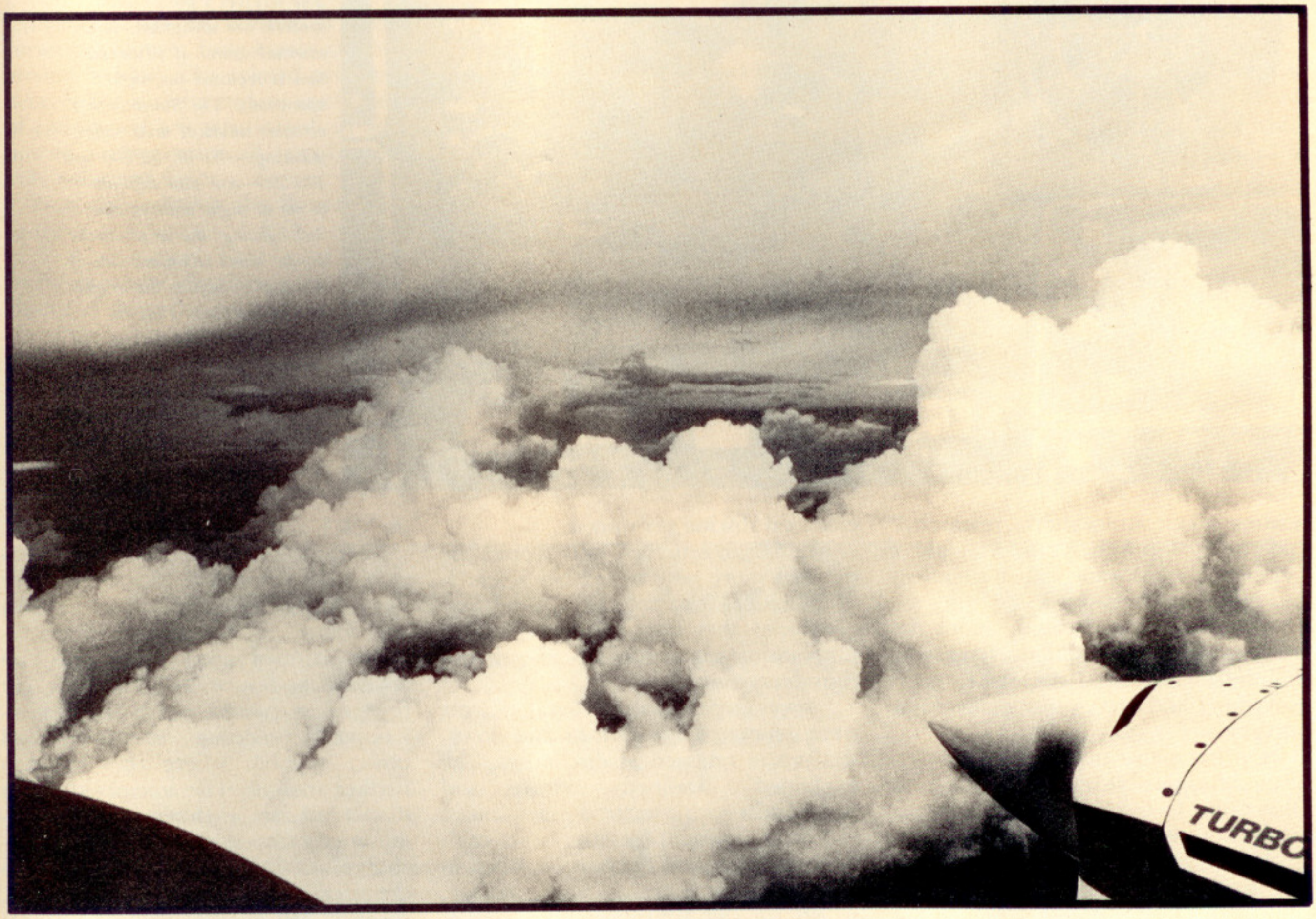
Weather Avoidance



An Alternative to Radar

Electrical discharges and turbulence go together and Stormscope points them out

BY ROGER ROZELLE
AOPA 537321

"If it hadn't been for my own vivid experience of flying into a thunderstorm in 1958, I wouldn't have developed Stormscope," said Paul Ryan (AOPA 191058), a 47-year-old electrical engineer, who was flying a Cessna 182 at the time.

"It really shook me up. My family was with me, and for a long time after that flight my wife had a fear of clouds. I decided to do some research and learn what might help me avoid any future experiences like that."

Ryan, who claims to have been involved in the development of more than 150 scientific products, first considered the potential of adapting radar to single-engine aircraft.

