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CASE HISTORY OF FAA/SRI WIND SHEAR MODELS

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INTRODUCTION

In order to understand the development of the FAA/SRI wind fields, it is important to understand the operating philosophy of the FAA's Wind Shear Program Office at the time.

The goal of the program office was to ensure an integrated solution to the wind shear problem that addressed three areas:

- Ground-based equipment and coordination
- Airborne systems and procedures
- Weather prediction

This triply-addressed goal was central to the development of the wind fields. Without sounding too obvious, your organization's philosophies and project goals will have a profound effect on your use of the JAWS data along with its associated form and complexity.

The primary user of the wind shear modeling during the FAA's program was airborne simulation. The project requirement was to use wind shear models that resulted from accidents so that effective procedures and/or equipment could be found for hazardous wind shear encounters (see Figure 1). Our data sources in 1975 and 1976 were basically of two varieties: typically those that were recreated from actual accidents; and, at the other extreme, what might be considered untried models from tower measurements, and models that were mathematically synthesized. In order to make use of what had been proven to be the most hazardous wind shears at the time, the program office opted for wind models which were recreated from actual accidents. As you might expect, our sources were limited for a number of reasons, the most important being that the aircraft involved in the accidents were ill-equipped to record wind information. The methods, therefore, to recover this data were fraught with peril.

For those of you who are familiar with aircraft winds reconstruction, please bear with me. Figure 2 shows a simple overview of a typical accident recreation. I have taken the simple case of a 4-channel flight data recorder that collects airspeed, heading, altitude, and normal acceleration versus time. I have called the first phase of this "Recreation." It is primarily concerned with the flight dynamics of the aircraft and results in a number of wind models that approximate the data recorded on the flight data recorder. The next phase is "Selection," if you will; it is primarily a result of matching the meteorological conditions with the wind data extracted from the recreation. After iteratively working between "Recreation" and "Selection", the final wind model will converge as the wind shear model. This wind shear model could then be transformed into a profile against either altitude, distance, or some other combination, such as time.

