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THE USE OF WEATHER FACSIMILE IN AIRLINE OPERATIONS

By

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The Use of Weather Facsimile in Airline Operations

In these days of atomic developments, symposia on space travel and the like, a discussion of such a prosaic subject as weather facsimile is apt to be a bit dull by comparison. But this trick of being able to send by wire or by radio a picture of a weather map over thousands of miles of space in a matter of a few minutes is indeed a fascinating development, and an important forward step in man's continuing efforts to conquer time and space. For civilization in so many ways is measured by advances in the means of communication, and facsimile is one of those advances.

And it may be of interest to you or perhaps even a little surprising--at least it was to me--to learn that the idea and principle of facsimile is over 100 years old. Way back in 1843 Alexander Bain, an English physicist, took out the first patent on the facsimile principle--an electro-chemical recording telegraph. On November 10, 1855, 12 years later, Giovanni Caselli of Florence, Italy, filed a patent application in England for what he called "improvements in transmitting facsimile copies of writings and drawings by means of electric currents."

Dr. Arthur Korn, a German, in his book entitled Handbook of Photo Telegraphy, published in 1911, 40 years ago, is among the first to mention specifically the transmission of weather maps by facsimile. In his book he shows a picture of such a map. He apparently worked with V. Bjerknes on this project of using facsimile in Europe for map transmissions. However, evidently due to the imperfections in the equipment and the unwillingness or stubborness, if you will, of the meteorologists in affecting a compromise, the use and further development of fax in Europe died aborning.

By 1922 communications engineers had developed photo-electric cells, tuning forks, and electronic amplifiers which gave impetus to fax developments. The first commercial system was set up by AT&T about 1925, and Western Union handled the pictures which were transmitted. Fax transmission of pictures by radio was accomplished by RCA as early as 1924; they were transmitting weather maps to ships at sea even by 1932--20 years ago.

The slow, wet, photographic process of reception was unsatisfactory and after much experimentation a direct, dry paper process was evolved.

As is usual in so many scientific fields, war gave a great impetus to the development of fax. In 1942 I was in Presque Isle, Maine, at the receiving end of a fax circuit originating in Washington. At that time, I guess I didn't realize the full significance of this circuit, because we had a job to do and this circuit was of no help in getting that job done. It was based on the slow, wet, photographic process; the received material was much smaller than present maps, and the people in Washington had far less information than we had on which to base their maps and progs. However, as I look back today on this Washington-Presque Isle circuit of some 10 years ago, I believe it can be truthfully said that this was the direct forerunner by the present nationwide fax circuit, originally established by the Air Force; and from the Weather Central associated with that circuit grew the WBAN Center as we know it today.

This experiment indicated the need for bigger equipment and a dry process. In spite of many hurdles, administrative as well as technical, the Times Fax Company produced, in 1943, 20 machines giving 12" X 18" copy. A network centered around Mitchell Field was set up, running into Connecticut and over into New Jersey. This net worked so satisfactorily that it was picked up in toto and moved to England where it was operated to meet Air Force requirements in transmitting maps, charts, and other weather information from GH2 to the various USAF bomber and fighter bases over there. This equipment was standardized as the TXC machine. Ninety additional machines were ordered shortly. They were used in France, Germany, and in other European countries, as the net expanded with the progress of the war.

After the war was over, the Air Force was faced with a rapid disintegration of its weather service, along with other services, as demobilization proceeded at a rapid rate. But it was still necessary to maintain weather stations at many more bases than qualified personnel were available for. So the fax network established in Europe was moved back to the United States and set up as an Air Force nationwide service, after a preliminary test net in the Washington area.

The Air Force was faced with many problems in setting up and operating this national fax circuit. Funds had to be battled for to pay for the land lines from coast to coast. The equipment was poor, maintenance was poor and personnel, whose sole interest lay in the earliest date they could be discharged from the Service, were responsible for operating and maintaining the net, and for the resulting weather forecast service. To get weather personnel to use the fax at all required some drastic action including discontinuance of Service "C" drops at most Air Force bases. It was a hard struggle, but it was won, and the fax service is now paying dividends in many ways to many different organizations, including the Air Force, the Navy, the Weather Bureau and the airlines.