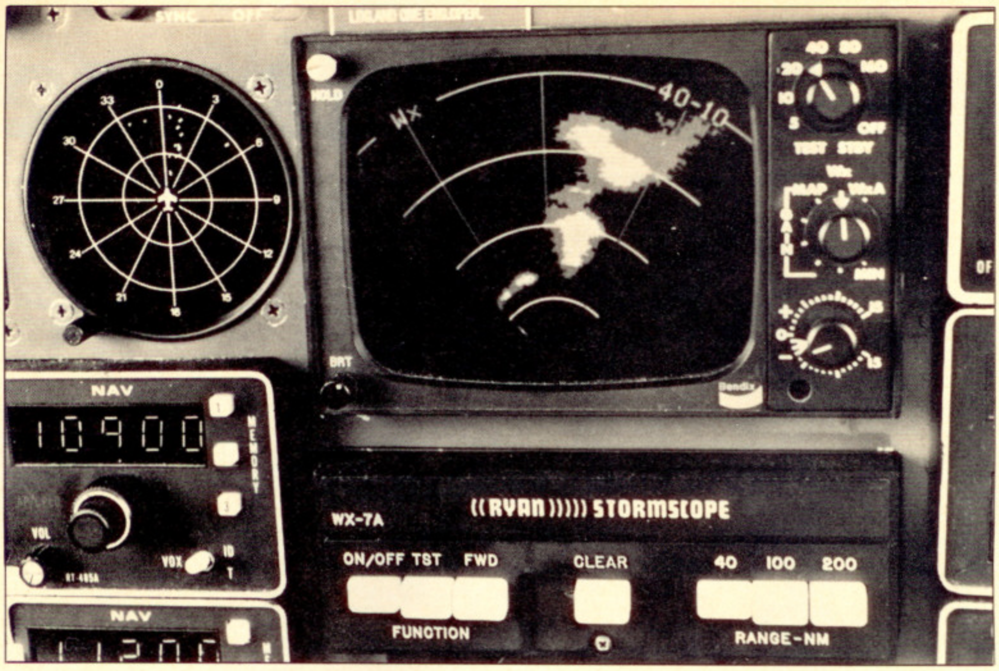
"The more I looked into radar, the more I decided it wasn't the way to go," explained Ryan, who averages 300 flight hours a year. "Getting the cost down and dealing with the technological complexities seemed to present too many problems, especially in the 1950's.

"My frightening experience with the turbulence inside the thunderstorm was marked by lots of lightning, so I kept thinking how electrical discharges might be related to detecting turbulent activity."

That interest in thunderstorms played a backseat role to his occupation as president of Dytronics, a Columbus, Ohio, company that specializes in developing sophisticated industrial instruments.

"I kept charging along in the business, but I spent considerable time

PHOTOGRAPHY BY THE AUTHOR



The Stormscope CRT display is located to the left of the Bendix RDR-160 radar; below it is the receiver/control unit. The receiver's push-button controls are unlighted, so an external source of illumination is required for night operations. The Stormscope's circular nautical mile range markings—20/40, 50/100 and 100/200—are also difficult to see at night without external lighting; the small knob on the lower left-hand side of the display adjusts the brightness of the dots. This inflight photo shows Stormscope indicating significant electrical activity that agrees with the radar rainfall presentation (note the absence of level three contouring).

reading about atmospheric research," said the soft-spoken Ryan, who has a commercial certificate with instrument and multi-engine ratings.

"I became so enthusiastic about the relationship of electrical discharges to thunderstorms, that I decided to drop everything and start putting my ideas into practice."

Ryan left active management of Dytronics for one year and enrolled in Ohio State University in 1968 to learn more about electrical discharges.

"I didn't think the business would fail in my absence," he said, with a smile on his face. "In fact, it turned out to be one of our more prosperous years.

"I discovered that atmospheric research was really in its infancy. What studies had been done were aimed at protecting things on the ground from lightning, and very little material related to other types of electrical discharges."

He readily admitted that the association of storms with electrical activity wasn't new. Benjamin Franklin knew about it, and Ryan credited a British scientist with using electrical discharges to track storms.

"Considerable research was conducted before World War II in tracking storms by the radio frequency (rf) energy generated by electrical discharges," said Ryan. "A British scientist named Watt actually set up a system to track storms worldwide by pinpointing electrical discharges received at listening stations on various continents.

"The technology available at that time called for gigantic antenna systems and large pieces of equipment, hardly suitable for aircraft. With the development of radar, and its recognition as a weather avoidance device, interest in electrical discharges waned."

After Ryan returned to Dytronics, he devoted more time to further research of electrical discharges. He became convinced that they were the key to pinpointing turbulence associated with thunderstorms.

"I recognized that electrical charges were generated by updrafts and downdrafts and released as discharges," he explained. "Defined updrafts and downdrafts with a vertical extension of at least a thousand feet are sufficient to generate electrical discharges. Keep in mind that for every discharge we see, which we call lightning, there are at least 100 discharges that we don't see.

"It is the convective windshear associated with the opposite vertical air movements that creates the turbulence that can destroy an airplane.

"My research—backed up by sophisticated equipment and computer analysis—finally established specific characteristics—a 'fingerprint'—of the electrical activity that I was most interested in, discharges associated with convective windshear."

Ryan developed an airborne system to detect and display those discharges that he was convinced were sure signs of turbulence. He introduced the ((Ryan))))) Stormscope Weather Mapping System to aviation at the Reading Air Show in 1976.

The present Stormscope, WX-7A, is a 19-pound system of three separate boxes and an antenna, and reflects some changes made during the past three years. The current price is $5,680 with a one-year warranty on parts and labor. That price doesn't include installation, which could run from $400 to $1,000 depending primarily on how much panel work is required to mount the CRT and the receiver.

Radio frequency (rf) signals, generated by electrical discharges, are picked up by a single flat-pack antenna and routed to the panel-mounted receiver (control unit) where they are analyzed and sorted. They are either rejected or passed on to the remote-mounted processor (computer and power supply), where they undergo further analysis. The assembled data is displayed on a three-inch, panel-mounted cathode ray tube (CRT). Discharge activity is displayed relative to the aircraft's nose, in the form of dots, covering 360 degrees with the aircraft at the center. Range is selectable—40, 100 or 200 nautical miles. However, Ryan said that the CRT display beyond the outer range marker extends the range to 267 nautical miles.

