The Development of WRK Analysis Equipment and Operation S.A.F.E.

BY
Richard W. Whitney

Preface….Thirty years ago a sequence of events began, that in aggregate, was to have an impact on the entire Aerial Application industry. Some of these events appear to have occurred out of chance, while others were products of planning and foresight by a relatively small number of people, with a common interest in aerial application. The following contains part of the story of Operation S.A.F.E., along with the names of those most involved in its development. Dr. Lawrence O. Roth is the major contributor and I have included some of my own recollections from a previous article, "A String of Pattern Technology".

It was a fortunate set of circumstances that took Dr. L. O. Roth (the "R" in WRK) to the NASA sponsored Workshop on Agricultural Aviation Research, conducted and hosted by Dr. Fred Bouse at College Station, Texas in 1976. NASA representatives were there and, as a result of a conversation between Roth and Dr. Bruce Holmes, NASA Scientist, an unsolicited proposal from Oklahoma State University was developed and funded for about $150,000 over three years. The objective of the work was to "Develop Rapid Pattern Assessment Methods and Equipment for Spray Aircraft". Dennis Kuhlman (the "K" in WRK) was also working with aerial application at Kansas State University, and his acquaintance with us at OSU soon led to cooperative efforts. Although he was not an official participant in the NASA project, he was the essential third member. It was ultimately from this NASA grant, the cooperative research by Whitney, Roth and Kuhlman, and the interest and support of the NAAA and others, that Operation S.A.F.E. would be created. The company WRK, Inc. and the WRK equipment would also follow.

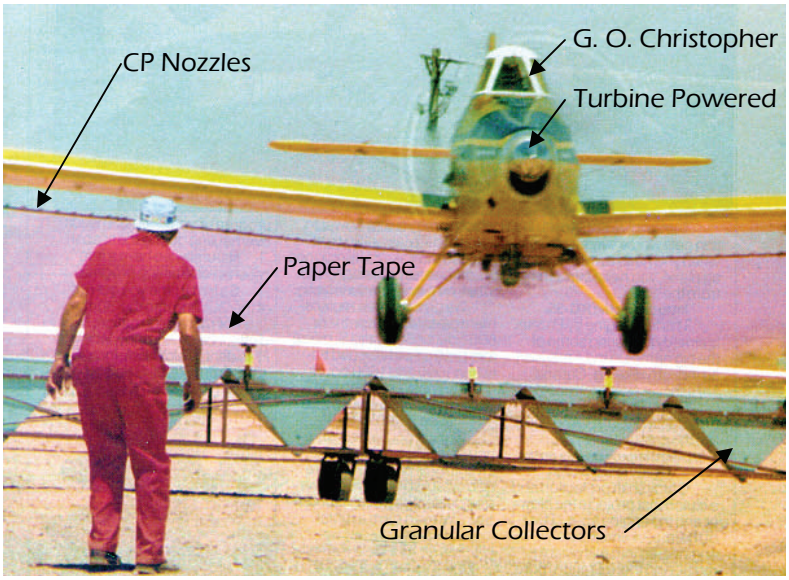

Figure 1. Dr. L. O. Roth awaits a spray pass over the original OSU bin collectors. (Chandler, AZ 1980)

Work was begun during 1977, producing the first OSU analysis system in 1979. The main features of this first pattern analysis system included a four-section framework of one-meter square hopper-pyramids constructed so that, when attached together, they formed an 80-ft collector for collecting granular material. A paper-tape strip was positioned on the top of the bins so that the system could be used for both granules and liquid spray analysis. The analysis equipment, fluorometer and strip chart (no computer involved, as yet) were fastened at one end of the sample line. For liquid spray patterns, the plot of the deposition was developed as the paper tape was reeled in. For granular patterns the collections from each hopper were weighed and the numbers plotted. All of this equipment was moved about the country via a gooseneck trailer and a one-ton truck.