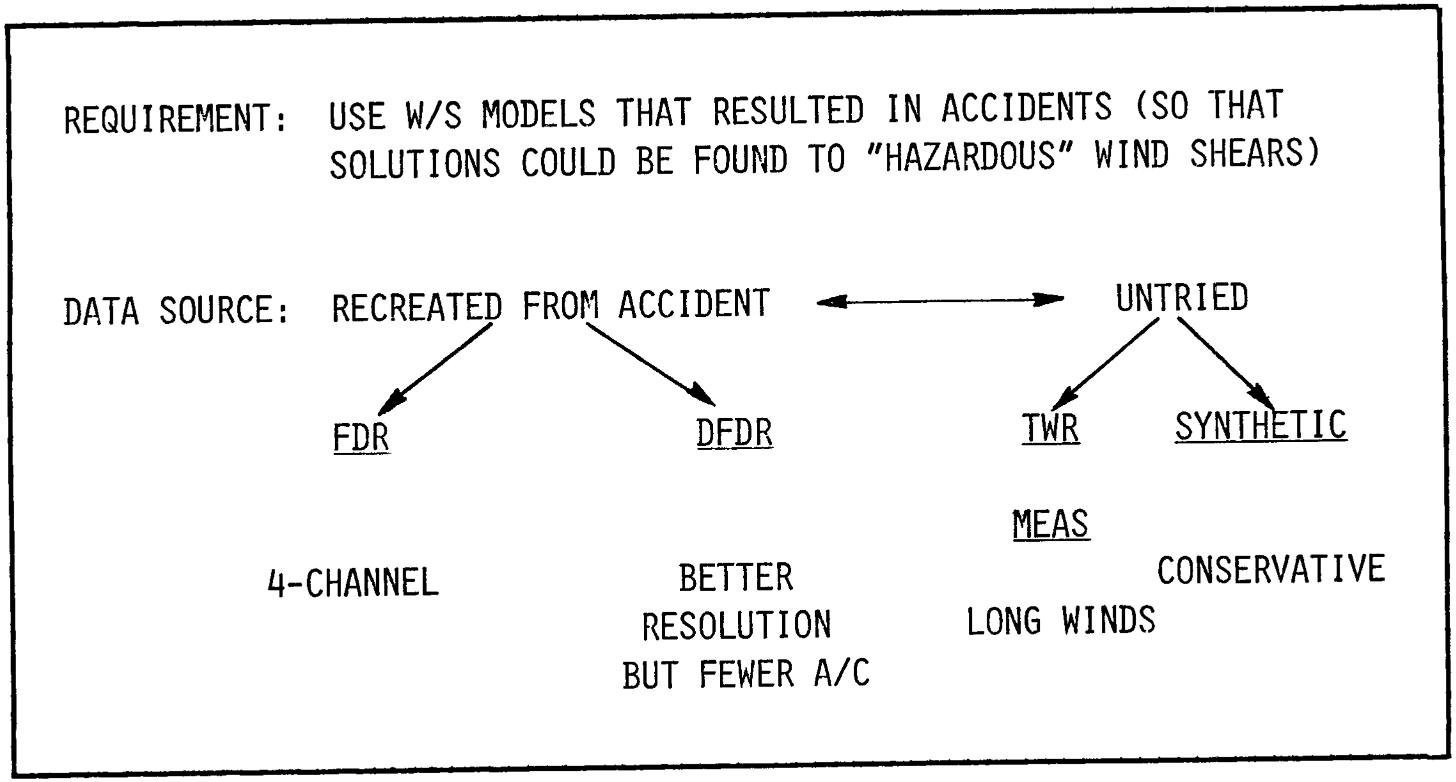

Figure 1. Airborne Simulation

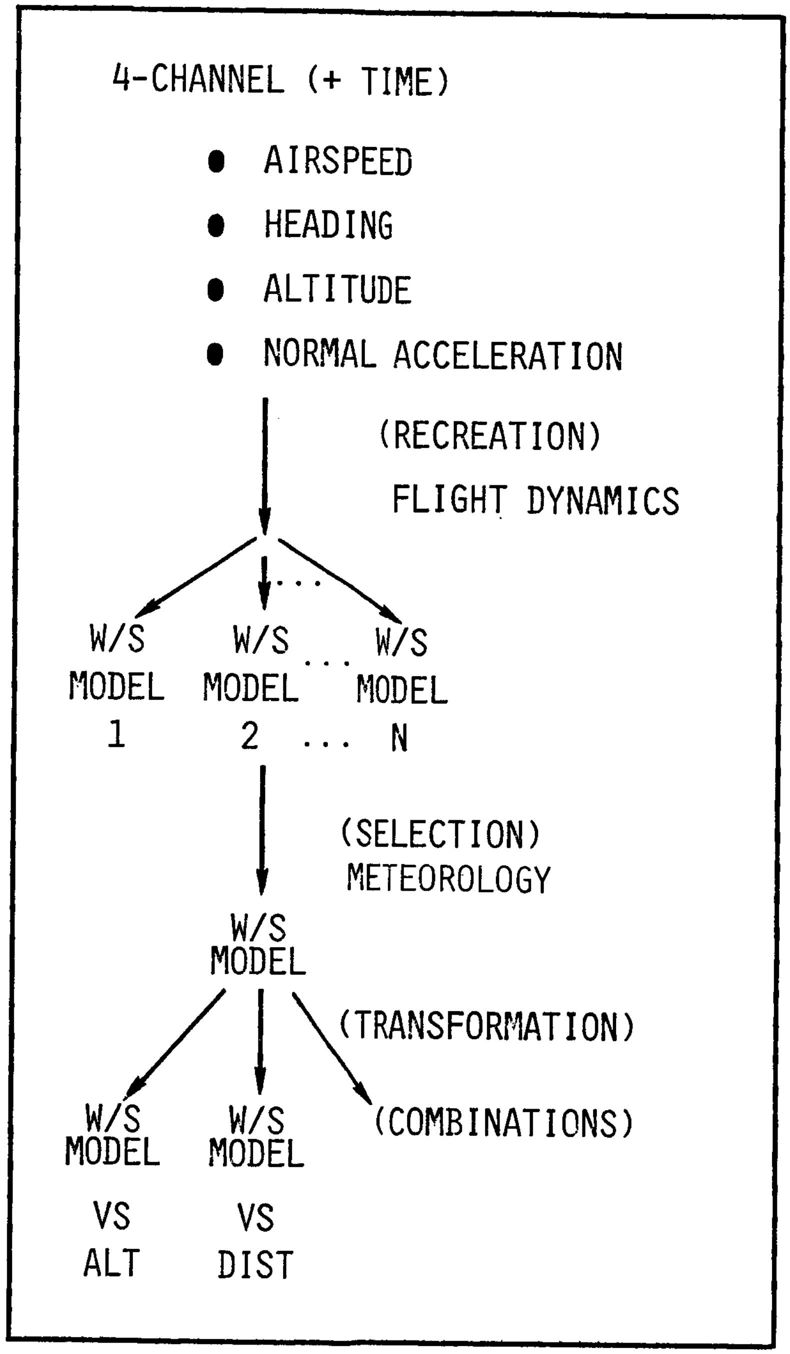

Figure 2. Accident Wind Shear Recreation Overview

As outlined in Figure 3, a number of wind shear models were developed in this manner and were used in our Phase-I piloted simulations using a DC-10 aircraft model at McDonnell Douglas, Long Beach. The wind shear models were the Eastern 66 accident recreation at JFK, and the Iberian DC-10 at Boston Logan. As a baseline, we included a logarithmic wind speed profile also. We used a wind shear profile that consisted of winds versus altitude and we found that the pilots, unfortunately, could cancel the wind shear by leveling off. The pilots could actually improve their performance by performing a missed-approach climb-out. In essence, the wind models were only usable in the restricted flight scenario that we established for our Phase-I test; i.e., an ILS approach, 3° glide slope, and committed to land.

To evaluate anything more sophisticated, we had to revise the wind shear models (Figure 4) while maintaining the essence of the models used in the Phase-I test. In order to perform this expansion, our contractor, SRI International, pulled together a very formidable team of experts in meteorology, fluid dynamics, and simulator technology in order to produce a wind field. This field was a matrix that represented the longitudinal, lateral and vertical winds at various altitudes and distances.

As I mentioned earlier, the goal of the FAA wind shear program office was to be an integrated triad of supporting solution. We used the wind fields to meet two elements of the triad (Figure 5), namely, the airborne systems and procedures investigations, and ground systems analysis. Our piloted flight simulations included the Phase II, III and IV DC-10 simulations at Long Beach, the NASA Ames 737 and 727 simulations, and support for an Air Force test at Altus with their C-5 simulation for the Military Airlift Command. We also attempted to support the surface wind measurement system (the research predecessor to what