While azimuth information has been considered good (it is derived from the same principle by which an ADF needle points to a station), Ryan's decision to label the range switch "pseudo range" on the first 50 units, generated doubts about that aspect of accuracy.

"Unfortunately, in trying to be honest with users, I decided to call the range 'psuedo range,'" he lamented. "While I believed ranging was accurate, based on my research and experience, I recognized that it wasn't exact. As a scientist, I decided to take a conservative approach. But users repeatedly told me that ranging was very accurate and they persuaded me to drop 'psuedo' and the implication that range was inaccurate."

Range is determined by the computer after careful examination of several parameters of each electrical discharge, over a time period measured in microseconds. The intensity of the rf signal is analyzed, and measurements are made of the time required for it to reach a peak, in addition to the time necessary for it to decay. Frequency patterns are looked at with special attention paid to the amount of energy present at certain frequencies centered around 50 kHz. The related properties between the electric and magnetic fields of each signal are scrutinized, in addition to an inspection of specific vertically polarized fields.

Ryan claimed that the Stormscope's range is accurate to ± 10% over each of the three ranges. That figure is based on the operator identifying the primary cluster of dots, the area where most of the activity is concentrated. While he said that the device requires little interpretation by the operator in comparison to radar, he admitted that there are some situations that could cause confusion.

The Stormscope has a tendency to display unusually strong electrical discharges closer to the airplane than they really are, a phenomenon that Ryan calls "radial spread." He said that characteristic is really an advantage to the pilot, because it indicates a moderate or severe storm.

"Severe storms cause dots to pop up on the display in a line from the primary cluster along a radial to the center of the CRT," he explained. "Those dots are the result of electrical discharges that are stronger than the processing computer's fingerprint for the standard electrical discharge, so they are displayed closer to the airplane than they actually are, while weaker ones are displayed further away. Only 10% of the electrical discharges fall outside the computer's fingerprint and the majority of those discharges are stronger than the fingerprint."

Stormscope users are also cautioned that at night, rf signals generated by electrical discharges well beyond 200 miles could be received and falsely displayed in the 200-mile range, as a result of those signals being reflected off the ionosphere. Night effect doesn't influence signals on the 40- or 100-mile ranges.

Once dots are on the CRT, they remain stationary even when the aircraft's direction is changed. Failure to maintain a constant heading can result in erroneous information by displaying indications of electrical activity over a wider area than is actually present. In fact, the pilot could turn his airplane 180 degrees and the dots wouldn't move, while any new information would continue to be added, always in relation to the aircraft's nose.

To prevent the display from becoming cluttered with extraneous dots, the system has a "clear" feature that empties the computer and clears the CRT display. The pilot can clear the system

Electrical Discharge Linked to Turbulence

The results of a report, prepared by RCA Service Co. under a National Aeronautics and Space Administration (NASA) contract, were published in December 1978.

The report, "A Preliminary Test of the Application of the Lightning Detection and Ranging System (LDAR) as a Thunderstorm Warning and Location Device for the FAA Including Correlation with Updrafts, Turbulence, and Radar Precipitation Echoes," was based on data gathered at the Thunderstorm Research International Program (TRIP) during the summer of 1978 at J.F. Kennedy Space Center in Florida.

TRIP-78 offered independent scientists and researchers from across the United States the opportunity to share certain government equipment and facilities, in an environment where thunderstorms frequently occurred, although their particular storm research was not necessarily related.

The LDAR system computed the location of electrical discharges by utilizing two independent receiving networks. Each one used four separate antenna sites, each separated by 6.2 nm.

Using computers, LDAR was able to determine the location of radio frequency (rf) signals (60-80 MHz) generated by electrical discharges, by measuring the differences in the arrival time of the signals at different antennas. Laser calibration tests established that, within a 40-nm radius from the central LDAR site, range was accurate to ± .5 nm and azimuth ± .1 degree.

Data from the LDAR display was carefully compared to data from ground-based radar displays. The comparison was based on information gathered during three thunderstorm days. Additional information was provided from instrument data gathered by an armored T-28 aircraft ("Inside the Boiler Room," October 1978 *Pilot*) that made thunderstorm penetrations into activity also plotted by LDAR. According to the report, the inclusion of the T-28's data was "a first since no comparison of LDAR with updraft/downdraft wind velocity or with turbulence has previously been presented."

The emphasis of the report was placed "on those capabilities of the LDAR system that are expected to be of interest to the FAA" and intended to suggest areas of improved utilization of LDAR by the FAA.

The conclusions drawn by this report are as follows:

1. Visual comparison of radar echoes with LDAR plots of electrical activity gave excellent agreement. LDAR agreed in azimuth and range with the precipitation echo indicated on radar. In the absence of LDAR activity, the weather was observed to be either fair or consisting of only light precipitation.

2. Pilots' visual observations of lightning flashes at distances of 5 to 25 miles were in agreement with the areas of electrical activity indicated by the LDAR.

3. Detailed comparison of LDAR with radar showed LDAR activity was present only over a portion of the precipitation echo. In general, only a portion of the precipitation echo corresponds to an electrified thunderstorm cloud.