In my opinion, by far the greatest credit for this accomplishment goes to General Don Yates, at that time Chief of the Air Weather Service. Only through his vision, patience and determination to see this job through to the end, in spite of many obstacles and discouraging setbacks, was success assured.

The first airline to show an interest in applying fax to weather and dispatch problems was United. Inquiries were made as early as 1944 and installations were made in 1946 shortly after the war, when they could get the equipment. Their problem was primarily one of pilot briefing and dispatching due to the fact that their dispatch office was located at Cheyenne, Wyoming, but their transcontinental flights were stopping at Denver, Colorado, or Lincoln, Nebraska. A similar problem existed in the New York area where their dispatch office was at LaGuardia, but many flights were departing from Newark.

The ideal situation in briefing and dispatching is of course where

the pilot and dispatcher can discuss weather problems face to face over a map; but if the discussion takes place over a telephone it is highly desirable that each party be looking at the same map. Although the Weather Bureau had stations at the various localities concerned, use of their facilities was not a satisfactory arrangement.

At the time United installed their fax circuits, the national circuit was just being organized so they could not get drops on it. Thus United's service was complete within itself, where they used their own maps for transmission purposes. The Cheyenne-Denver circuit was so satisfactory that they later established the Denver-Lincoln and the LaGuardia-Newark circuits. Subsequently United moved their dispatch office to Denver and discontinued their western circuits. And when the airlines were permitted drops on the WBAN circuit, they got on at Newark--and LaGuardia too--and discontinued their own service between those stations. Thus they were the first airline to make use of weather facsimile. And it was their original arrangements with the Times Facsimile Corporation which established the rental system for fax. A rate of around $50/mo/machine was agreed to on the basis of it being a pioneering deal, although this would not cover costs. So when the Navy came along in 1947 to rent equipment, it was necessary to develop the present RG recorder to keep the rate low enough. This as you may know is the latest type equipment presently available, and incidentally, it is a rugged piece of equipment and easily maintained. It might be well to mention here that the Air Force bought all its equipment outright rather than rent it.

Immediately after the war many of the airlines including American overexpanded in many departments, including meteorology. The result was operation in the red. Then when the pendulum swung the other way, personnel were released in large numbers and it became, for American, basically a financial problem to solve in finding ways and means of operating the same weather service at a considerably reduced cost.

So it was the profit motive pure and simple that caused us to turn to facsimile. We were able to eliminate our map spotters and a few professional meteorologists. The overall savings were approximately $20,000/yr or roughly 10% of our salary costs.

Perhaps a word or two right here might be well to try to allay some misunderstanding that a few may have regarding fax versus the maps and charts usually used in a weather station. We don't for one minute claim that present day fax is the perfect substitute for unlimited personnel--if you can afford them--and nice white maps and charts with fine-print plotting on them.

But we do say that it is a satisfactory substitute NOW, and we expect that it will gradually get better and better--it already has, in fact. If we stand by waiting for the perfect machine we'll be waiting a long time, and in the meantime where's the pressure for improving present

equipment coming from? But if we're depending on a tool and it fails, we raise H---, and something gets done about it.

Now if we ask the average meteorologist (who has the time or the help to plot nice, neat, white, large-scale maps and charts and has no financial worries as to who's going to pay the bills) what he thinks about facsimile, naturally he's going to be "agin" it. He will find plenty of reasons for not liking fax. I'd like to mention as many of them as occur to me, so that if any of you are going to be using fax for the first time soon, you'll know what to gripe about. Well, first of all, there's the squeal. Fax machines let out a high pitched squeal that can be nerve-racking--if you're the nervous type. Then there's the odor. The fax process is essentially a burning process by which some of the paper coating is burned off. Some have complained that this is an unpleasant odor. But after a while you'll get used to the squeal and not notice the odor, although we did have to box in one of our machines on account of these complaints. At any rate this can be done satisfactorily.

