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IN MEMORY OF DR. TIMOTHY L. CRAWFORD,
NOAA AIR RESOURCES LABORATORY FIELD RESEARCH DIVISION,
IDAHO FALLS, IDAHO

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1. INTRODUCTION

"It's not about the flying. It's about the science." That was one of the favorite quotes from the late Dr. Timothy L. Crawford (Fig. 1), Director of the Field Research Division (FRD) of the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL). The scientific community suffered a tragic loss with the passing of Dr. Timothy L. Crawford on August 3, 2002. He was 53 years old.

Tim suffered a cerebral hemorrhage (stroke) while piloting the LongEZ (registration N3R) during a research flight for the Coupled Boundary Layers Air-Sea Transfer light wind (CBLAST-Low) field study over the Atlantic Ocean. N3R crashed into the ocean several miles south of Martha's Vineyard, Massachusetts and was destroyed.

Tim brought to FRD an unabashed enthusiasm for science and life. He was a man who always focused on the positive and avoided dwelling on the negative. As FRD Director for nearly four years, he gave every staff member "ownership" of the division. He led by example and believed in doing what was right. He maintained the highest level of honesty and integrity. Tim encouraged every FRD staff member to strive for excellence. He wanted everyone to enjoy their job. He trusted everyone to do their job and treated each with courtesy and professionalism. At the same time, he was a friend to all. Tim always sought input from every FRD staff member on ways he could improve as a supervisor.

Extremely intelligent and very clever, he always looked towards new innovations and technological advances to push the leading edge of science. Everyday he sought ways to improve himself and to learn something new. Tim also strongly believed in education. He would always make the time to talk to youngsters who had an endless list of questions about his airplane and the science he was doing with it. Tim wanted to make a difference. He did.

2. FAMILY

Tim was born in Springfield, Illinois on September 21, 1948 to Frederick L. "Bud" Crawford and the late Carmel Claire "Kay" Wiedlocher Crawford. He was one of five children. He married Sharon Aldrich Crawford, also of Springfield, Illinois, in 1971. They had two daughters,



Fig. 1. Dr. Timothy L. Crawford with LongEZ N3R.

Tiffany and Ann, who were born in 1976 and 1978, respectively.

Survivors include his wife and father; daughter, son-in-law, and grandson, Tiffany, Jeffrey, and John Wheeler of Chapel Hill, North Carolina; daughter Ann of Philadelphia, Pennsylvania; sister and brother-in-law Susan and Hank Cronister of Springfield, Illinois; sister and brother-in-law Drs. Karen and Steven Soltys, of Springfield, Illinois; brother and sister-in-law Frederick and Judy Crawford of Springfield, Illinois; and brother and sister-in-law Larry Crawford and Cathy Posehn of Woodland, California.

3. EDUCATION

Tim earned a B. S. degree in 1971 with High Honors in Mechanical Engineering (Thermal Sciences) from the University of Illinois. A year later, he earned his M. S. degree in Civil Engineering (Air Resources) from the same

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school. Tim was awarded a Ph. D. in 1977 in Mechanical Engineering (Geophysical Fluid Dynamics) from the University of Waterloo. His dissertation was entitled “Numerical modeling of complex two and three-dimensional flow and diffusion problems in the natural environment.” He worked his way through school as a consultant to the Canadian Atmospheric Environment Service and to local utility companies in developing air pollution control strategies.

4. EMPLOYMENT

Tim began working in science and engineering early in life. Even before Tim earned his B. S. degree, he was employed as a Junior Electrical Engineer in the summers of 1969 and 1970 with the Dicky-John Corporation in Springfield, Illinois.

Tim began his federal career in 1972 as an Environmental Engineer with the Air Quality Branch of the Tennessee Valley Authority (TVA) in Muscle Shoals, Alabama. His responsibilities included planning and executing various field studies, data management, environmental assessment of various particulate and chemical emissions, and developing control strategies for power plants, cooling towers, and fertilizer facilities.