is now known as the Low-Level Wind Shear Alert System (LLWSAS)) by performing sensitivity analyses of some of the proposed sites. As you can see, the wind fields were also used to investigate wind shear warning system designs and low-cost ground speed sensors performance, and for parts of the head-up display program development in the research and development days.

As you might imagine, the wind fields were beginning to gain some popularity as an ad hoc standard, and they were provided to approximately 25 people in the U. S. (Figure 6). The documentation was limited and included an overview (along with usage and limitations) and a listing of the image of the wind field data, which was supplied on either magentic tape or punch cards. The Wind Shear Program Office was the focal point for the data. Because of the ad hoc nature of this distribution--I think this is crucial--there was little or no formal procedure for incorporating revisions and disseminating them to the users. (In defense of this statement, however, there was really no follow-up from any of the users to which we had shipped the data.) I find that is one of the crucial points in the use of the JAWS data. How do you disseminate it; how do you control it?

Finally, where does that leave us with the JAWS data? As you have heard, the JAWS data is rich. The olympic feats that were performed to extract first the FAA wind profiles, then the FAA/SRI wind fields, are almost trivialized in the light of the kind of wind shear information captured in the JAWS data; but in order for us to get you, the research users, good JAWS information as soon as possible, we need help in understanding your use of the data and the control for disseminating the data that you expect from us.

- W/S MODELS
  - JFK INTERNATIONAL AIRPORT
  - BOSTON LOGAN AIRPORT
  - WIND SPEED PROFILE
- WINDS VS ALTITUDE
- WIND MODEL FINDINGS:
  - PILOTS CANCEL W/S EFFECTS BY LEVELING OFF
  - PILOTS COULD IMPROVE PERFORMANCE BY CLIMBING OUT
- THE WIND MODELS WERE USABLE ONLY IN A RESTRICTED FLIGHT SCENARIO (ILS APPROACH AND COMMITTED TO LAND)

