TITLE: The Joint Airport Weather Studies (JAWS) Project

RESEARCH INVESTIGATORS: John McCarthy
and
James Wilson
Field Observing Facility
National Center for Atmospheric Research
Boulder, CO 80307

Dr. T. Theodore Fujita
Dept. of Geophysical Sciences
University of Chicago
Chicago, IL 60637

SIGNIFICANT ACCOMPLISHMENT TO DATE IN FY-83:

The Joint Airport Weather Studies (JAWS) Project, formed in 1980, conducted a major field investigation during the summer of 1982 (15 May to 13 August, inclusive) in and around Denver, Colorado. The project is jointly conducted by the National Center for Atmospheric Research (NCAR) and the University of Chicago. The principal objective of JAWS was to examine convectively driven downdrafts and resulting outflows near the earth's surface known as microbursts, a term coined by Dr. Fujita of the University of Chicago, Microbursts can be lethal for jet aircraft on takeoff or landing because of the extreme magnitude of the flows.

The JAWS effort has concentrated on three aspects of microburst-induced, low-level wind shear: basic scientific investigation of microburst origins, lifecycles, and velocity structures; various aspects of aircraft performance, including numerical models, manned flight simulators, instrumented research aircraft response, and operational air carrier performance; and low-level wind shear detection and warning using surface sensing, airborne systems, and radar sensing.

The data collection phase was truly extraordinary. Of 91 possible operational days, 75 had convective weather on which at least one of 38 pre-planned JAWS experiments could be conducted. We expected to observe 10 to 12 microbursts with more than one Doppler radar, but saw 87! We collected many data sets not only on wind shear events but on mesocyclones, tornadoes, gust fronts, hailstorms, and flash floods. Our collection also included a broad data set on operational uses of Doppler weather radar, which will be used to support the Next Generation Radar (NEXRAD) Doppler development and procurement in the United States.

During FY-83, we prepared a 276 page report "The JAWS Project, Operations Summary 1982," which was distributed to sponsoring agencies and interested scientists. The report contains an up-to-date summary of the available JAWS data, instruction on how to obtain them, and a daily summary of data collection. We describe the meteorology of each day and the weather event highlights, and discuss each significant experiment conducted. For each operational day, a table shows the operating hours of each observing system (i.e., radars, lidars, aircraft, surface network, etc.) Finally, on days of significant JAWS weather, a map of the network showing the event location is included. Table 1 indicates the complete scientist, institution and sensor involvement in the JAWS field experiment. Complete details can be obtained first from the Operations Summary or from the individuals listed as appropriate in the Table 1.

While the data set was extraordinary in its extent and number of significant weather events, the summary, although not exhaustive, identifies events of principal interest to the many JAWS objectives.

CURRENT FOCUS OF RESEARCH WORK:

At present, we are concentrating on an evaluation of the low-level wind shear alert system (LLWSAS), on preparation of four dimensional multiple Doppler radar fields on the capability of a single Doppler radar to identify microburst and shear events, and development with assistance from the Federal Aviation Administration of a wind shear information film.

We have just compiled a prioritized list of the most interesting microburst cases for multiple Doppler editing and analysis using an over-determined dual Doppler analysis (ODDAN) program which is currently being made user friendly.

Work by subcontractor (FWG Associates, Inc.) is progressing on the development of a six-degree of freedom aircraft performance model. Under a subcontract with NOAA, Al Bedard has constructed programs to analyze and display low-level wind shear alert system (LLWSAS) and Portable Automated Mesonet (PAM) data and to produce plots combining PAM/LLWSAS data showing wind vectors sequentially for selected case studies.

Working with scientists from NASA and NOAA, JAWS personnel are modifying computer programs to help prepare dual-lidar analysis comparisons.

NCAR Doppler radar data are being used to support the NASA's B-57B Gust Gradient effort to identify both longitudinal and internal gust components of turbulence and wind shear.