4. Airborne measurements of updraft and turbulent parameter by an armored T-28 aircraft penetrating thunderclouds established close agreement between the presence of LDAR and high updraft/downdraft activity and increased values of the turbulent parameter.

5. No LDAR response indicates a lack of thunderstorm and updraft/downdraft activity as clearly as the presence of LDAR activity serves as a warning of thunderstorm and high updraft/downdraft activity.

6. The excellent correlation of LDAR with thunderstorm and high updrafts reported herein indicates that LDAR could serve as a useful adjunct to the FAA for air traffic control in thunderstorms.

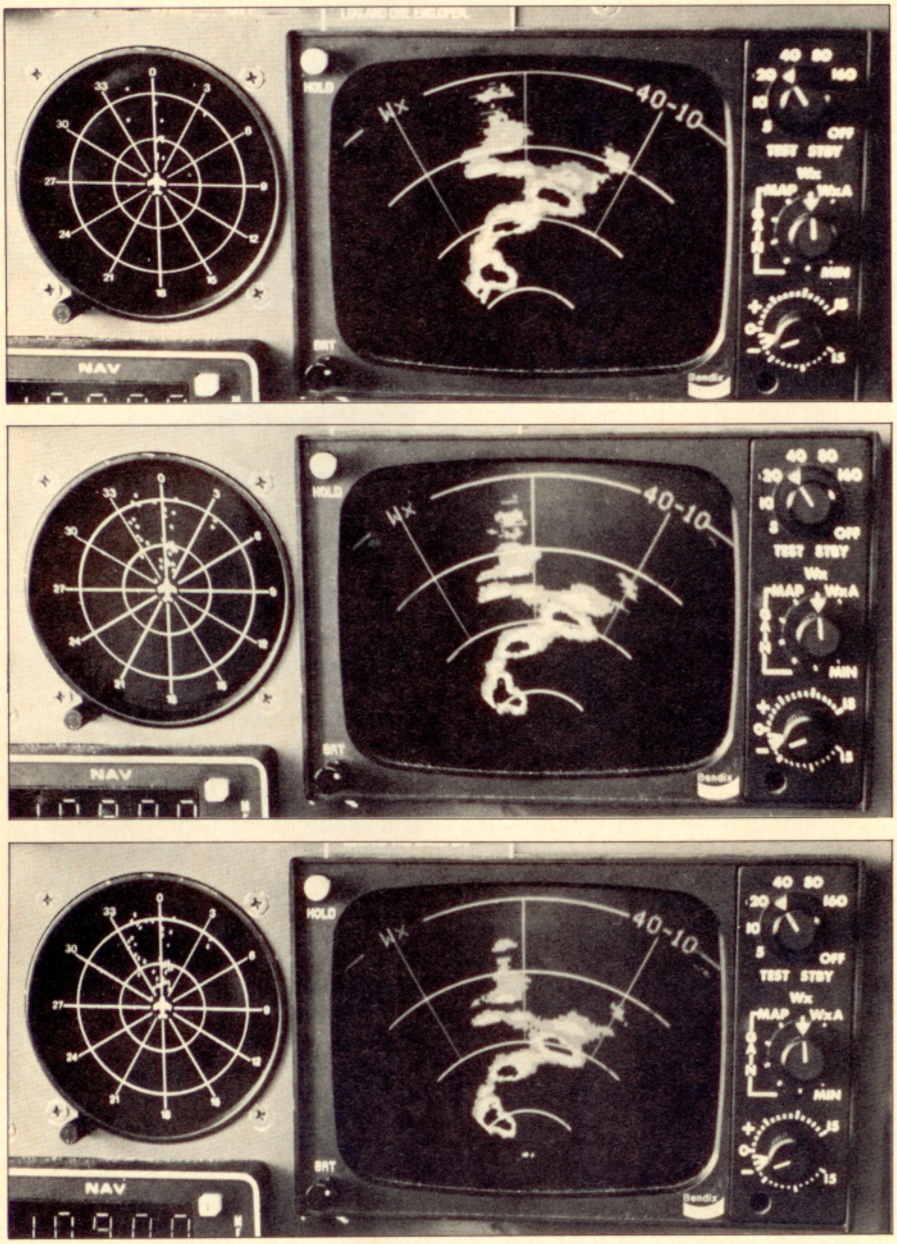
[John Prodan, the pilot of the T-28, told the *Pilot* that his experience bears out what the report has cited: the T-28 was damaged by multiple lightning strikes during a thunderstorm flight in Oklahoma this past summer; the aircraft equipment recorded updrafts in excess of 100 mph and +7 G's during that storm.

The aircraft which is operated by the Institute of Atmospheric Science of the South Dakota School of Mines and Technology, will be equipped with a Stormscope for flights next year. The school uses the aircraft in an ongoing thunderstorm research program, and data will be gathered by making direct penetrations into areas where electrical activity is indicated by Stormscope.]—RR manually, or the computer will remove any dot that is older than five minutes.

Very active, or severe, storms will also clear the display by rapidly updating it with new information. Those are the conditions where Ryan claimed his invention "really shines."

"Severe storms cause the computer to continually replace the oldest dots with the newest dots," he said. "The processor can store 128 dots, so a really active storm can produce a dazzling display as the dots change. Those conditions will change rapidly enough so that even as the aircraft heading is changed, the information will be accurately presented on the display."

A "forward" mode on the receiver is intended for use during such severe conditions. It allows the 128 dots to be concentrated in the forward 180° sector of the display.



