Figure 3, one sees that the only difference is the 2.5 kps headwind loss in Figure 4. Surely, those of you who have observed a free-flight model in a wind tunnel will attest to the almost vertical perturbations caused by slight changes in wind velocity. The movement is near vertical because of lift change, and altitude loss has little horizontal effect on the model's movement. The acceleration/climb chart is valid in stable air where a change in flight path produces the effect of descending an inclined plane.

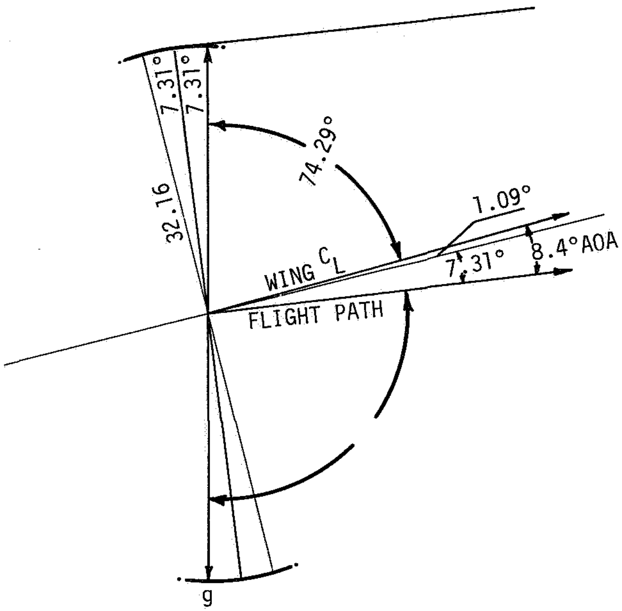

Figure 4. O-A = A-B = 4.222FPS

When a mass descends an inclined plane due to the influence of gravity (see Figure 5), its velocity will equal that acquired by a mass falling freely the height of the plane. All horizontal acceleration derived from descending the inclined plane results from the resistance to gravity provided by the plane.

As simple as this sounds, there can be complications. If you place the inclined plane on an elevator, any vertical acceleration, up or down, will affect the velocity imparted to the mass. Horizontal acceleration of the inclined plane will also affect the velocity acquired by the mass down the plane.

In an airplane, the "inclined plane" is totally formed by the geometry of the air. When the air geometry is unchanging, a solid "inclined plane" such as displayed here, and on the accelerate/climb chart (Figure 1), exists.

Figure 5. Display of an inclined plane

There is nothing relative to the airplane which gives any relevance to horizontal except the air geometry and gravitational ("g") force direction. When a continuing headwind loss is present, the airplane's horizontal is changed to a new direction and so is the "g", so the inclined plane is also changed. The result is altitude loss without the resultant horizontal acceleration, just as if the inclined plane were to be accelerated toward the rear at the same rate as the headwind is diminishing.

I know from experience that with no wind, a 747 can leave 39,000 feet 120 miles from destination, descend at idle power, and land 20 minutes later using power only the last 1500 feet on final. When you have a 150 knot headwind at 39,000 feet, it takes no more than 85 miles and just over 12 minutes. A much larger nose-down attitude is required to get the same airspeed during the headwind loss. There is a large altitude loss without the speed gain. This is obviously the result of a large change in the "inclined plane" and these changes are just as valid on the approach as they are at altitude. If the accelerate/climb chart values (Figure 1) were valid, at least the time for descent would be the same in either case. Obviously it is not.

Essentially, safe flight path control in the new airmass can only be assured by the use of a safe actual speed relative to the new airmass before entering. The safe speed cannot be resolved by using airspeed alone, which disregards the environment ahead.

For take-off, the best defense seems to be a pause in take-off position to scan the departure path, visually and with radar, for problem cells. If present, taxi off the runway, don't take-off.

For landing approach, where the environment ahead is known, a safe speed can be resolved for the approach. A method and instrumentation has been described here at a previous meeting. It is the airspeed/groundspeed method. This sytem automates the process and the only additionl work load is to insert the surface wind.

Presently, wind shear training (a requirement for most airlines) is like asking a student a question for which there is no answer. Conversely, the airspeed/groundspeed system gives him a tool with quantitative information from which real answers are available. Judgment can be developed which is impossible otherwise. Actual training is then possible with skills developed and enhanced.

Most importantly, true safe speeds are used on every approach regardless of headwind loss. By eliminating the need for acceleration, full climb capability is available for downdraft, even during headwind loss. With large headwind loss alone, a power reduction is required for stabilized speed. This is done, quantitatively, by using two minimum speeds. The airspeed is not allowed below normal, and groundspeed is never below the value expected over the threshold. Either speed can be normal or above, but neither below. The pilot then has full quantitative knowledge of what to expect ahead at all times, and he can expect both speeds to be normal at the threshold. If they are not, (groundspeed excessive) he can go-around and approach from the proper direction, which he can discern from his draft on the approach.

There are too many advantages to enumerate now, but no pilot will ever control wind shear without controlling actual speed. Runway overruns or undershoots cannot be controlled without controlling airplane speed relative to the runway.

"LABORATORY MODEL OF FLIGHT THROUGH WIND SHEAR"

Walter Frost

This address deals with the simulation of an airplane flying through a downdraft, or microburst. This project came to pass about this time last year, at the time when the Pan Am accident had just occurred. The television company, Alan Landsburg Productions, which produces the television show, "That's Incredible," decided they would like to do a series on wind shear. They talked to John McCarthy, Bill Melvin, and a few others. Finally, Norm Crabill at NASA Langley Research Center directed them to FWG Associates, Inc. One of the things they were insistent upon was an actual model study of an airplane flying through a microburst, and they would not be satisfied with a computer graphic simulation.

We had, roughly, two weeks to design, construct, and carry out the simulation. We decided to use a large building next door to FWG Associates, Inc., the small research and development company located in the UTSI Research Park. This building is approximately 50 feet wide, and we had to do some quick scaling laws to determine the best method of handling the project. We decided to show the takeoff because it is the easiest to do. We needed to simulate a constant take-off thrust; subsequently, we used, roughly, 100 feet of surgical tubing stretched through the door of the laboratory. This gave us an essentially constant thrust of about 2-1/2 pounds, which is what we calculated as being needed for the size of aircraft being modeled. We hung a large fan in the ceiling which had about 16,000 cubic feet, and scaled the velocity coming out of that fan relative to the velocity of the aircraft as it passed through the microburst.

Our tail was on the line because we had an agreement with Landsburg that if it indeed worked, they would pay us a relatively adequate sum of money. However, if it did not work, we were going to eat it! So, we were trying very hard and getting very anxious near the end. Nevertheless, it did work very well. We actually put a control into one of the aircraft models and learned a little about the dynamics of the aircraft. We found that if you pitched up, as Bill Melvin and others at that time were saying, when you passed through the wind shear, often times the model would come out of the wind shear and not crash. However, if you tried to put the nose down and pick up speed at all, which was the other option, the aircraft invariably crashed.

A lot of people have asked whatever became of the video results. It was supposed to go on national television; but it didn't sell, because it was competing against 60 Minutes, and the second sequel of the series which we were supposed to be in was never released. I have, however, brought a short clip that I have put together on my 1/2-inch video tape and I would like to show it to you. Incidentally, one of the airplanes which had a controlled system in it flew right into a television camera. Another of the models was glued back together so