In 1978, Tim became a Research Analyst for the Air Quality Branch in TVA. Tim conducted theoretical and experimental investigations of long-range air pollutant transport. This research required the development and use of airborne tracking systems and deployment of many ground measurement sites.

From 1979 to 1986, Tim was the Supervisor of the Atmospheric Physics Unit (APU) in TVA which included six scientists and engineers and three technicians. The APU conducted pioneering field investigations and developed models to understand and describe long-range transport, visibility impairment, and acid rain. Under Tim's supervision, the APU developed a three-dimensional dynamic trajectory model, an acid rain assessment model, and established a high-elevation forest-decline research station for the Environmental Protection Agency's (EPA) Mountain Cloud Chemistry Program.

Tim began his tenure with NOAA in 1986. He joined FRD as a Physical Scientist in Idaho Falls, Idaho. Tim planned and directed sampling for NOAA's Across North American Tracer Experiment (ANATEX). This included the development of standard operating procedures for various sampling systems. He was responsible for the training and direction of two hundred U.S., Canadian, and European instrument operators, and oversaw the quality control of more than 13,000 air samples.

In 1988, Tim transferred to ARL's Atmospheric Turbulence and Diffusion Division (ATDD) in Oak Ridge, Tennessee. His original responsibilities included model development to simulate material transport, diffusion, and deposition. He expanded this scope to include field studies for model validation, including the development of a mobile flux platform (MFP) that enabled turbulence measurement from a variety of small aircraft and boats.

Tim became Chief of ATDD's Air-Surface Exchange Branch in 1992. He led the branch of twelve scientists and engineers in the development and validation of innovative

models describing atmospheric transport and air-surface exchange. He also continued refinement of the MFP and led its deployment, along with stationary systems, in numerous field studies.

In 1998, Tim returned to Idaho Falls to become the Director of FRD. He led a staff of more than a dozen scientists and engineers in theoretical and experimental investigations of atmospheric transport and diffusion. He also oversaw FRD's responsibility of providing meteorological support to the Department of Energy's (DOE) Idaho National Engineering and Environmental Laboratory (INEEL).

5. BUILDING AIRPLANES

One weekend in 1980, Tim attended a “fly-in” sponsored by the Experimental Aircraft Association (EAA) in Tullahoma, Tennessee. The EAA is an organization comprised of amateur plane builders. At the fly-in, Tim met pilot Dick Rutan, who would gain fame six years later when his *Voyager* airplane circled the globe without refueling. Dick had flown the prototype LongEZ from California to the event. The fly-in and newly-designed LongEZ made an impression on Tim. He quickly learned that it was possible to build and fly his own airplane. Although Tim had never taken a flying lesson, he decided to build a LongEZ whose sleek-looking design and clean lines appealed to him.

Over the next three years, the LongEZ slowly took shape, first in Tim's basement, then later in his two-car garage. The airplane often became a low priority — he had responsibilities to TVA, helping Sharon raise two young daughters, and managing apartments on the side. Building the LongEZ was also an expensive hobby. Thus, Tim scrimped and saved until the plane became a reality. A year after finishing the LongEZ, Tim sold it.

But Tim was never one to idle for long. Even before selling his first LongEZ, he went into a partnership and began building a twin-engine Defiant, yet another Rutan-designed airplane. Tim sold the Defiant within months of its completion.

Tim had gained quite a bit of experience when he started his third airplane — LongEZ N3R (Fig. 2). He started building N3R on his birthday, September 21, 1985 and finished it less than nine months later on July 4, 1986. This plane, however, was known as a Wide-Body LongEZ. Tim made it wider, longer, faster, and with greater range than that of a conventional LongEZ. The modifications were driven by the lack of space in the instrument panel of a standard LongEZ. Tim wanted N3R to have instrument



Fig. 2. N3R in front of the Wright Brothers National Memorial at First Flight Airport, Kill Devil Hills, NC.

flight rule (IFR) capabilities, thus, additional instruments were needed. He made the N3R instrument panel 3 inches wider to include the IFR instruments. From there, he scaled the rest of the airplane accordingly. The fuselage was 4 inches wider, 2 inches deeper, and 14 inches longer than a standard LongEZ. Other enhancements included a stronger airframe, larger engine, expanded fuel tank, and a three-blade propeller. N3R would become Tim's "scientific workhorse", logging nearly 3600 flight hours, most of which were dedicated to research studies.