This series of photographs was taken over a period of about 30 seconds, when the Cessna 414 was at 17,000 feet and moving closer to a storm, where tops were reported above 30,000 feet. Stormscope and radar were operating on 40 mile ranges and the radar tilt was adjusted for the best presentation. In the first photo, the Stormscope displayed several dots immediately after the displays had been cleared; additional dots continued to accumulate in the following pictures. Discernable clusters of dots near the 20 mile range marker closely correlate with level three contours on the radar display. Stormscope also indicates electrical activity further left of course than the radar's rainfall presentation. A pilot using Stormscope to avoid areas of turbulence would make a course correction to the right or left then clear the display, allowing new information to appear for more accurate course selection.

"There can be times when a severe storm may be located behind the aircraft," said Ryan. "In that case, a weaker storm ahead of the aircraft may not be presented accurately since the more intense activity may be using the available dots."

While Ryan said the Stormscope performs best by showing active storms, he suggested that it has other potential as well. He believes it may prove to be an indicator of clear air turbulence (CAT).

"Scattered dots represent lifting action and establish the fact that there is turbulence and a good possibility for convective thunderstorms to develop," he declared. "We don't make any claims that it can detect CAT, but we strongly suspect that there is a relationship between CAT and electrical discharge. There just hasn't been enough research in that area yet."

Ryan was quick to point out that Stormscope displays weather history. Unlike radar, Stormscope shows the past, not the present.

"The dots on the CRT represent electrical discharges that are no longer present," he said. "The pilot has to make some simple decisions on how to use that data, based on how active it appears and how far away it is. As he moves closer to the activity, he can determine if course changes will be necessary."

Ryan recognized that radar and Stormscope are attempting to pinpoint the same thing—turbulence—but he claimed that Stormscope does it better.

"Thunderstorms can't exist without lightning, or electrical discharges," said Ryan. "So, Stormscope is on solid ground.

"Radar transmits a signal through an antenna, then waits to receive any signal that may be reflected by precipitation. The reflected signals are presented in most modern airborne radars as one of three levels, or contours, of intensity. Steep gradients—increases from light rainfall to heavy rainfall over a short horizontal distance—are associated with turbulence. But we all know that rainfall—even heavy rainfall—can exist without a thunderstorm."

In spite of his claim that Stormscope does it better, Ryan has run an uphill battle with radar in the marketplace. But he predicted that will change.

"It is difficult to overcome 30 years of user experience, as well as conditioning, that radar is the primary answer to severe weather avoidance," he said, while admitting that in the early days of Stormscope even he believed that radar was the best tool for the job.

"However, recent research indicates that the radar manufacturers admit that present-day radar is unable to pinpoint turbulence, except by chance association with rainfall. Now they are touting Doppler radar as a better means of turbulence detection and they plan on providing it—at $50,000 or more per unit—for airliners of the 80's.

"Stormscope does it now, for a lot less money."

Ryan said that he had informal discussions with RCA and Bendix about his device. He said that the possibility of integrating the two concepts—radar and Stormscope—was discussed.

"I provided drawings and equipment to Dr. William Firestone, vice president of RCA's Avionics Systems Division," said Ryan. "But with the advent of the WeatherScout radar, nothing more has been discussed."

[RCA introduced WeatherScout I as a low-cost radar for the single-engine weather radar market. The 15.5-pound system, including 9.5 pounds that is located in the leading edge of one wing, has a range of 90 nautical miles and a scan of 60 degrees. It sells for $5,455 uninstalled ($7,595 installed on a Piper Lance, for instance).]

Ray Daddario, program manager for general aviation radar at Bendix, said that the Stormscope concept had been looked at, but his company has no plans to leave the radar business.

"We debated the value of Stormscope vs. radar," he said. "We looked at two phenomena that attempt to describe the same situation and we felt that radar did it best.

"We believe there is significant value in detecting the intensity of rain and the precise range information provided by radar, in addition to the added feature of ground mapping. And radar in the marketplace is outstripping our most optimistic predictions."

Although Daddario said that radar did it better, he recognized that the Stormscope concept appeared to be valid. In fact, he echoed a feeling

Air Force Evaluates Stormscope

The Air Force Flight Dynamics Laboratory published a report in December 1978—"In-Flight Evaluation of a Severe Weather Avoidance System for Aircraft"—that released the results of its evaluation of the Stormscope "to determine its capability to identify thunderstorm activity with sufficient accuracy to permit use as an in-flight lightning and severe weather avoidance system."

The USAF blamed lightning as a cause in 55% of its weather mishaps during the period from 1970 to 1975 and noted that "frequently, the occurrence of lightning in a weather formation indicates the presence of other violent atmospheric conditions such as hail, icing and turbulence."

It stated that "the detection of hazardous atmospheric conditions cannot, at present, be accomplished with absolute certainty," while noting that radar, the most common severe weather avoidance tool, is "far from perfect" and "influenced by many atmospheric aberrations and requiring substantial training for proper operation and display interpretation."

Ground weather radar pictures were correlated to LDAR (see "Electrical Discharge Linked to Turbulence") and in-flight data; a USAF T-39B Sabreliner was equipped with a Stormscope, in addition to a Bendix RDR-1300 radar.

