Improved upper-air forecasts have been a special requirement since the dawn of commercial aviation. It is even more significant today. Operating costs of most airlines have quadrupled during the past decade. There has been very little improvement in the forecast models that could offset some of these rising costs. We are encouraged with the work of NASA's Bob Steinberg and his MERIT program. This kind of research is encouraged by the aviation community. Some examples of the impact of upper winds on operating costs are the following:

For an airline the size of Delta, that operates approximately 1,500 flight segments per day, a change in wind that affects the flight time by as little as six seconds and 20 pounds of fuel adds up to approximately $ 3,900.00 per day in operating costs. This is almost $ 1.5 million per year. This kind of money is more than enough to cover the operating budget of an airline's meteorological/flight planning department. One knot of tailwind for a DC-10 operating between Los Angeles and Honolulu is worth 200 pounds of fuel. One knot! These are real numbers. Wind speeds equal to 40 percent or more of a commercial jet's true airspeed occur. Not all of the time, but they do happen, and we feel that ATC system does not consider the impact of this phenomenon. We could plan and fly great circle routes on every trip. However, we must use the wind as an energy source, a free energy source. Atmospheric winds are not constant; large variations with time, as well as vertically and horizontally, mandate that we plan and fly in order to reduce the negative impact of headwinds and increase the beneficial effect of tailwinds. Temperatures are important also but wind makes the greater impact on economy. Upper wind forecasts must be improved.

Finally, the requirement for meteorological instrumentation needs to be mentioned. Many of you in the audience probably deal with this and have a similar interest. The low-level wind shear alert system (LLWSAS) is an airline requirement - absolutely! We need further development and installation of the Doppler Radar System. These, and all other weather measurement instruments and systems, are going to be of interest to the airlines for many years to come.

This concludes our presentation on Airline Meteorological Requirements. I thank you for listening and bearing with us.

"GENERAL AVIATION'S METEOROLOGICAL REQUIREMENTS"

Dennis Newton

The theme of this year's workshop is Communication and Appplication of Atmospheric Data for Aviation Needs. One could certainly say that this theme has been implicit in all of these workshops. However, the stress on communication seems to me to be both important and appropriate, for two reasons. First, the value of weather data to aviation is often extremely perishable. It becomes quite useless if not quickly and accurately communicated to the people who need it. Furthermore, communication of weather theory and information about weather service products to pilots in an accurate and comprehensible manner is essential to flying safety in general. Probably no one needs weather knowledge more than the people who fly through it.

The specific subject of this overview paper is General Aviation's Meteorological Requirements. However, before one addresses the subject of General Aviation's requirement for anything, it is well to say something about what is meant by the term, General Aviation. In the broad view, the term can be, and often is, taken to mean all of civil aviation except the airlines. It would be virtually impossible to cover the meteorological needs of all of that in a single paper, in addition to which, one result of trying would be considerable overlap with Mr. Olcott's forthcoming paper. Therefore, I would like to limit the subject somewhat by listing some common characteristics of that portion of the broad category of General Aviation with which this paper will be concerned. The following items should not be taken as a definition, but more as a working hypothesis derived from experience of the makeup of the spectrum of weather customers, if you will, whose needs are considered here.

1) The segments of General Aviation treated here will be those which operate below an altitude of about 25,000 feet. Within that operating regime, there is a broad spectrum of aircraft types, ranging from light, single-engine airplanes to pres-

surized twins powered by turbocharged piston or small turboprop engines, and a few helicopters.

2) The operations considered are non-revenue transportation of persons and property under both the visual and instrument flight rules of FAR Part 91. Non-revenue should not be taken to necessarily imply non-business; however, as much of this transportation is business related.

3) The pilots are generally the owners or renters of the aircraft, as opposed to persons who make their living flying. They encompass a broad sepctrum of flying qualifications. Many of them are instrument-rated pilots. Some of them, praticularly pilots of higher performance aircraft, have Commercial Pilot Certificates. However, they are not often rated as Airline Transport Pilots.

4) Of the aircraft flown, only the pressurized models can generally be considered to be fully equpped for weather flying, i.e., to be equipped with weather radar and certified for flight in known icing conditions. Among the non-pressurized models, the amount of thunderstorm avoidance equipment and ice protection equipment is widely variable, down to frequently none in the fixed landing gear and in many of the retractable single-engine models. Most of these aircraft carry, at least, the basic equipment required for flight under IFR, however.

5) The financial resources of this segment of General Aviation are more limited, and more limiting, to its operations than those of, for example, a corporate flight operation. The necessity of sometimes having to cancel trips is accepted, albeit, probably reluctantly, as the price of not having some types of equipment or services available. In this regard, this segment of General Aviation is much less likely to employ a private weather service than is a corporate or commuter operator.

