"ADVANCE PARTICLE AND DOPPLER MEASUREMENT METHODS"

Chris Busch

I want to make just a few brief comments this morning concerning advanced diagnostic work in which various companies and government agencies are involved and which we think may have some possible application to the aircraft safety programs being addressed at this workshop. We want to point out that we have a healthy regard and respect for the measurement capabilities that are being used today. As Richard Jeck mentioned earlier, there have been a lot of improvements in the last decade which really improve the quality of data being obtained today. It is our opinion that the measurement capability is still on the upslope of the ramp, and that by implementing some of this technology, the results of the safety programs being addressed here may be enhanced.

The focus of my talk is particle environments, i.e., rain, ice, and snow particles. Two types of particles which we wish to address are: 1) the natural environment in which airplanes fly and conduct test flights; and 2) simulation environments that are encountered in ground-test facilities such as wind tunnels, ranges, etc. There are characteristics of the natural environment that one wishes to measure. The liquid water content (LWC) is the one that seems to be of most importance; size distribution may be of importance in some applications. Like snow, the shape of the particle may be an important parameter to measure. As one goes on to environment in simulated tests, additional parameters may be required such as velocity distribution, the velocity lag of the particle relative to the aerodynamic flow, and the trajectory of the particle as it goes through the aerodynamic flow and impacts on the test object.

We have been involved very much with optical implementation, laser implementation in aerodynamic tests for simulation in wind tunnels, ballistic ranges, and sleds; for example, conditions which one expects to encounter in flight. As a result of having worked on this for five or six decades, we have arrived at the point where we have very good precision at measuring the appropriate aerodynamic parameters and aerodynamic tests so that one can extrapolate from one set of flight tests to another or from ground facility tests to the flight tests. The key to that is being able to have instrumentation which can measure those appropriate properties accurately enough, so that one can transfer from one set of conditions to another.

In the area of particle measurements in icing tunnels, heavy water tests, and the like, my opinion is that we are not far advanced, as in the aerodynamic case, simply because not as much time and resources have been devoted to it. I think technology may be available that can help us along that path.

A couple of questions I think need to be answered. What data is really required for flight tests and simulation tests? For environmental characterization programs, exactly what data is needed? I do not think, if we get down to the basics of it, that those questions are really all that obvious. Another question is this. Is current instrumentation adequate? Certainly, devices that have been used extensively have made a major contribution to these program activities; but are they adequate? If not, we need to look beyond, especially when we embark on five-year terms in these technology programs.. Finally, can the new technology help? That is by no means obvious either. I think it takes some careful study and examination to answer that last question. Some candidate methods that may be considered are broken into two areas: 1) imaging methods; and 2) scattering methods.

The imaging methods are basically photography and holography. You are very familiar with the photography method which is being enhanced now by the advent of computerized image analyzer systems. This can really speed up the rate at which data can be extracted from photographs. I have had the opportunity to look at some of this data taken in the heavy rain program down at NASA Langley and good quality data is obtained. There are cases where photography cannot yield information needed; in which cases, one needs to go to holography. I do not want to get into the details of holography; but suffice it to say that it gives a three-dimensional image of the field from which one can extract high-resolution data over the whole three-dimensional volume. For example, in a wind tunnel, one could make a hologram of the particle flow and extract high-resolution data over that whole three-dimensional field. There are limitations with it which I will touch on subsequently.

In the scattering methods area, there are a couple of approaches: 1) the single particle approach; and 2) ensemble approaches. They have advantages as well as some disadvantages.

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