Figure 3. Phase-I Piloted Simulation Experience

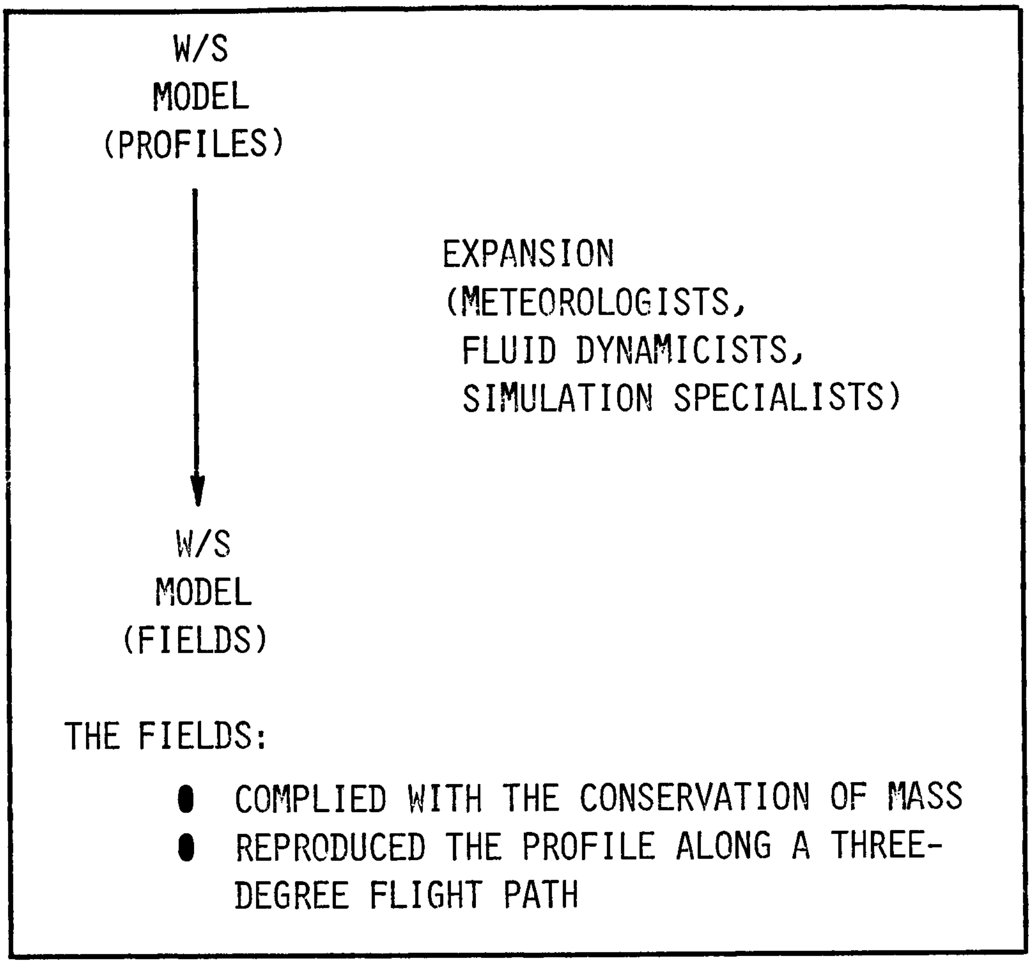

Figure 4. Wind model revision

- PILOTED FLIGHT SIMULATIONS:
  - PHASE II, III, AND IV (DC-10)
  - NASA/ARC (B-737/727)
  - USAF (C-5A)
- GROUND SYSTEM ANALYSIS
  - SWIMS
- AIRBORNE SYSTEM ANALYSIS
  - WIND SHEAR WARNING
  - GROUNDSPEED SENSOR
  - HEAD-UP DISPLAY

Figure 5. FAA Use of the Wind Fields

- WIND FIELDS WERE PROVIDED TO 25 PEOPLE IN THE U. S.:
  - DOCUMENTATION
    - OVERVIEW AND USE
    - LISTING IMAGE
  - DATA
    - MAGNETIC TAPE
    - PUNCH CARDS
- FOCAL POINT
  - FAA WIND SHEAR PROGRAM OFFICE
- UPDATES/REVISIONS
  - NO FORMAL PROCEDURE FOR INCORPORATING AND DISSEMINATING TO USERS

Figure 6. Public Dissemination of the Wind Fields.