During 1980, fly-ins were organized and conducted all over the country, refining the equipment after

each fly-in along with developing and streamlining the procedures. Fly-ins were held in Oklahoma at Enid, Ponca City, Olustee, Chickasha, Texoma, Webbers Falls, and Checota; in Texas at College Station; three in Illinois at Litchfield, Lincoln and Steward; at Chandler, AZ; Hutchison, KS; Easton, MD; Wallops Island, VA and Gettysburg, PA. The rate of technological advance was rapid, driven by the interest of agricultural aircraft operators to schedule fly-ins, the chemical companies wanting to sponsor them, and the NAAA seeing the potential benefit to the industry. We developed a team (this author, Roth, and Kuhlman, along with Tom Underwood, OSU Lab Technician) that conducted tests together, during the NASA project work. Sometime during 1980,at a fly-in at Hutchinson, Kansas the computer and the fluorometer were first connected together to draw a deposition pattern in "real time". Kuhlman had been experimenting with an Apple II (64K of RAM operating at 2 mHz). His tests had made use of the paddle game ports to draw a pattern on the computer monitor screen. After that fly-in, intense cooperation commenced between Kansas State University and Oklahoma State University, albeit only at the professor level, so that every time a fly-in event occurred, there was at least one major piece of equipment that was new or one which was improved over the time before. The comment was true, "We never went out with the same equipment twice".

It was this team that was called on by the NAAA to conduct a fly-in at Chandler, AZ, hosted by Bob Copeland in June, 1980. (Worth noting in the photo of Figure1, dated 1980: CP nozzles were being used, the aircraft was turbine powered, and G. O. Christopher was the pilot.) There had been a claim, regarding dust that had drifted from a loading site onto surrounding dwellings and the publicity had stirred up some of the local population resulting in derogatory media reports. It was believed that a fly-in might show the professional attitude of pilots and the agricultural aviation industry which would help offset the wild and irrational claims the media was intent on publishing about those "barn-storming crop-dusters". The event was held with at least three TV stations on hand to document the event and to interview the team members. Fortunately, we were able to control our tempers, ignore the leading questions about dangers of pesticides and instead, respond with educational and/or informative answers. We were pretty naïve about TV interviews and weren't very polished. Airplanes are very photogenic, however, and the red dye coming from the aircraft as they flew the pattern passes, the aircraft making steep turns, and the bustling activity on the ground by our team overwhelmed the negative intent of the media and turned the event into something of curiosity and plausibility for the TV interviewers and subsequently for the TV viewers.

The Chandler fly-in was an important event due to the TV coverage, but the Easton, MD fly-in on Election Day, 1980 was also significant. This location was chosen by the NAAA for its proximity to Capitol Hill. During that event, all or nearly all, of the Senate Agriculture Committee members and more than forty EPA desk jockeys were escorted to Easton by Harold Collins (NAAA Executive Director) and other NAAA personnel where they were given a personal "tour" of our fly-in operations. These two NAAA fly-ins demonstrated the importance of this work to a national audience and the NAAA began thinking how this activity could be developed into a national education program for the industry.

During 1981, the bins were replaced by an extruded aluminum track to support the 35 mm paper tape which made the system air mobile and could be transported by four-place aircraft. Again, numerous fly-in activities with improved system operating procedures, computer software development and other developmental work and research studies were conducted.Fly-in event requests and simultaneous technological improvements to the system began to mount up. For the first time, we could answer such questions as, "Just where do individual nozzles spray the ground?". Single-nozzle studies were conducted on aircraft volunteered by interested pilots who gave of their time and resources to fly the experiments. That information is still in use by analysts today. Ten days were spent in Boise, ID where a single nozzle study was conducted on the new Eagle aircraft using the pattern analysis equipment.