Then, of course, there's the dissatisfaction with the size of the charts, the lack of sufficient data on them, the illegibility of the data, the small scale of the raobs, the occasional failure of proper reception, failure of someone in the station to start the machine on time, late receipt of some maps, necessity for using a grayish-tinted paper instead of white--which doesn't help appearance any--poor analysis by WBAN personnel, and so on.

I've heard them all, I think, and they are all legitimate gripes. But in spite of them we still believe, after over 2½ years of operation, that the advantages far outweigh the disadvantages, and we'll never go back to the old system, I don't believe. I am probably more favorably inclined toward fax than some of the other large airline chief meteorologists, but the general trend in the industy, I think, is indicated by the fact that there are now some 27 airline drops on the circuit for 10 different companies.

Insofar as the effect of installation of fax on the actual operation of the weather stations is concerned, we believe that fax, if anything, actually improves the quality of the forecasts primarily because it gives the forecaster time to concentrate on the particular problem at hand. This is hard to prove, but we have good reason to believe it is so. Before fax was installed, the spotters and forecasters were constantly under pressure trying to keep ahead of the great mass of material that was continually pouring into the station. The routing process of plotting and/or analyzing occupied much of the forecaster's time. Now most of this is done for him so he can concentrate on forecasting. We find that the surface map is still the basic forecasting tool. And because of deficiencies in the fax surface chart for this use, we still plot and draw sections of the U.S. for which it forecasts. We do this because of late reception of the fax maps, even though it has been scheduled earlier in the last month

or so, and also because the fax map is too small, does not have enough reports on it, and is difficult to read--that is, the color scheme and sharpness of definition is not good enough.

In addition, we plot and analyze sections of the 3-hourly maps, and frequently the hourly maps whenever we have a critical situation. We do, however, use the fax surface maps of the U.S. for pilot briefing, and copies are also distributed to the dispatchers and to some administrative personnel. This requires considerable duplication, and although they have some of the faults previously mentioned (to a lesser degree), they are quite satisfactory. Nevertheless we still want to see improvements as suggested by the gripes we previously mentioned.

We are sorry to have lost some of the upper wind charts formerly sent via fax and we must plot these now, but only because they are not received via fax. The various upper level charts, surface charts of areas surrounding the United States (e.g., Atlantic, Pacific and Canadian) are all adequate for our use. It is a distinct advantage to receive the prognostic charts all plotted out rather than in coded form. Application of a celluloid overlay to raob charts makes it possible to use them fairly satisfactorily, although we've got to develop ways of improving raob presentation. There is, of course, considerable upper air data for the higher levels that is of no use to us, but the Air Force and Navy make use of it for jet operations. We hope to use it too some day.

Aside from the use of fax by airline meteorologists, it has found two other important airline uses: (1) for briefing of pilots, and (2) for providing weather information directly to dispatchers. As I indicated earlier, United was the first airline to apply fax to their service, and it was principally to solve the pilot briefing problem. American now has fax drops at Newark and Dallas solely for this purpose, and it has worked out quite well. In fact, when I called our station manager at Newark the other day just to check on this statement, the first question he asked was, "You're not thinking of taking it out, are you? - 'Cause I won't let you. We couldn't get along without it."

In connection with the dispatching problem, it has been fairly standard procedure in the past for the larger airlines to operate a weather forecasting service in conjunction with each dispatch office. A year or so ago both United and Northwest discontinued their weather stations at LaGuardia, released their personnel and substituted fax. United did the same at Seattle. This summer we have taken similar action at Nashville. It might be pointed out that airline dispatchers must have a very comprehensive knowledge of meteorology, and in fact are in many cases former airline meteorologists. It is no doubt true that the service of the meteorologists at these minor or less important dispatch centers is missed, but the fax service has proven a safe and adequate substitute.