We are preparing nine papers for the 21st Conference on Radar Meteorology: (1) "Dynamic Interpretation of Notches, WERS, and Mesocyclones Simulated in a Numerical Cloud Model"; (2) "Analysis of Bias Measurements in Relation to Small-Scale Meteorological Events"; (3) "The Structure of a Microburst: As Observed by Ground-Based and Airborne Doppler Radar"; (4) "Aircraft and Doppler Air Motion Comparisons in a JAWS Microburst"; (5) "Weighted Least Squares Methods for Multiple Doppler Radar Analysis"; (6) "Microburst Wind Structure Using Doppler Radar, PAM and LLWSAS Data"; (7) "JAWS Data Collection, Analysis Highlights, and Microbursts Statistics"; (8) "Aircraft Performance in a JAWS Microburst"; and (9) "Evaluation of Doppler Radar for Airport Wind Shear Detection."

PLANS FOR FY-84 & 85:

A very brief outline of the complete complement of tasks being addressed in FY-83 & 84 is given in Table 2. More details are available by calling the JAWS Project Office on (303) 497-0651.

New NASA research objectives for FY-84 & 85 that should be addressed focus around manned flight simulation theory and practice in wind shear conditions. The current work of Frost (FWG Associates) and at NASA Langley Research Center, utilizing high resolution JAWS wind shear data to better understand aircraft performance, leads to the following projected tasks for FY-84 & 85:

(1) Research and training simulator frequency response to wind shear input visuals.

(2) A careful study of simulator equations of motion with regard to wind shear.

(3) Extensive communication with simulator technology experts regarding the findings of (1) and (2).

These tasks need to be refined and examined, not only through JAWS and NASA research, but through a close association with airborne and flight simulator manufacturers.

<u>RECENT PUBLICATIONS</u>:

"The NCAR Research Aviation Facility Fleet Workshop, 18-19 February 1982, Boulder, Colorado," Bull. Amer. Meteor. Soc., to be published in May 1983 by P. H. Hildebrand and J. McCarthy.

"Low-Level Wind Shear Detection and Warning – A Systems Update," AIAA 21st Aerospace Sciences Meeting, Jan. 10-13, 1983, Reno, Nevada, by J. McCarthy and J. W. Wilson.

"Applications of Doppler Radar to Aviation Operations – JAWS Experiences," AIAA 21st Aerospace Sciences Meeting, Jan. 10-13, 1983, Reno, Nevada by J. McCarthy and J. W. Wilson.

"The Joint Airport Weather Studies," 17th Annual Southern Methodist University Air Law Symposium, March 3-5, 1983, Dallas, Texas by J. McCarthy.

"The JAWS Project Operations Summary 1983," printed in February 1983 by the National Center for Atmospheric Research, limited distribution, copies available upon request.

TABLE 1. ORGANIZATIONS AND EQUIPMENT IN JAWS

Organizations Participating in JAWS	Contact for Data	Sensors/Equipment	Comments
Federal Government			
National Science Foundation			
o National Center for Atmospheric Research			
– Convective Storms Division	Ed Zipser Pete Johnson	NCAR Sabreliner Multiple Aircraft Positioning System	Mesoscale Analysis Calculates aircraft location using interferometry
– Field Observing Facility	Phyllis O'Rourke	Portable Automated Mesonet (PAM) Doppler Radars	27 Stations two 5-cm and one 10-cm
Federal Aviation Administration	Marty Natchipolsky	Low-level Wind Shear Alert System (LLWSAS)	Funding agency
National Aeronautics & Space Administration			Funding agency
o Marshall Space Flight Center (MSFC)	Dennis Camp Warren Campbell George Fichtl	B-57B Aircraft, CO_2 Doppler Lidar	
o Langley Air Research Center		B-57B Aircraft, Manual Flight Simulator	
o Dryden Flight Research Facility		B-57B Aircraft	
National Oceanic & Atmospheric Administration			
o Program for Regional Observing & Forecasting Services (PROFS)	Ron Valdez Ron Valdez Ron Valdez Ron Valdez Ron Alberty	Mesoscale Surface Network AFOS Products Limon & Cheyenne Radars Lightning Detection Array Satellite Data	