Tim's fourth airplane was yet another twin-engine Defiant. However, he sold it when it was about 80% complete. His fifth airplane was a Velocity Elite RG which is a four-seat version of a LongEZ. Tim humorously called his Velocity a "LongEZ on steroids."

Tim was an experienced pilot with more than 3300 hours of flight time. He was a FAA-certified commercial pilot with an instrument rating. Tim was a FAA-certified aircraft builder and held an Airframe and Powerplant (A&P) mechanic license which allowed him to maintain general aviation aircraft. He was also an EAA Technical Advisor (#1692).

6. IT'S ABOUT THE SCIENCE

As much as he loved flying and building airplanes, Tim loved science even more. Tim always saw himself as a scientist first, a pilot second. He was able to put his hobby of building airplanes to work for scientific research.

There is little doubt that Tim was an experienced pilot and had an extraordinary ability for building airplanes. He was also an exceptional engineer and scientist. Tim was able to seamlessly weave all of these talents together and create a small environmental research aircraft (Crawford et al. 1990, 2001). Tim chose to use N3R for scientific research because its unique aerodynamic design made it ideally suited for making high-fidelity turbulence measurements with minimal flow distortion at low altitudes and slow aircraft flight speeds (Crawford and Dobosy 1992; Crawford et al. 1996a). N3R and its suite of state-of-the-science sensors was a truly innovative platform for measuring turbulent fluxes of heat, moisture, mass, and momentum.



Fig. 3. Tim fabricating a new BAT probe.

The center piece of the N3R instrumentation package was the "best aircraft turbulence" (BAT) probe (Fig. 3). Tim designed, tested, and built the BAT probe in collaboration with Jörg Hacker of Airborne Research Australia (Crawford and Dobosy 1992; Hacker and Crawford 1999).

Designed to be able to measure wind speed and turbulence to just a few centimeters per second, the probe integrates state-of-the-art instruments with sophisticated electronics. Unlike any gust probe, the BAT probe contains all of the instruments required to calculate the wind velocity at a rate of 50 times a second, dramatically reducing complexity associated multi-located instruments. The advent of the BAT probe also allowed the accurate measurement of high-fidelity wind and turbulence from a small aircraft. Through cooperative efforts with other scientists, Tim has helped create and disseminate BAT probes which have been used on other research aircraft.

Tim never compromised safety and left nothing to chance. He made sure that flights with N3R were conducted in compliance with all FAA regulations. Tim incorporated a number of important safety features into N3R. These included a 406-MHz Emergency Locator Transmitter (ELT), solid rocket ballistic parachute, 40-G four-point harness and foam impact seats, auto-pilot, life jacket, survival suit, inflatable raft, flare gun, signal mirrors, flashlights, chemical light sticks, and emergency rations.

N3R participated in over 35 experiments dating back to the late 1980s. Field studies have been conducted in diverse locations throughout North America, including the Alaskan North Slope, the Boreal Forests of Saskatchewan, the Florida Keys, and over the coastal waters of Massachusetts, North Carolina, California, and Hawaii. Tim used N3R to examine various research problems including boundary layer structure and evolution, air-sea interaction, carbon dioxide flux exchange, meteorological processes in nonhomogeneous and complex terrain, high-altitude clear-air turbulence associated with regions of strong wind shear, and transport and diffusion of various pollutants (Crawford et al. 1993a, 1993b, 1994, 1996b; Sellers et al. 1995; Brooks et al. 1997; Dobosy et al. 1997; Sun et al. 1997, 2001; Oechel et al. 1998, 2000; Crescenti et al. 1999, 2001, 2002; Eckman et al. 1999; Vogel and Crawford 1999; French et al. 2000; Mahrt et al. 2001; Vandemark et al. 2001; Vickers et al. 2001; Doran et al. 2002 Poulos et al. 2002). These research studies have been sponsored by funding agencies including NOAA, DOE, National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), Office of Naval Research (ONR), and the Air Force.

