Session I. NASA Flight Tests

Program Overview / 1991 Flight Test Objectives

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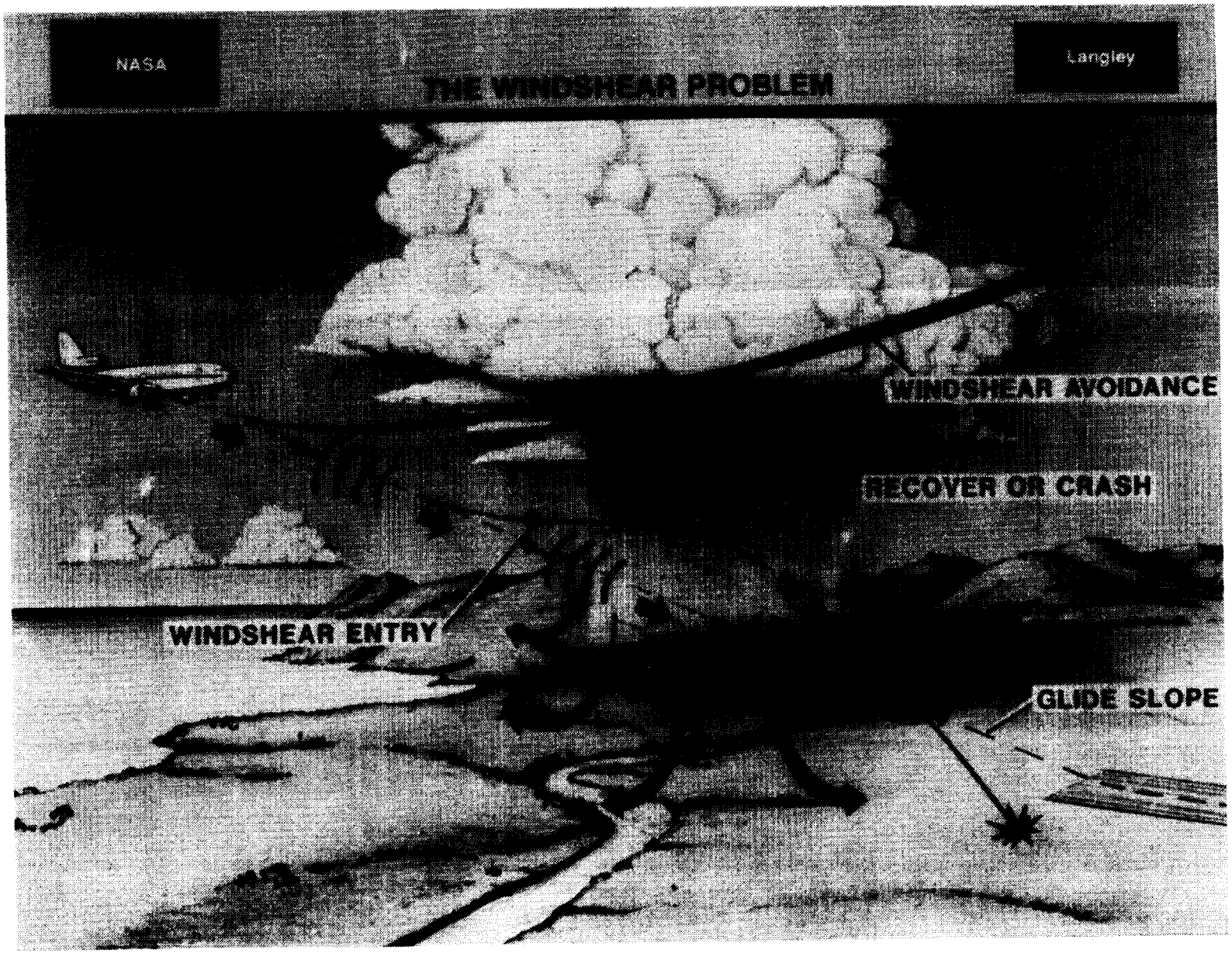
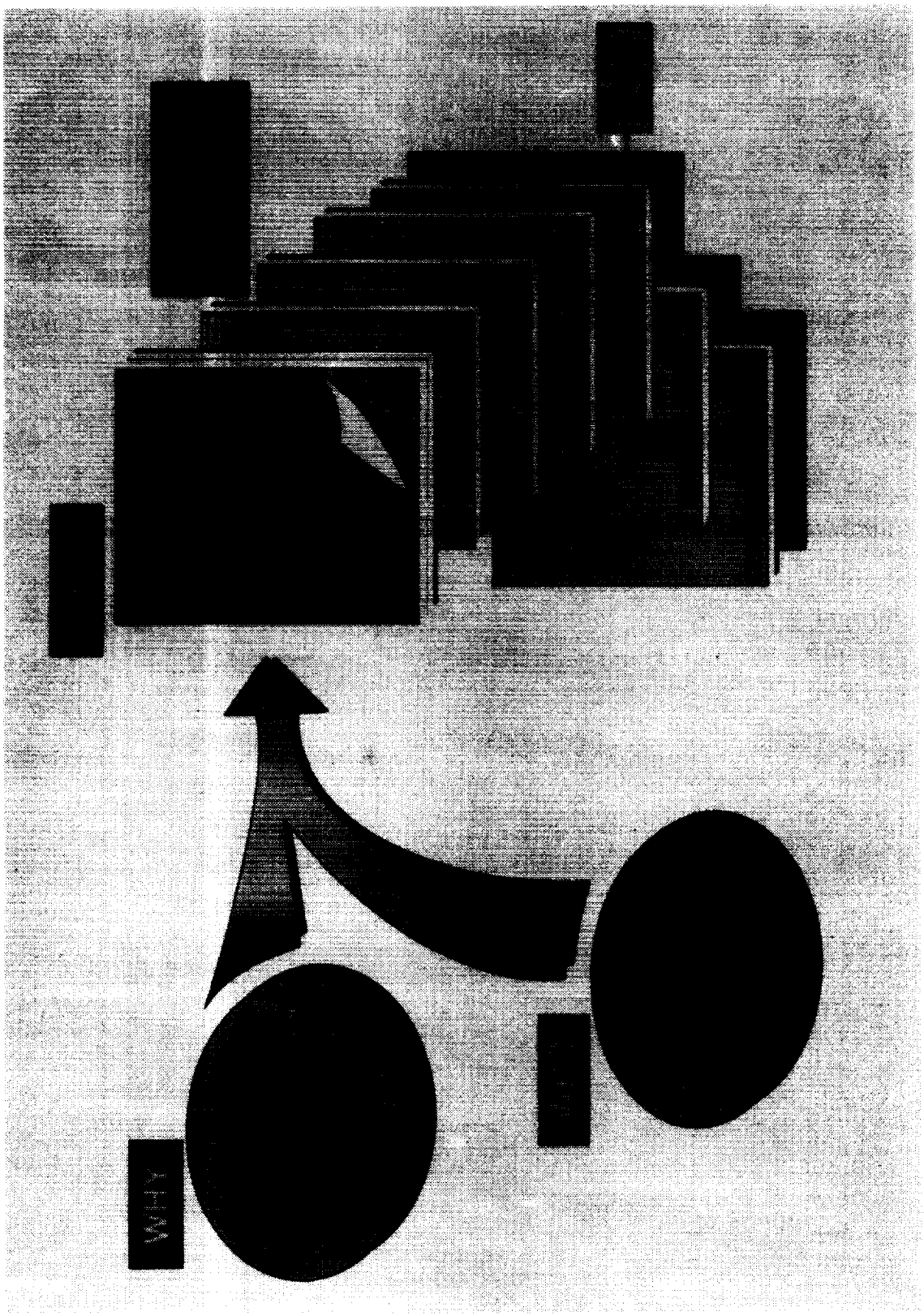
WIND SHEAR PROGRAM