The project was conducted at the Kennedy Space Center during the 1978 Thunderstorm Research International Program (TRIP) (see "Electrical Discharge Linked to Turbulence"). Flight missions were flown when thunderstorm activity was present, with the aircraft being vectored directly toward or away from a storm, ranging 20 to 70 miles from the storm center. Twelve hours of data was collected, and three hours of that was used in compiling the report.

The report indicated that interpretation of the results had to keep in mind "two significant differences between the systems."

First, the LDAR system did not discriminate between types of electrical discharge, but recorded and displayed wide ranges of electrical activity.

However, Stormscope received radio frequency signals generated by electrical discharges in the range of 50 kHz, thereby rejecting or failing to detect signals recorded by LDAR.

LDAR also used a more complex antenna system, as well as three computers to store and display data, whereas Stormscope as an airborne unit was limited in those respects. Therefore, its data was "somewhat degraded compared to LDAR."

In comparing Stormscope and LDAR, Stormscope tended to display the primary activity area more distant than LDAR, averaging 15 nautical miles. That activity area averaged 11 degrees difference in azimuth between the two, although the activity area overlap averaged 60%. The Stormscope activity areas averaged 150% larger than corresponding LDAR areas.

Comparisons of Stormscope and radar displays indicated that Stormscope activity usually occurred in areas of second- and third-level precipitation radar contours. The Stormscope activity correlated with the precipitation gradient, not intensity. Weather avoidance paths, based on second- and third-level radar contours and Stormscope electrical activity, showed "good agreement," despite range and azimuth differences.

The report noted that Stormscope displays were "highly variable in nature, at times being widespread with instances of apparently extraneous activity, and at other times being tightly clustered, showing good correlation with LDAR and radar indications."

It did conclude that the "coarse definition of electrical activity areas was shown in most cases to be adequate for the purpose of severe weather avoidance," while adding that there were instances of unresolved discrepancies that would have required penetration to resolve.

The report went on to say that Stormscope's passive design (no transmitter) and lack of complex electro-mechanical antenna system should result in a higher mean-time-before-failure (MTBF) than radar. It also saw the 360° field of view as an advantage over radar, which is typically limited to 120 degrees.

However, it also found that Stormscope was very sensitive to electrical currents created by other aircraft equipment, so it required careful placement of the antenna. Additionally, the requirement to update the display by manually clearing the unit was seen as a disadvantage. Neither of those negative aspects was seen as serious.

In an attempt to discover if the Stormscope would be affected by precipitation static, the T-39 was flown into a thin cloud layer at the freezing level. "The aircraft evidently went into corona during this time causing an immediate loud squeal on the radio headset . . . the digital time code generator started counting backwards and forwards randomly, the digital radar stopped functioning, the digital Stormscope display populated rapidly with a random display of dots and the digital computer stopped functioning. . . . the corona condition lasted for approximately three minutes, during which time none of the above systems was operational."

The report recommended that additional data be accumulated by direct penetration flights into radar contour areas where Stormscope shows electrical activity. It also said consideration should be given to a single display of both Stormscope and radar information.—RR shared by Ryan.

"Personally, I would want both devices for maximum protection," he said. "The Stormscope would provide a useful second view."

Ryan agreed that both are better than either, and he has a Bendix RDR-160 radar installed alongside Stormscope in his Cessna 414; but he sees radar as the source of "a useful second view." While the merits of the separate systems are argued, Ryan predicted that they eventually will be integrated into a single unit.

"Actually, I have the patents that pretty well tie up the concept," he claimed. "Any manufacturer who wants to use it, will have to do so through me.

"I feel sure that radar and Stormscope will eventually be integrated, probably with a switching system that will provide the operator with either display."

In the meantime, Ryan will continue to push his product as being a better indicator of turbulence. But he cited other advantages too.

"Stormscope has been installed in everything from a Cessna Skyhawk to a BAC-111 to an F-104," said Ryan, who helped install the first two dozen units so he would know what problems installers faced.

"Expensive radomes or structural changes are not required, and since the unit is passive—it only receives signals—the maintenance is low.

"Printed circuit boards are epoxy-based and glass filled, and the edge-connectors are gold plated. Cable connectors are top quality, and we have taken care to mount heat producing components in the remote-mounted processor, away from the radio stack."

Ryan, whose 200 dealers are allowed to change circuit boards or boxes, but perform no other circuitry repairs, claimed a high mean-time-between-failure (MTBF) based on the repair rate of the first few hundred units.

"We determined a MTBF based on actual repairs to the first few hundred units in the field," he said. "We estimated 200 flight hours per year per unit and came up with a 3,500 hour MTBF. And we believe it will prove to be higher, because that figure included a batch of short-lived CRT's."

Ray Cole, avionics engineer for Federal Express, said that the high MTBF was a primary reason for considering the installation of Stormscopes on larger jets in the company's fleet. Downtime in its business of transporting parcels costs money.

"This looks pretty attractive to us as a backup system on our 727 jets, which are legally required to fly with radar," Cole said. "The impact of a 727 missing a flight into Memphis, Tenn., because the radar (800 hours MTBF is typical on one model used in the Federal Express fleet) is inoperative, is significant. Instead of 100 angry passengers, we have 2,600 angry customers."

Cole said he would have to persuade the FAA to approve the device for Part 121 operations (air carriers and operators of large aircraft). That effort should not be too difficult, since the FAA recently approved Stormscope for Part 135 operations (air taxi operators and commercial operators) that require storm detection equipment.