Research from N3R has resulted in nearly 70 publications, of which more than 25 are found in prestigious peer-reviewed journals and book chapters. The research Tim conducted also found its way into the popular media. Articles were written by Jefferson (1995) and by Richmond (1999) for *Destination Discovery* and *Sport Aviation* magazines, respectively. N3R was featured in a television documentary entitled "Planes for Global Warming" which aired October 11, 1996 on *Discovery TV*. It was not unusual during field studies for local newspapers to run a story about Tim and his research efforts using N3R.

7. HE MADE A DIFFERENCE

Over his professional career, Tim was an author or coauthor on more than a hundred journal articles, book chapters, conference papers, and technical reports. He was an author or coauthor on nearly 30 peer-reviewed journal papers and book chapters which include *Monthly Weather Review*, *Journal of Geophysical Research*, *Boundary-Layer Meteorology*, and *Global Change Biology*.

Tim was officially recognized for 30 years of distinguished service to the Federal government. He also received twelve Department of Commerce certificates for superior job performance. Tim was one of several team members that won the NOAA Administrator's Award for the Twin Otter aircraft instrumentation effort in November 1995. In October 2000, he was awarded a NOAA Bronze Medal for the design and application of a novel airborne instrument system to advance knowledge of air-sea exchange.

Tim held professional memberships with the American Meteorological Society (AMS) (Fig. 4), the American Geophysical Union (AGU), the Aircraft Owners and Pilots Association (AOPA), and EAA (Fig. 5). He was also an EAA Chapter President from 1983-1986 in Muscle Shoals, Alabama. Tim was a member of the Pi Tau Sigma Honorary Mechanical Engineering Fraternity. He was an advisor to the National Research Council (NRC) and the Electric Power Research Institute (EPRI).

In one of the highest honors bestowed on an individual, the Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator, Vice Admiral Conrad C. Lautenbacher, Jr. (U.S. Navy, Retired), ordered all NOAA offices and laboratories to lower their flags to half-staff for three days immediately after Tim's death. In another touching tribute to Tim's memory, scientific colleague and astronaut Piers Sellers will take a picture of Tim into space on the Space Shuttle *Atlantis* during STS-112 scheduled in early October 2002.

In keeping with the spirit of educating today's youth, the Timothy L. Crawford Scholarship was created to help students studying environmental science. Contributions can be sent to the Experimental Aircraft Association



Fig. 4. Tim with the extreme turbulence "ET" probe (a spin-off of the BAT probe) in the ARL booth during the 81st AMS Annual Meeting.



Fig. 5. Tim with N3R at EAA's AirVenture 2002 in Oshkosh, WI.

Aviation Foundation, P. O. Box 3065, Oshkosh, WI 54903-3065, Attn: Bonnie Lueck, Director of Development.

Timothy L. Crawford will be sorely missed by his family, friends, and colleagues. However, he will not be forgotten. He has touched so many lives in ways that cannot be measured. He wanted to make a positive contribution to science and society. Tim graciously shared his vast knowledge and experience of science, engineering, and aeronautics with those who knew him and wished to learn. He had an unbridled enthusiasm for his job. Some would say it was a passion. Dr. Timothy L. Crawford made a tremendous and positive difference.

8. ACKNOWLEDGMENTS

I am deeply honored to write and present this paper as a keynote speaker at the Twelfth Symposium on Meteorological Observations and Instrumentation in conjunction with the 83rd Annual Meeting of the American Meteorological Society. This paper is dedicated to the memory of Timothy L. Crawford, who was my supervisor, mentor, big brother, and one of my best friends. Thank you, Tim, for making a positive difference in my life.

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