NASA
Langley
THE WINDSHEAR PROBLEM
WINDSHEAR AVOIDANCE
RECOVER OR CRASH
WINDSHEAR ENTRY
GLIDE SLOPE

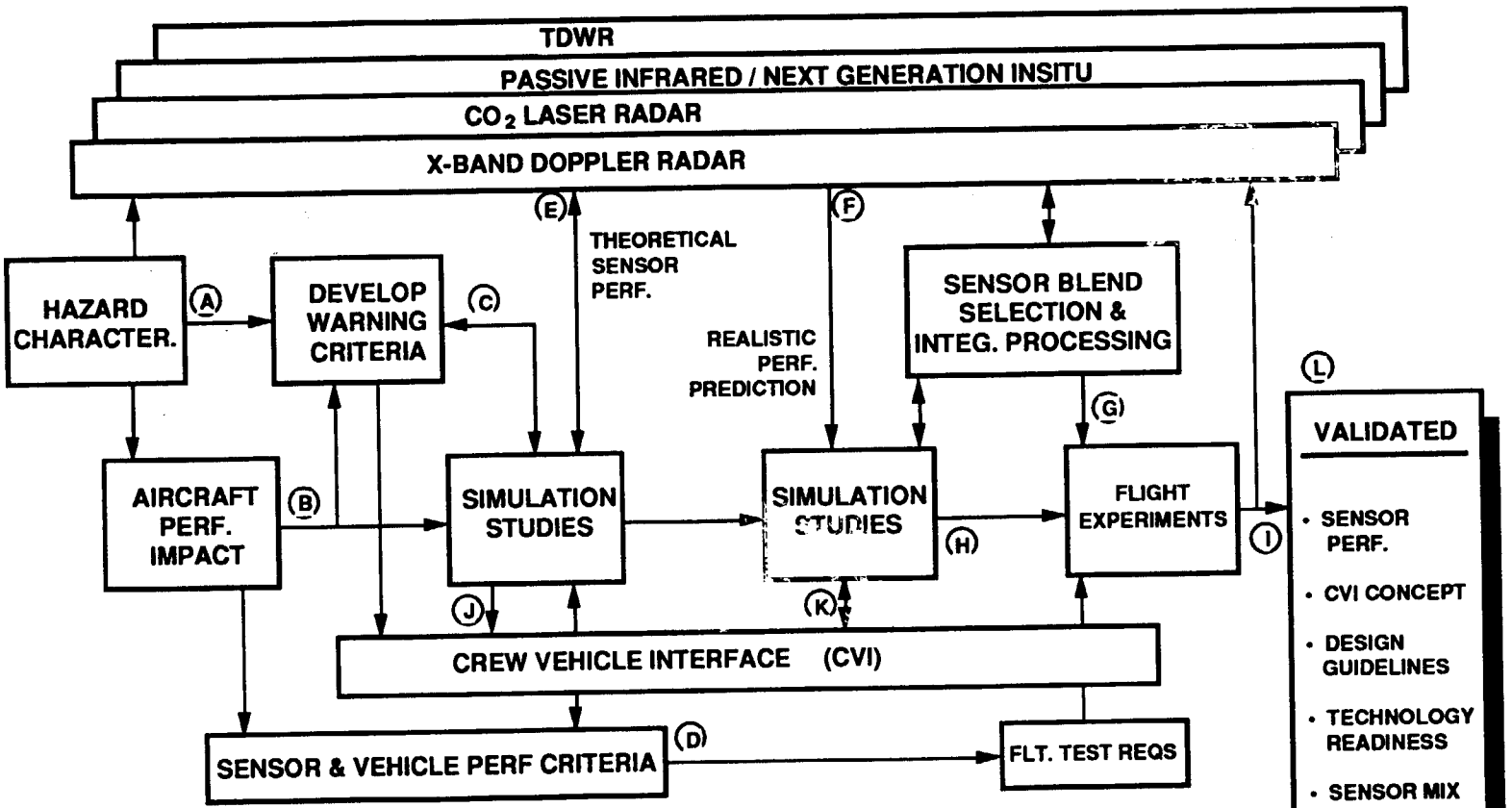


NASA/FAA WINDSHEAR PROGRAM OBJECTIVES

- TO DEVELOP AND VALIDATE TECHNOLOGY LEADING TO REDUCED RISKS ASSOCIATED WITH WINDSHEAR & HEAVY RAIN THROUGH AIRBORNE DETECTION AND AVOIDANCE

- SUPPORT NATIONAL AVIATION POLICY INITIATIVES TO REDUCE WIND SHEAR HAZARDS THROUGH COCKPIT INTEGRATION OF TDWR AND AIRBORNE DETECTION SYSTEMS

WIND SHEAR PROGRAM ROADMAP



A VALIDATED MATH MODEL CHARACTERIZING HAZARD, LARGE SCALE HEAVY RAIN TESTS
B PREDICTED AIRCRAFT PERFORMANCE IN WIND SHEAR/HEAVY RAIN
C WARNING CRITERIA DEFINED
D PERFORMANCE GOALS FOR SYSTEM ESTABLISHED
E THEORETICAL SENSOR FEASIBILITY/PERFORMANCE ESTABLISHED
F REALISTIC SENSOR PERFORMANCE DEFINED
G SENSOR INFORMATION REQUIREMENTS AND MIX ESTABLISHED
H SYSTEM PERFORMANCE, OPERATING PROCEDURES & DESIGN GUIDELINES ESTABLISHED
I FLIGHT VALIDATED SENSOR PERFORMANCE, OPER. PROCEDURES, & DESIGN GUIDELINES
J FLT. CREW ALERTING PROTOCOLS AND OPERATING PROCEDURES DEFINED
K PREDICTED SYSTEM PERFORMANCE WITH KEY VARIABLES PRESENT
L RESEARCH PRODUCTS IN SUPPORT OF ELIMINATING WIND SHEAR RISK