In its approval for Part 135 operations the FAA said "Tests have shown that this system has enough correlation with ground and airborne weather radar that the Ryan Stormscope may be used for thunderstorm and severe weather avoidance. . . . The Ryan Stormscope was not tested for thunderstorm penetrations. Therefore, this approval does not include this authorization."

Recognition by the FAA that his device is a legitimate weather avoidance tool, and not a gimmick, was incentive for Ryan to move more aggressively into the marketplace. He said that refinements can be expected, but he expected no drastic changes in Stormscope.

"Stormscope will undergo evolutionary, rather than revolutionary, changes," said Ryan, who was the co-inventor of the first nonrotating ADF antenna after World War II.

"For instance, the antenna system went from a shared system with the ADF (a switch changed the antenna from the ADF to Stormscope, an arrangement that was installed on only two aircraft) to a combination Dorne and Margolin whip with a King flat-pack antenna on the next couple of hundred units. Today, the antenna consists of a single flat-pack antenna of our own design.

"Specified range markings have increased from 100 to 200 nautical miles, and the "forward" and "test" modes were added to the WX7-A we are now marketing. However, the basic circuitry and the concept have remained the same.

And the future? He says it goes beyond aviation.

"We will develop sophisticated units for airline use, where more money can be spent for equipment," predicted Ryan. "We may slave the display with a direcitonal gyro and use a different method of displaying the data, including color or some other enhancement of the image. The CRT and digital processing also allow us to consider displays that would include checklist and RNAV information.

"Of course we are already looking at other markets, perhaps marine applications. And we have produced about a dozen fixed-base units ($6,800), with built-in power supplies that are already in some rather unique markets. For instance, the Saskatchewan Power Corp. is using one to anticipate power station outages during thunderstorms, so they can preplan the rerouting of electricity if lightning causes a shutdown.

"The applications that Stormscope can fill are sure to provide me with a lifetime of challenges." □

Using the Stormscope

Just before we landed at Charlotte, N.C., the Stormscope display began to come alive with a few dots that clustered beyond the 200-mile marker. A check with the National Weather Service (NWS) facility located at the airport indicated that there were thunderstorms building along the southern coast of Georgia and throughout central Florida. The latest radar summary chart showed cloud tops reaching 57,000 feet along the coastal areas.

Ryan and I took another look at the Stormscope before we departed. While we sat in his Cessna 414 on the ground, we watched the green dots appear on the screen, clustering at the outer range marker and gathering along a radial from there to the center of the CRT. No activity was indicated on the 100-mile and 40-mile ranges. Ryan said the Stormscope was unaffected by terrain or height, so it offered an excellent means of getting an indication of weather, even on the ground.

When there is no electrical activity, the Stormscope screen is blank, so a test function is incorporated into the system to verify that it is operating properly. When the test button is pressed, a steady sequence of dots is generated. They appear on the CRT at the 45 degree bearing at approximately 100 miles, in either the 100-mile or 200-mile range position. The dots are cleared from the screen by pushing the "clear" button.

We departed VFR and elected to use the Stormscope to navigate directly to the indicated storm area. The weather became more ominous as we neared Savannah, Ga., with clouds high above us and dark masses ahead, covering the area across Savannah and out to sea, but Stormscope activity had subsided. Although the Stormscope indicated a few isolated areas of light electrical activity within 40 miles, the radar showed no targets.

Ryan insisted that although Flight Service, NWS and Air Traffic Control (ATC) had earlier called the activity "severe," his experience with Stormscope indicated that wasn't the case. In fact, other weather areas to the south appeared to be building, so he suggested that we fly there and attempt to penetrate a storm for some first-hand comparisons of radar and Stormscope.

We had to file IFR, and Jacksonville Center gave us permission to navigate directly to the storm in the Jacksonville, Fla., area.

About 60 miles out of Jacksonville, the radar began to paint areas of precipitation that agreed with the Stormscope's presentation. Before long, we found ourselves in the middle of Sigmet material.

Ryan assured me that his experience, and the experience of other Stormscope users, had repeatedly shown that unless the aircraft penetrated an area where Stormscope was mapping electrical activity, the ride should be relatively smooth; more important, the airplane wouldn't penetrate turbulence that would break it. He also assured me that the type of activity that generated hail—rapid and concentrated clustering of dots—was not evident in this storm.

We advised ATC that we were radar and Stormscope equipped and doing weather evaluation, and they allowed us to navigate at 15,000 feet as necessary. We certainly weren't going to fly into other aircraft, because they were being vectored away from where we wanted to go, amid frequent reports of "moderate turbulence."

The next hour was incredible. Using radar and Stormscope, we literally wandered around inside the bowels of the storm. We avoided any areas where Stormscope mapped activity. Usually it coincided with the radar display, but often it was beyond the scan of the radar, and a turn to check the correlation would frequently have put us into the activity indicated by the Stormscope. Its 360-degree view of the weather was impressive.

We penetrated level three radar contours with steep gradients, usually associated with turbulence. Ground controllers repeatedly told us that we were in the most severe portions of the storm, a fact emphasized by high pitched voices that reported we were in areas where tops were above 55,000 feet, and punctuated by the question, "how's the ride?"

According to the definitions, the ride throughout the flight was characterized as smooth to light turbulence, marked by a few moderate jolts.

Even when we penetrated level-three contours, we usually encountered only heavy rain. Sometimes it was heavy enough that we had to shout at each other above the loud pounding on the airframe, but the ride was never rough.