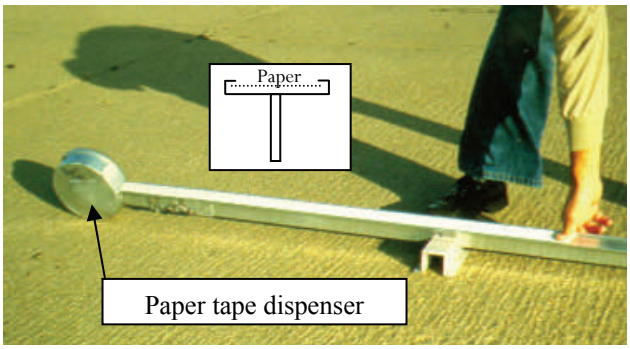

Figure 2. Aluminum extruded track to hold paper collector tape. (OSU, 1980)

The NAAA with the assistance of the OSU/KSU team was developing the guidelines for Operation S.A.F.E. and

revealed that the acronym stood for **Self-regulated Application and Flight Efficiency**. Since the existing equipment belonged to OSU, the NAAA commissioned a contractor (John George engineering firm in Fort Scott, KS) to develop two analysis units, based on the OSU/KSU system, to be owned by the NAAA and sent around the US in two vans for use by individual state associations for fly-ins. This first contracted system was used in the inaugural Operation S.A.F.E. fly-in held in Franklin, Virginia in October, 1981 and was conducted by Whitney and Roth. Two days later, a follow up fly-in was held at Orange, New York and was conducted using the same equipment and crew. **Operation SAFE** was now officially underway!

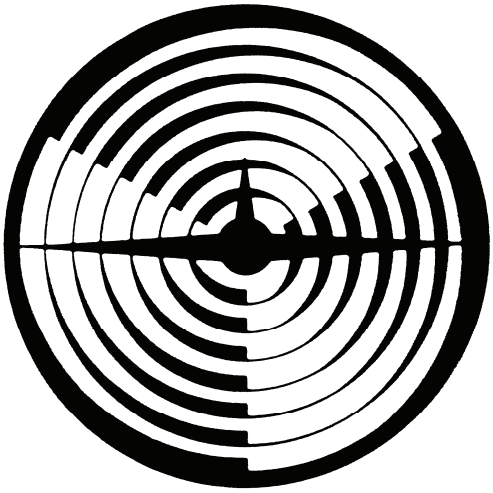

Figure3. Original NAAA S.A.F.E. Emblem

More discussions were held with NAAA officials during the year as to how fly-in analysts might be trained on a national basis. In October, Kuhlman and Roth met with the NAAA R& T Committee in Washington D.C. where the Operation S.A.F.E. equipment and techniques were discussed at length.

By 1982, the Pattern Analysis System had more improvements. The computer had changed to the more portable Apple IIC, a paper track had been designed which could be disassembled and packed into 4-Ft boxes, and the entire system could be transported in a single Cessna 206 or Cherokee-6. The team (Kuhlman, Roth and Whitney) made numerous trips to fly-ins using a Beech Sierra and a Sundowner. On January 29 & 30 the team flew to California and conducted a fly-in in the Imperial Valley at Calipatria, hosted by Mr. Jim Pankratz and in the San Jaquin Valley at Corcoran , hosted by Darrell Frey of Lakeland Dusters. Paul Dale of Sanag organized and assembled the funding for these fly-ins.

In February, the team organized and conducted a NAAA sponsored "Trial Operation S.A.F.E. Training Workshop" where sixteen analysts were trained in the use of the Operation S.A.F.E. equipment and in the management, organization and operation of an Operation S.A.F.E. fly-in. During the summer, Whitney & Roth developed and submitted a proposal to the USDA Extension to conduct three week-long S.A.F.E. Analyst training classes across the country to train a cadre of Operation S.A.F.E. analysts. Funds totaling $80,000 were received and used to conduct two classes in 1982 at Chickasha, OK and Sacramento, CA. A third class was held at Winter Haven, Florida during 1983.

During the period 1983-1985, many Operation S.A.F.E. fly-ins were conducted using the OSU and the NAAA equipment. A second set of equipment was purchased by the NAAA from the contractor, however, this design proved to be prone to breakdowns and both of the NAAA equipment sets made several trips through the OSU shop for repairs and re-conditioning. By 1985, this equipment had become unusable.