TABLE 1. (Concluded)

Organizations Participating in JAWS	Contact for Data	Sensors/Equipment	Comments
o Wave Propagation Laboratory (WPL)	Freeman Hall	CO_2 Doppler Lidar	
	Al Bedard	LLWSAS Analysis	
	Al Bedard	Pressure Jump System Data Collection and Analysis	
	John Gaynor	Boulder Atmospheric Observatory Tower	
	Ron Valdez	Atmospheric Profiler	
o Weather Research Program	Fernando Caracena	Microburst Forecasting/Nowcasting Techniques	
o National Hurricane & Experimental Meteorological Laboratory/NCAR	Dave Jorgensen Peter Hildebrand	NOAA P-3 Aircraft/Airborne Doppler	Joint NOAA/NCAR Experiment
o National Weather Service	Phyllis O'Rourke	Rawinsonde (4 daily, 2 regular, 2 special)	
o PROFS/JAWS/CSD	Mary McCoy	Cooperative Storm Intercept Group	Photograph & verify weather hazards identified by Doppler radar
Transportation Systems Center (Dept. of Transportation)	Lloyd Stevenson	Air Traffic Control Data	Study effects of weather on terminal air traffic
Universities and Colleges			
University of Chicago	T. Theodore Fujita	Whole Sky Camera	Photographed from CP-2
University of Wyoming	Al Rodi	King Air Aircraft/Microphysics Instrumentation	Aircraft leased to NCAR
Dartmouth College	Robert Crane		Test Crane cell tracking and turbulence algorithms
Foreign			
United Kingdom			
o Royal Aircraft Establishment	Alan Woodfield	Hawker-Siddeley 125 Aircraft	
o Royal Signals and Radar Establishment	Michael Vaughan	Airborne CO_2 Doppler Lidar	

TABLE 2. A VERY BRIEF SUMMARY OF TASKS BEING ADDRESSED AT NCAR BY THE JAWS PROJECT

Physical Mechanisms

1. Microburst Climatology
2. Microphysical Interactions with Microburst Negative Buoyancy
3. Microburst Precipitation Physics/ Dynamics Feedback
4. Microburst Cloud Modeling (Klemp)
5. Boundary Layer Interactions in Microburst Situations

Definitions & Statistics

1. Variability of Microbursts in Time & Space (Radar and PAM)
2. Microburst/Downburst Scales
3. Terminology/Definitions — Wet vs. Dry Microbursts

Techniques

1. Kinematic Fields in Microburst Analysis
2. Complete Multiple Doppler Synthesis Program
3. Sensor Intercomparison
4. 3 Airborne/Surface Doppler Synthesis

Aircraft Performance

1. Flight Simulation Using Multiple Doppler Data
2. Doppler Derived Turbulence
3. Aircraft Performance in Microbursts
4. Penetration Techniques for Microbursts
5. Flight Simulator Fidelity in Microbursts
6. B-57B Correlation Synthesis
7. Heavy Rain Aircraft Performance
8. Rotocraft Performance in Microbursts

Detection and Warning

1. Redesign of LLWSAS
2. Radar Siting for Terminal Doppler Radar
3. Airport-Located Doppler Radar Microburst Detection Techniques
4. Airborne Detection & Warning Synthesis
5. Observational Precursors for Microbursts
6. Avoidance Techniques (Pilot) for Microbursts
7. Evaluation of Detection & Warning Concepts
8. Evolution of Crane Cell Tracking and Turbulence Algorithms
9. Microburst Pilot Forecast Advisories
10. Sampling Theory/Detection Using Surface Arrays
11. Lidar Surface Detection & Warning
12. IR Radiometer Detection of Microbursts

Miscellaneous

1. Prioritization of Cases
2. Wind Shear Information Film for Pilots
3. Analysis of Meteorological Features Affecting Formation of Microbursts
4. Terminal Air Traffic (TSC) Impacts Due to Convective Storms
5. Documentation