THE COCKPIT WEATHER DATA LINK

Pilot Weather Advisor - How It Came To Be

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Pilot Weather Advisor, the concept for displaying weather data in the cockpit of airplanes, was sparked by work being done at NASA Langley Research Center (LaRC) in the late 1970s.The technology was first developed in LaRC`s Storm Hazards Program to provide better information to the pilot flying into thunderstorm weather. The subsequent development of the commercial version involved many people who made suggestions and made it work, and it was not till 1993 that the patent was obtained and sold to the WSI in 2002. Today, versions of it are available on panel mount displays in aircraft as well as on iPads and other portable devices.

Langley's Storm Hazards Program

1982	First F-106 "weather in the cockpit"
1988	FAA Cockpit weather white paper
1990	ViGYAN Phase I for Pilot Weather Advisor
1991	First PWA demonstration in aircraft
1991	ViGYAN Phase II for Pilot Weather Advisor
1993	Patent issued
2001	ViGYAN Phase III for Pilot Weather Advisor from NASA Glenn
2002	Sold to WSI

In the 1970s, there were a lot of airliner accidents involving summer weather, such as heavy rain, lightning, gusts, wind shear, and hail. In response, the National Transportation Safety Board telegrammed a plea to many US agencies to investigate the causes and determine what could be done to prevent them. A copy of that telegram landed on my desk at NASA Langley Research Center. My Division Chief, Joe Stickle, asked me, "What are you going to do about this?"

At that time, I was in Langley's Flight Research Division, after working on several space programs. I was also a licensed Private Pilot with about 2000 hours with an Instrument Rating. I had flown single engine aircraft all over this continent: Montreal, the Bahamas, the west coast including Florida to Pasadena, another trip to Douglas and Lockheed in California and then to Boeing in Seattle and back to Virginia. Another trip was made from Virginia to Fairbanks, a 4000 mile trip in a Citabria that took ten days. And yet another from

Newport News and back to the National Severe Storms Lab (NSSL)in Oklahoma was made to learn how to use the new Doppler Weather Radar prototype NSSL had developed for the National Weather Service. Many of those trips were in the summer time, and I had many encounters with summer weather elements, causing significant diversions due to the lack of adequate weather data.

So, to answer Joe's question, I proposed that we at Langley develop our *Storm Hazards Program*, in which we would fly a strong and well equipped airplane into severe conditions and, with adequate ground based equipment, find out things such as the incidence of heavy precipitation, winds, turbulence, and lightning, their effects on the aircraft, avoidance of them, and design criteria for conditions that could not be avoided. We would also look at weather prediction methods in a separate program.

Next, what airplane would we use? The late 1970s, I travelled around the country and looked at several, including the F-4, and an F-106B at NASA Lewis Research Center (now NASA Glenn Research Center) in Cleveland, Ohio. This latter delta winger had a cockpit for two, and *no horizontal tail to come off in a thunderstorm*; it was my choice for a strong airplane. It also had a large weapons bay in the bottom of the fuselage which could house our airborne data acquisition system. We had all the aircraft systems lightning hardened by Andy Plumer of Lightning Technologies of Pittsfield, Massachusetts. You can see this important aircraft on display in the Virginia Air and Space Museum in Hampton, Virginia. (Figure 1).

A NASA Cleveland Test pilot flew the F-106B to Langley for our use. After a thorough overhaul of its systems by Mike Klebtiz and his crew in the hangar, Felix Pitts developed our data systems. We had all of these data systems lightning hardened by Andy Plumer. In 1980, Langley test pilots started flying it as NASA 816 into storms, with me on the ground vectoring them into the storms using the National Weather Service S band WSR 57 weather radars located at Patuxent, Maryland, Roanoke, Virginia, and near Cape Hatteras, North Carolina. These radars only measured precipitation, and were not mosaiced together, so I had to scan them separately, and give the pilots the locations for the storms to penetrate. The low power X band onboard radar had a small antenna in the nose of the airplane and did not see the same things the more large and powerful S band ground radars were showing me. After that 1980 first years' experience, I asked my crew to figure out how to send the ground-based radar picture to the airplane. One of my contractors on another project did it during that winter using machine language coding. That second year, we used it, and the pilots and I were seeing the same radar picture! It improved our operations significantly, and after one such flight with Test Pilot Phil Brown and Flight Test Engineer Bruce Fisher, I turned to my ground crew in the control room and said, "I want that in MY airplane!" So, it came to be.