WRK, Incorporated was created in 1984 to manufacture and provide sets of the pattern testing equipment and related technology to enable this important educational program to spread throughout the United States and Canada. Also during 1984, the OSU Paper Tape System underwent a significant improvement with the paper tape being replaced by 1-mm cotton string. WRK rapidly adapted this new technology to produce an entire field collection system that could be packed into a single carrying case. The WRK String System reduced deployment time by at least two-thirds and rotating the collector line became a simple two-person job. Concurrently, the development of a "String Door" for the fluorometer was undertaken and a fluorometer/computer interface board was designed and tested. New DOS software was written by Dennis Gardisser and Joel Walker to control the string, to read the fluorometer signals and to plot out the resulting deposition patterns.

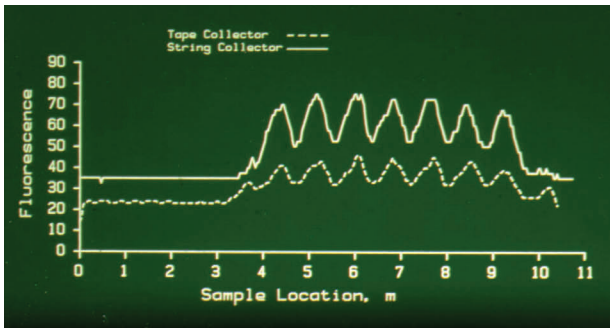

Figure 4. String compared with paper-tape collector.

Dennis Kuhlman submitted a proposal to the USDA Extension in 1985 to fund an Update Operation S.A.F.E. Workshop to train more analysts and to update analysts who had attended one of the first workshops. This was held in Phoenix, Arizona in 1986. Approximately 20-25 people from around the country attended this workshop.

Figure 5. WRK Granular Analysis System

The first complete WRK System was delivered to Washington State University in June, 1986. During the next several years, over 25 WRK String Systems were sold to organizations in the US and Canada. With the distribution of the analysis equipment and trained analysts being available, Operation S.A.F.E. fly-ins could be held just about anywhere in the US. WRK personnel continued to conduct fly-ins at times and places where no equipment existed.

Figure 6. WRK Drift Tower

Dr. Dennis R. Gardisser joined WRK, Inc. in 1992, which added technology and expertise in the field of aerial granular application. Although granular applications were not envisioned as part of Operation S.A.F.E., WRK manufactures granular analysis systems and many fly-ins have included dry distribution analyses for the benefit of operators who routinely use their aircraft for such applications. A section addressing dry distribution is included in the current Operation S.A.F.E. Analyst training manual.

Pesticide drift reduction has been a central topic since the early 1990's so WRK has also added the Drift Tower System to the line of products. The tower initially provided associated components that permitted string to be used as the collector, with the string being analyzed using DOS software and the fluorometer. Subsequent development of the DropletScan™ software has resulted in drift tower modification so that witness cards can be mounted and used as the collector media. Although the WRK Drift Tower System was not included in the original Operation S.A.F.E. program, drift mitigation is now a major consideration and must be addressed by Analysts at Operation S.A.F.E. fly-ins.

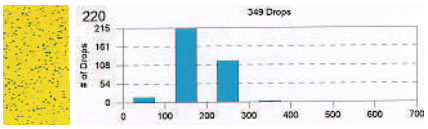

Figure 7. DropletScan™ Software for Witness Card Analyses

In 1995 Dennis Kuhlman, on behalf of WRK, approached Devore Systems, Incorporated to investigate the possibility of developing software to scan multiple small witness cards that could be operated on laptop computers with off-the-shelf flat-bed scanners. Initially, WRK anticipated that this software could be used to evaluate aerial spray distribution patterns and that it would become the system of choice due to it's price advantage over the string system. Work was initiated by Devore Systems in 1996 and the first version of DropletScan™ was produced for beta testing. Version 2.2 is the current release and upgrades are now available for purchase by existing owners. DropletScan™ can be used for pattern analysis, as originally envisioned, however sample cards must be placed no less than every two feet across the pattern which results in at least 50 cards to analyze. The resulting analysis time is usually too long for most fly-in applications so only about ten cards are used to ascertain droplet size and spectrum. The DropletScan™ system has come into it's own since it offers the analyst measurements of the droplet spectrum that deposits from an aircraft within the pattern. DropletScan™ software operation and application is now included in the Operation S.A.F.E. training topics.