It was fascinating to watch a dot appear on the screen, followed by another and another, until there was a well defined cluster. Often, the activity would slow, until no new dots were being added and they would disappear from the screen after a few minutes, while a new cluster would begin to form at another location.

There was no difficulty in navigating between the various areas mapped by the Stormscope on the 40-mile range. A few times when we moved along the border of activity indicated by Stormscope we could see lightning, and a random scattering of dots would suddenly appear on the screen. I just cleared the CRT and allowed new information to be displayed.

We had moved into the Jacksonville area as darkness fell, so when we were close to the electrical activity indicated by Stormscope, we could see the reflections of lightning in the dark clouds.

We repeatedly saw cloud-to-cloud discharges—long yellow bolts of lightning that illuminated the clouds around us. Several times electrical charges built up on the airplane and streaming displays of electricity leaped from the static wicks on the electric windshield. Stormscope never recorded any of the cloud-to-cloud or aircraft discharges. (According to Ryan, it isn't supposed to, a fact that he gleefully enjoyed seeing demonstrated.)

Precipitation static repeatedly drowned out the radios with loud squeals, but Stormscope and radar functioned without any problems. Charts clung to the windshield and the hairs on my arm stood erect (probably from sheer fright rather than static buildup), but we encountered little or no turbulence.

The cockpit took on an eerie green glow from the green dots on the Stormscope and the green presentation of the radar display; both units had adjustable brightness controls. The radar display was aesthetically more pleasing, a point Ryan readily admitted.

During the entire hour we spent inside nature's boiler room, we used the autopilot to change headings, but disengaged the altitude hold. Yet, the greatest change in altitude that we encountered was +100 feet, and that was cumulative over several minutes.

The next day we carefully watched the weather; the cold front moving in from the west had stalled. By afternoon the Stormscope indicated activity within 30 miles of Jacksonville, Fla.—a fact verified by the nearby NWS.

Once again we explained our mission to cooperative controllers, who apparently had heard of our flight the night before. They provided us with a block altitude from 9,000 feet to 11,000 feet and turned us loose. We spent more than two hours in the storm (tops exceeded 50,000 feet), carefully penetrating level-three radar contours at maneuvering speed, but avoiding areas of Stormscope activity.

We worked north and south, from one side of the storm activity to the other, aided by a series of controllers who provided us vectors to the most intense weather as shown on their radars.

It was daylight, and we saw few visible discharges, but the communications frequency was alive, as it had been the night before, as aircraft asked for deviations to avoid weather. Once again we had the storm mostly to ourselves, but enjoyed a ride no bumpier than the previous day. In fact, the biggest bump we encountered—a moderate one—was outside the clouds.

On one occasion we approached two separate cells with equally steep gradients, one at our 11 o'clock position, the other at one o'clock. According to Stormscope, the smaller cell at one o'clock was alive with electrical activity, while the other cell, about four times larger, was quiet according to Stormscope. The controller bet us a "rough ride on the left," but it was smooth.

One aircraft did venture into the weather area, apparently encouraged by our reports to ATC. He was vectored into an area where the controller said, "That 414 went in there, and he said he got a smooth ride."

Well, that pilot didn't get a smooth ride and was hollering for a way out. We correlated his position with our equipment and with the controller's ground-based radar and determined that he was in the midst of some electrical activity that had developed behind us; we had penetrated the area a few minutes earlier when no electrical activity was indicated.

Navigation with Stormscope information was adequate, although suggested deviations would have been more coarse without the additional aid of radar. Azimuth and range showed close correlation between Stormscope and radar. Ranging to specific cells was better defined with radar, but only a small percentage—perhaps 25% or less—of those cells showed any signs of electrical activity. On some occasions, the electrical activity was clearly located in a certain small portion of the percipitation area painted by radar.

I found myself automatically reaching to tap the clear button whenever we made a heading change, so the display information would not be cluttered with extraneous dots. Things were active enough for new dots to rapidly appear in correct relation to our new course.

However, it was a bit disconcerting to watch dots appear on the Stormscope at 30 miles, and see them remain stationary, while the radar display continued to move toward us (as the airplane moved), growing in size. Of course, sometimes that electrical activity continued and built a line as we moved toward it.

Later, when we examined the radar summary charts that were applicable to those two flights, I felt like fainting. I would have never ventured into that stuff in my Piper Archer. Yet, just as Ryan had promised, the ride was never rough; it would have presented no problem for the Archer or its pilot had we had the necessary equipment. And while we were required to make few deviations to avoid areas of activity on the Stormscope, other pilots, including the airline jockeys, were making wide deviations based on ground and airborne weather radar.

At this writing, I have about 80 hours of Stormscope experience, most of it in weather conditions that were generating electrical activity, versus about 800 hours of radar experience (when it worked). Although my experiences inside the storms were rather dramatic, they are not unique among Stormscope users I have talked to.

I am not suggesting that every pilot go out and buy a Stormscope so he can play "I gotcha" with ground-radar or feel a sense of immunity from turbulence. If there is one thing we can say about the weather, it is that we don't know everything about it; Mother Nature may get the last word.

In any event, Stormscope is intended as a weather avoidance tool to supplement other weather information, not a license for penetration. It deserves careful consideration, not only as a supplement to radar, but as an alternative to radar as primary airborne storm avoidance equipment.—RR