During the years shortly after the war, when we were faced with the

problem of finding ways and means of cutting down our expenses, we were confronted from all angles with the question, "Why don't you people in the airline business consolidate your forecast offices into one large weather central at each airport, thereby saving space, personnel and money?" At a superficial glance it looks good, and we chief meteorologists were confronted with this proposition from our own chief executives, investigators in the military service, private operators who wanted to get the business, and others. For example, at LaGuardia at one time there were no less than 8 airline weather offices, besides the U.S. Weather Bureau, including American Airlines, American Overseas Airlines, Pan American, Eastern, Colonial, Northwest, TWA and United. Similarly at Chicago, Los Angeles, and other big airports numerous airlines operated weather offices on the same field. I could spend some time on the pros and cons of a central office, but suffice it to say that rapid distribution of maps and charts was always one of the biggest stumbling blocks. Committees appointed to study the problem in minute detail always came to the same conclusion--that an airport central office would be more expensive and less efficient than the old individual office setup.

But it was recognized that a national central with adequate means of distributing the data would be a possible solution. We believe time has proved that to be the case. At any rate, when the airlines first decided to obtain drops on the then existing national fax circuit, we ran into the stumbling block that the circuit was primarily military and although the military did not object to our getting on, the Weather Bureau did--until the Bureau also became a partner in the Washington Central. So we feel we enticed the Bureau into earlier participation than might otherwise have been the case. Now there are only four airline weather stations at LaGuardia instead of eight, and several of these have fax. Installation of fax was not the sole cause of this decrease, but it was an important contributing factor.

We obtained our drops early in 1949, installing them in four of our five forecast offices, and several other airlines, perhaps even a little earlier, obtained drops on the fax circuit. Due to special arrangements for obtaining maps from the Weather Bureau at Los Angeles, we do not have a fax drop there. Currently, as we previously mentioned, there are 10 different airlines who have a total of 27 drops on the circuit. They include American, Braniff, Capital, C&S, Eastern, Mid-Continent, Northwest, Pioneer, TWA, and United.

Another important application of fax in airline operations was made in the New York area, due to the scattered arrangement of weather and operations offices between LGA, EWR, and IDL. The Weather Bureau maintains its overseas forecast offices at LGA, although practically all international airlines operate out of IDL, and to get the maps and charts from their LGA office to IDL, the Weather Bureau installed fax. Anyone who has visited IDL knows the vast extent of that field. When American Overseas had their operations office at Idlewild it was several miles from the Weather Bureau

briefing offices. Therefore it was quite a problem getting back and forth between our own office and the Weather Bureau's to pick up the maps and charts several times daily. An arrangement was therefore worked out whereby we obtained a drop on the local Weather Bureau fax circuit to obtain all the maps, etc., and our own company meteorologists briefed our pilots, after having discussed the weather with the Weather Bureau. It worked out extremely well.

Thus we see the flexibility of the fax service and the many ways it can be used to solve various types of airline problems.

Now what are the future prospects for fax? Where do we go from here?

Well, one of the several faults with the present fax machines is that an operator must stand by at the completion of each transmission, ready to take the paper off, insert another piece and start the machine at the next transmission. Some improvement in this situation has resulted from development of a so-called start and transfer unit which is used with two machines. This unit automatically transfers the transmission from the first to the second receiver, thus obviating the necessity for standing by at the end of the first transmission. Thus the meteorologist has a twenty-minute leeway for picking up the completed map and reloading the machine. But this means you've got to have two receivers.

Of course, this is not altogether satisfactory, so the Times Fax Company has developed an endless roll machine like the teletype machine which will operate entirely unattended. Furthermore it receives material 18" wide instead of 12", which has finally been settled on as the new standard width. The machine has four speeds--30, 60, 90 and 120 scanning lines per minute. Sixty is the standard for the national network at the present time. Times Fax engineers believe that wireline facilities are not adequate at the present time for the 120 speed but would handle nicely the 90 speed. Slower speeds are needed for radio reception under difficult conditions.