My FAA Work in DC and Move to Develop Pilot Weather Advisor

After I retired from NASA in 1986, I spent about two years working for the FAA in Washington as a contractor, helping them develop the weather data systems for their Next Generation Air Traffic Control System, including the development of the first national weather radar mosaic using data from the new S Band doppler weather radars that not only measured precipitation, but also velocity and turbulence. Another aspect was the use of Terminal Doppler Radars for measuring wind shear during approaches to landing. I recommended the locations for the 50 such radars based on thunderstorm incidences. While there, I also discussed the idea of putting the radar mosaic in all airplanes, but one of the officials said "NO! The pilots wouldn't know what to do with it!"

That sparked my decision to leave that job, go back to Hampton and form Aero Space Consultants in 1988. I began to develop the Pilot Weather Advisor, with encouragement from another FAA official, Malcolm Burgess. He steered me to ViGYAN, an engineering company outside the gates of NASA Langley, where we hoped to get NASA funding to do this. Eventually, we were able to successfully apply for funding through the NASA Small Business Innovation Research program.

We were awarded a Phase I contract in December 1990, which showed in detail what we would do. At some point, I uplinked satellite weather data to Jack O'Neil's Piper Malibu with engineer Allen Kilgore back in the cabin with the prototype system on a computer in June 1991 (Figure 2). When we received the Phase II contract in April 1992, we developed the more complete system and demonstrated it in a Cessna 172 and 182.

The Final Steps

It worked! We received the patent #5,265,024 in November 23, 1993, with the displays as shown in Figure 3. Further development was delayed to later in the 1990s until satellite time become affordable and multi-function displays/portable devices became common. At that point, Mr. Keith Hoffler of ViGYAN led an effort to fully commercialize the system using SBIR Phase 3 funding from NASA Glenn and private investment from Paul Volk. Eventually, the system was sold to WSI and they marketed the system as WSI InFlight. Other companies began offering similar systems (such as XM Weather) as well as the FAA in providing their version as part of ADS-B, as shown in figure 4. These two displays were obtained on Keith Hoffler's iPad as he was returning to his home base at Portsmouth, with convective activity nearby. This display shows only the weather radar data.

The *NASA Office of Aerospace Technology Aviation Award* was made to ViGYAN in May 2002 for the original Pilot Weather Advisor System. In September 2003, ViGYAN won the nationally recognized *R&D 100 Award* for our Pilot Weather Advisor System.

Keith Hoffler received a *Turning Goals Into Reality* award from the NASA Aviation Safety and Security Program in 2004 for getting it to market. The June 2018 AOPA PILOT magazine states that “Cockpit datalink weather, one of general aviation’s great technological advances, makes weather flying safer than ever before”.

Acknowledgements

This story is just the overview. There were many people involved in the various phases, and each made significant suggestions to make it work. Among them were the following:

- NASA crew who made the Storm Hazards Program successful
- Malcolm Burgess -- FAA
- Sudhir Mehrotra -- President of ViGYAN who oversaw and funded much of the program
- Ernie Dash -- Weatherman
- Scott Shipley -- provided the weather data for the Malibu flights
- Allen Kilgore – ViGYAN Phase I manager and engineer who operated the prototype system in the proof-of-concept flights in Jack O’Neil’s Piper Malibu in Wisconsin
- ViGYAN programmers Shashi Seth, Binyun Xie, and Richa Garg – ViGYAN software developers
- Keith Hoffler – Project Manager for the final Phase III commercialization effort. Keith was key in developing a detailed business plan and led the effort to create a prototype of the commercial system. He spoke with MANY potential investors and led the NASA Phase III SBIR funding development of the commercially viable prototype system needed to get it to market. He and Damon were the core of what was “sold” to WSI.
- Damon Hill -- Created the code that is what WSI acquired
- Paul Volk – Our major private investor and demonstrated the WSI InFlight in his 1994 Piper Saratoga.

A GREAT TEAM!

Contributors to the development of this story include Sudhir Mehrotra, Richard White, Bruce Fisher, Keith Hoffler, and Paul Volk.