The above elements describe a very broad, active segment of aviation. Furthermore, it is a segment which is very dependent on the skill of its pilots in coping with weather for the safety of its flights; and on the quality of the weather services it uses, which services are almost exclusively provided by the National Weather Service (NWS) and the Federal Aviation Administration (FAA). Its aircraft do not, in general, have the performance to rapidly climb and descend through the weather. It must, therefore, frequently operate in the weather, or not at all.

It is essential to both its safety and usefulness that this segment of aviation be provided with the training to give its pilots an adequate knowledge of weather, in general; and the avoidance of hazardous weather, in particular. This done, it is then essential that these pilots have available to them weather products and services which will enable them to make intelligent decisions about routes, altitudes, times, fuel, and everything else influenced by weather down to, and including, the consideration of whether or not they should even be thinking about making this flight today. Let's think a bit about training first, and then about the products and services.

It is easy to wax hopelessly philosophical about weather training for pilots. Question: How much training is enough? Answer: Enough to be safe! Question: How much is THAT? The discussion goes rapidly downhill from there. In keeping with the function of this paper as an overview, and, hopefully, as a basis of later discussion, I would like to set forth just a few basic observations on the subject, together with a suggestion or two. First, I submit that the amount of training, which is the minimum necessary for pilots at any given skill level, is that which:

1) Instills in them a profound respect for weather which is beyond their capabilities (or the capabilities of their equipment) at whatever current stage of flying development they may be; and

2) Provides them with the knowledge required to recognize and avoid that weather.

For example, a beginning pilot, whose flying is entirely visual, must be trained in visual recognition of hazardous weather. He must also be trained in recognition of conditions conducive to reduced ceilings and visibilities which are hazardous, in themselves, at that stage. This training must also include the elements of weather briefing necessary to anticipate such conditions prior to flight. If the pilot's limitations are to expand, further weather training, to permit recognition of the new limits, is required.

Now, how much training will a pilot actually get? I submit that this is driven primarily by the requirements for weather knowledge on the FAA written tests for pilot ratings. People are most willing to invest time, effort and money in training for which there is some tangible reward, such as meeting a requirement for a license. I, therefore, suggest

that, realistically, the amount of weather training which these pilots will acquire is strongly affected by the weather content of the Private Pilot and Instrument written examinations. There are, essentially, no other requirements to demonstrate weather knowledge, unless the pilot seeks an Airline Transport Pilot Certificate. These tests are, therefore, among the first things to look at if one wishes to do something which will actually have an effect on weather training of pilots. At present, weather questions constitute, roughly, 15% to 20% of the Intsrument Pilot written test. Since a passing score on the test as a whole is 70%, it is possible to miss most (or even, conceivably, all) of the weather questions and still pass the test. I can, personally, think of nothing which would be more likely to have an effect on the quality of weather training than to score this section of this test (and, perhaps, also the weather section of the Private Pilot Test) separately from the rest of the test; and to make a passing score on this section of the test, by itself, a requirement for passing the entire test.

The requirements for recurrent training of General Aviation pilots (as limited for the purposes of this paper) are, at present, minimal. There is, however, a requirement for a biennial flight review to be given by a flight instructor. There is also a much stiffer requirement for the renewal of Flight Instructor certificates biennially, which instructors can meet (among other ways) by taking a three-day refresher course. I would suggest that a refresher course for the renewal of Flight Instructor certificates devoted entirely (or nearly so) to weather and to the teaching of weather be created, and that this be accepted as satisfying the renewal requirement instead of the regular refresher course on something like an every-other-renewal basis. It would be no big trick to put together such a course, which could and should be made available to any pilot. The carrot of actually giving something tangible for taking it (i.e., the instructor revalidation) would induce far more people than would ever take an avanced weather course otherwise. What better people to take it than flight instructors? It would then be, at least, plausible to expect a general improvement in pilot weather training to take place over a period of time, and to expect that pilots might get more and better exposure to weather knowledge during Biennial Flight Reviews given by these instructors.

Turning to the subject of the weather products and services needed by General Aviation, I would like to submit some fairly specific comments for later consideration in the working sessions (including some of my own personal value judgments as to where improvements have been made and where they are needed), as follows:

1) Thunderstorm products are generally very good. Among those products of most value to pilots, I would list convective outlooks and the associated severe weather outlook charts, severe thunderstorm and tornado watches and warnings, stability charts, radar summary charts, and convective SIGMETS. I believe that little in the way of additional products is required in this area. Fast dissemination is critical to their utility, howver. This is particularly true of the convective SIGMETS and radar summary charts. In addition, the stability chart is a very valuable briefing tool and should be given much faster and wider dissemination.