Ten machines are now being built, after having worked out the bugs, but due to military priorities, it may be a couple of years before we can look forward with assurance to bigger maps, faster transmissions and fully automatic reception.

A whiter paper has been developed and the problem now is to get the cost down equal to that for the paper currently used. This whiter paper will improve the appearance and legibility of the maps.

Continuous improvements are also being made in the WBAN center itself--the heart and brain of the fax system. More personnel have recently been added to step up the schedules and prepare new charts. Some of the maps have also been cleaned up by eliminating unnecessary markings and hieroglyphics.

Thus we see that the fax net is not a static setup. Improvements are constantly being made. It is going to get better and better. Yes, weather facsimile is here to stay and, though not without opposition, it is gradually going to edge its way into more and more weather stations even to the point of occasionally causing technological unemployment--which it has already done. But that seems to be the history of many advances in this day and age. When one comparatively inexpensive machine can, in effect, place a 150-man weather station at one's disposal for the preparation of maps and charts, it is sure to find a place in the scheme of things. True enough, land lines are expensive, but we may even do without them some day. Although I have not previously mentioned it, the U.S. Navy--and the Air Force too--have extensive radio fax broadcast systems. They serve to exchange analyzed maps instead of raw data between the continents; and the Navy broadcasts to many ships at sea equipped to receive the maps and charts. There is no reason why this can not be done over land masses as well as over the sea. It would require several frequencies and presently is not quite as dependable as wire, but it is feasible.

Not knowing whether you have a drop here in Toronto on our national fax net, I have brought along a number of map samples that you may be interested in looking over later this evening.

I might just take a moment or so to mention briefly one or two of the other thoughts that are in the minds of the airline meteorologists these days. The Met Committee of the Air Transport Association has recently held its annual meeting in Denver, so the more important items are still fresh in mind.

A few years ago there were many different types of weather conditions that adversely affected airline operations, such as fog or low ceilings and visibilities, extreme cold, icing conditions, aloft or on the ground, and wing or carburetor icing, heavy wet snow in the carburetor intake, and thunderstorms. Such conditions have in the past been considered dangerous and have caused numerous aircraft accidents. However, modern ingenuity has conquered most of these weather problems, at least to the point of eliminating the dangers involved, and even most of the aggravating time-consuming delays and cancellations they used to cause.

This may not seem true if you have waited around an airport several hours for an overdue flight to arrive or depart, or have been cancelled out at the ramp at the last minute. But by and large, these are the rare exceptions rather than the rule. For example, American Airlines now operates about a quarter of a million miles per day. In 1950, 98.4% of all scheduled flights were operated, or putting it another way, only 1.6% were cancelled. This year it is running slightly better--around 1.4%. This approximately 1.5% of cancellations includes not only those due to weather but all other causes--mechanical, lack of revenue, ATC, etc. Thus the influence of weather on airline operations is in fact a comparatively minor one today.

On high density routes delays are encountered when IFR conditions at terminals exist, but this is due to inadequate airport facilities, not the weather itself. Present day airports are not geared to handle the traffic in IFR conditions. Radar and ILS systems combined with modern airport lighting arrangements have made landings and take-offs normal procedure except in almost zero-zero conditions--and FIDO at LAX may soon prove that even zero-zero conditions can be modified sufficiently to permit operations. Experiments using a different principle to disperse fog are being conducted by United at Medford, Oregon.

Icing conditions, either wing, propeller or carburetor, are no longer a problem. And in all our operations, since we have used the heated wing, there has been no accident due to icing of any kind. Icing, though a common occurrence, is so easily handled that it is seldom reported by pilots any more.