WRK, Incorporated was dissolved in 1997, as Dr. Kuhlman resigned from KSU at Manhattan to become the Dean at KSU School of Technology, Salina, KS and Dr. L. O. Roth retired. WRK continues on, however, as two separate entities, WRK of Arkansas, owned by Dennis R. Gardisser and WRK of Oklahoma, owned by Dr. Richard W. Whitney. Each of these companies support all of the former activities of WRK, Incorporated but also provide the owners with

Figure 8. New Operation S.A.F.E. Logo

flexibility to conduct their private engineering endeavors. Both operations combine when necessary to conduct research for clients, Operation S.A.F.E. fly-in workshops, to produce Operation S.A.F.E. Analyst Training classes, and other educational activities. WRK continues to make product improvements and/or develop new products. The most recent include Windows software for operating the WRK String Analysis systems and WRK Granular Analysis Software for dry application pattern analyses. Wrapping up this history of Operation S.A.F.E. and the WRK equipment, a few comments regarding Operation S.A.F.E. are in order. During the 1990's, it seems that the interest in Operation S.A.F.E. fly-ins waned. The trained S.A.F.E. analysts continued to either retire or move on to other jobs that precluded their conducting Operation S.A.F.E. fly-ins for applicators. The NAAA's PAASS program was launched and that occupied much of the educational attention of the NAAA, the Chemical and Insurance Industries. These organizations have historically been major driving forces, as well as financial sources, for Operation S.A.F.E. fly-ins. Within the past few years, there seems to be a growing interest in the type of training available through Operation S.A.F.E. The NAAA is making an effort to revive interest in S.A.F.E. as a program and has included it as a sub part of the PAASS program. The industry recognizes that there is an inherent benefit when the educational and safety program includes the aircraft and equipment operation.

Figure 9. Joe Southerland checks out in Simcom1, the latest Agricultural Aircraft Simulator, Orlando, FL.

Two years ago WRK organized and conducted the sixth Operation S.A.F.E. Analyst training class. At the beginning of this 2005 class, there are only about 38 certified analysts. Three of these reside in Australia and one in South Africa, and only an estimated 18 out of the remaining 35 actually conduct Operation S.A.F.E. fly-ins. Aren't there enough analysts then? Perhaps not, because the trend in the aviation industry is for agricultural aircraft to continue to increase in value. The increased investment has increased the insurance risk. Today, turbine agricultural aircraft (most of the late model agricultural fleet) are in the $500,000 to $1,000,000 range and the insurers of these high dollar aircraft want to limit their risk. It is true that the aircraft already meet the highest safety standards and mechanical malfunctions do not contribute very much to insurance losses, however the major sources of loss (including drift claims that can exceed the price of a new aircraft) are associated with decisions and actions made by pilots and/or operators. This means that education and training can play a major role in reducing these accidents. Already, pilots of the higher-end general aviation aircraft are required by the insurer to undergo recurrent simulator training for their aircraft, as well as other educational activities. Ag aircraft operators and pilots will not be excluded in the future. There will likely be a time (probably sooner than later) that agricultural aircraft and their pilots will be required to have Operation S.A.F.E. certification, or some other similar training as a precondition for insurability. There are approximately 2400 aircraft operating in the US agricultural fleet but perhaps only about 50 active certified analysts, after this 2005 training class. The conclusion is obvious, there could be a heavy demand for your services.

We, the presenters of this 2005 Operation S.A.F.E. Analyst Training Class, thank you for choosing to be an analyst and for attending this training class. We believe that your analyst service will be a critical contribution to the aerial application industry and to the public which depends so heavily on its services.