2) Icing products are grossly inadequate. Despite the seriousness of the hazard, there is no long list of products like the one above relating to icing. The quality of icing forecasts has been generally conceded at these workshops to be poor. This, in my opinion, starts with the total lack of a generally accepted definition of the intensity of icing conditions in terms of forecastable physical parameters, particularly that of cloud liquid water content. I am aware that a great deal of research into this subject is underway at the present time. In the interim, however, much better use could be made of methods presently in hand. A reasonable definition of icing intensities was proposed by NACA in 1947, and a method of forecasting them has existed since 1952. They are not perfect, but they are a lot better than nothing.

3) There are many airports which have instrument approaches but no weather observations. There are also some remote locations, such as mountain passes, where observations would be very useful. Various types of automatic equipment are now being developed and installed to make such observations, which is good. I wonder, however, in these days of stuffing digital video data down wires, if remote television cameras at these sites might not be a better, and perhaps less expensive, solution. I realize that this will go against the grain of the natural deire of technical minds for quantitative data. However, the TV camera at Stampede Pass, which once provided a picture at the Seattle Flight Service Station, went out of service about six years ago and there is now a remote observation site in

its place. I have never found anyone who had used them both, myself included, who didn't prefer the picture.

4) On the subject of pictures, they are worth far more than a thousand words in a weather briefing. I refer, in this case, to the usefulness of a direct look at charts, particularly surface maps, weather depiction charts, radar summary charts, severe weather outlook charts, stability charts, constant pressure charts, and the various prognostic charts. No telephone weather briefing will ever come close to giving a pilot the information which can be had from a look at the charts. The increasing automation and consolidation of Flight Service Stations has, unfortunately, seriously reduced or eliminated the General Aviation pilot's opportunity to peruse charts in many locations. It is obviously not possible to put the system back the way it was. It was changed in the first place largely because it had become impossible to keep it the way it was. However, it seems to me that the proliferation of home and office computers may offer a good opportunity to restore pilots' access to the charts. I believe that a high priority should be given to making charts and other data, such as sequence reports and forecasts, available to those having equipment capable of displaying or printing them.

In the meantime, dissemination of weather data to General Aviation users is, and will continue to be, largely dependent on voice communication, either by telephone or radio. This, of course, is labor intensive and takes a lot of time. Due largely to these two factors, voice dissemination lends itself to the omission of items of data which are important to understanding of the weather situation. One of these items is recent past weather. It is unfortunate that most weather briefings are given as if nothing was known about what the weatherd had been from the dawn of recorded history until the phone rang; but it will probably continue to be the case simply due to time and workload constraints on the part of both pilots and briefers. Some automation of this process is possible, however, and some steps have been taken in this direction. Comments on these are as follows:

1) A system using touch-tone phones allowing pilots to obtain exactly the weather they want by following recorded instructions and entering the necessary commands has been used in a few locations. This concept is excellent and should be pursued and expanded.

2) A scheme has been implemented at the Seattle Flight Service Stations, and perhaps elsewhere by now, in which the caller receives a recorded announcement of briefings for various routes, also recorded, which can be accessed by proper keying of a touch-tone phone. Upon completion of the selected briefings, or if none are selected, a briefer answers if the caller stays on the line. This is also an excellent idea and its use should be expanded.

3) Transcribed weather broadcasts are offered over navigation frequencies throughout the country, and these can also often be listened to by dialing a telephone number listed in the local phone directory. These are good if kept current; but they are quite general, and it is often necessary to listen for a fair amount of time until the data in which one is interested comes around. In this regard, I would strongly recommend that Notices to Airmen (NOTAMS) be removed from these broadcasts. Unlike weather information, NOTAMS for airports and routes not involved in a given flight (and even some which are) are of no value whatever to a pilot in flight. There are few more aggravating wastes of time than listening to a recitation of NOTAMS, meanwhile flying an airplane, maintaining communication with air traffic control, etc., in the sometimes vain hope that the desired weather information will eventually come around. There is no way of knowing how often it happens that a pilot tunes up a TWEB for weather information, hears NOTAMS instead, and then simply turns it off and calls a briefer. I can testify that it is not uncommon. There are plenty of preflight sources of NOTAMS, and the TWEB would be a lot more useful without them.

4) Finally, the EFAS system (commonly called Flight Watch) of direct inflight pilot-to-briefer communication is an excellent service for General Aviation. It could be better if more frequencies were available for it, but functions very well otherwise.