But thunderstorms remain the one big hazard that hasn't been completely licked yet. When I speak of thunderstorms, I of course refer to all the hazards associated with the storm, such as lightning strikes, severe turbulence, and hail damage. Lightning strikes or the most frequent static discharges are actually no longer a serious problem since the advent of the all-metal airplane. Don't believe any story you hear about an airline ship being destroyed because it was struck by lightning. Our pilots are required to report every lightning strike they encounter and I see every one of those reports. As a result of our large scale operations, during the thunderstorm season there's hardly a day goes by that some one of our flights doesn't report a strike. A strike will momentarily blind the pilot if he's not prepared for it by turning the cockpit lights bright or putting on dark goggles; it will only very occasionally knock out some of the radios, rarely all of them, and will practically always leave only a tiny hole where it entered or left the aircraft. But it will never destroy a modern airliner.

Turbulence and hail are the real hazard. But I believe we have found the solution to thunderstorm flying. This lies in the use of airborne radar. I have had the opportunity of making numerous flights in aircraft equipped with airborne radar, including two weeks of thunderstorm flying in Denver in American Airlines Research Ship Gamma in 1949, and round trip flights DCA-MIA and DCA-DEN in the Navy's flying electronic laboratory, the "Delta", a DC-4.

I remember so vividly our flight out to Denver from Chicago in July of 1949. We departed CHI around 6 PM. Thunderstorms that had occurred that afternoon were already rapidly dissipating and we expected a routine flight. By the time we arrived near Omaha, however, the whole sky to the west seemed to be on fire with lightning flashing everywhere. So we decided to land at Omaha to check the weather and take on a load of gasoline. Sure enough, sequence reports indicated thunderstorms reported all along our route to Denver. I could not help feeling then that were I a pilot taking off into such a widespread area of thunderstorms, I would be very worried

indeed. But with our airborne radar we were all eager to get going. The storms showed up beautifully on the scope, indicating where the storm centers or rain was occurring. By avoiding these areas we were able to complete our flight with as smooth a ride as if we had been sitting right here in this room. During that very time an eastbound airliner flying in the same area was forced to land and could not proceed until a thorough inspection of the ship was made because of the severe turbulence it encountered.

Similarly our flights in the Denver area were made through or around the thunderstorms as we chose, depending on radar to select the desired path. This radar was specially equipped so that return signals above a certain strength could be erased, thus giving the pictures on the scope a sort of doughnut like appearance. Where the doughnut was thinnest represented the fastest rate of change of rainfall, and results seemed to indicate that these areas rather than the areas of heaviest rain were the most turbulent.

The Navy--NACA project now in progress will continue investigation along these lines, and also to determine where between the 3 and 10 cm band is the best for airborne radar. On our recent flights in the Navy "Delta", thunderstorms were encountered and navigated around by use of radar without the slightest difficulty. From what I have seen I'm completely convinced that this is the only real solution to the thunderstorm flying problem and it really is the answer.

Those most closely associated with this subject seem to feel that it may well be in general use on many commercial airlines within five years. I for one certainly hope so.

Clear air turbulence, especially in the higher levels, is another subject that is of particular interest to airline meteorologists these days, not so much because of present problems but because of possible problems when jets come into airline use.

My impression is that clear air turbulence is not a problem in present day airline operations up to around 22 or 23 thousand feet, about the maximum altitude at which we operate today. At least no reports of severe clear air turbulence below this altitude have come to my attention either in our own operations or those of other airlines, excepting of course a few cases where pilots got a little too close to the mountains in high winds.

As you may know, a clear air turbulence reporting program is now in operation and reports are being collected from military and civil sources. American is participating in that program. Mr. Talmadge of NACA, who is working with the project, informed us at Denver that around 160 reports had been received of clear air turbulence between 10,000 and 55,000 feet. Of these eight or nine were severe, the rest light to moderate. The Weather Bureau plans to analyze these reports to see if they can be tied in to the synoptic situation with a view to forecasting the turbulence if possible.