AIRBORNE WINDSHEAR SENSORS

Doppler Radar

Infrared Radiometer

Doppler Lidar

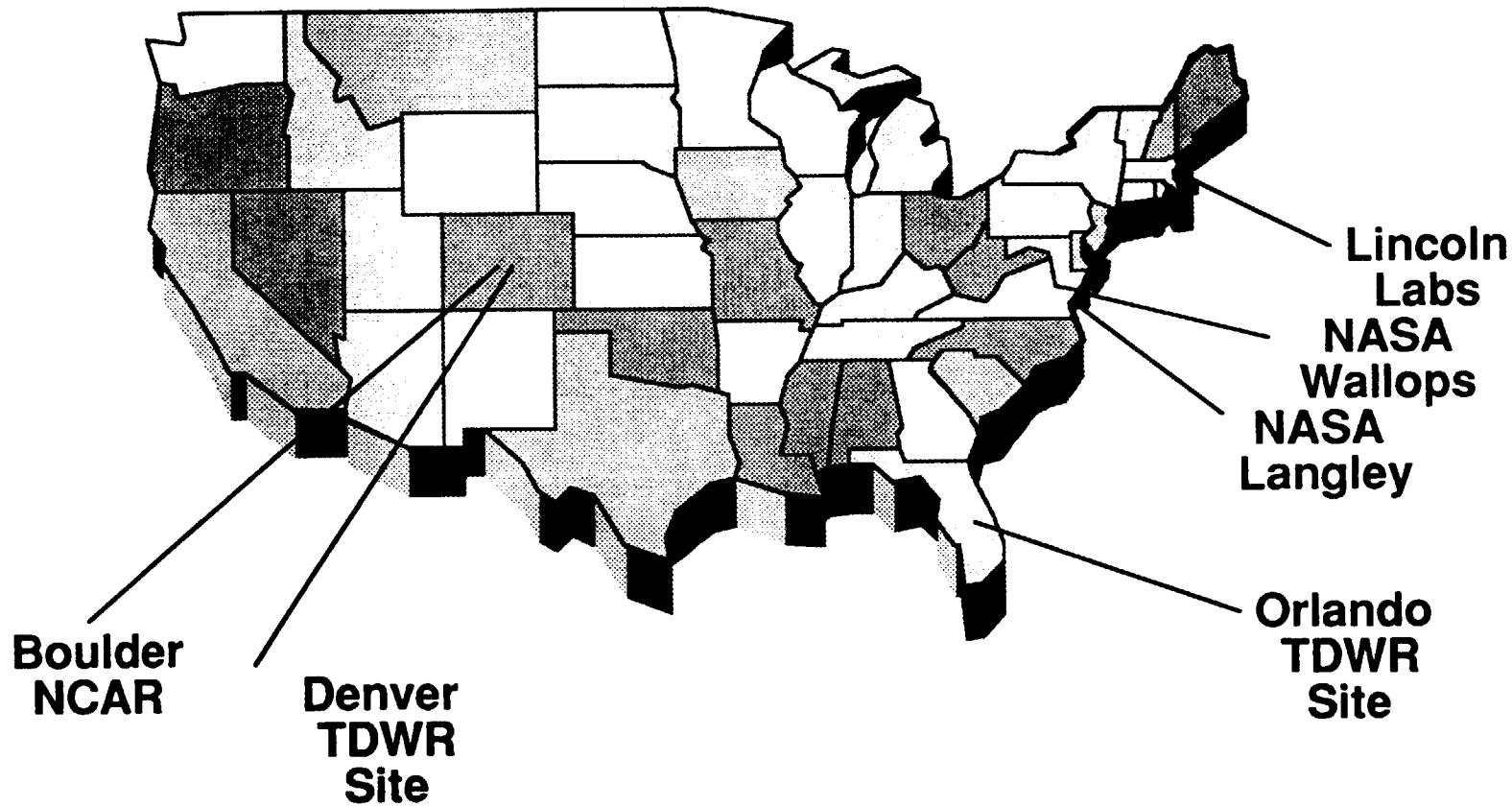
1991 WIND SHEAR FLIGHT EXPERIMENTS

DEPLOYMENT AT A GLANCE

- 30 DAY CAMPAIGN
- 52 PEOPLE DEPLOYED
- 42 FLIGHT DATA HOURS
- SUPERB TDWR PARTICIPATION (NCAR, LINCOLN)
- EXCELLENT ATC SUPPORT
- NO SIGNIFICANT DOWN TIME DUE TO FAILURE OF AIRCRAFT OR RESEARCH SYSTEMS
- A GOOD PLAN RESULTED IN A SAFE OPERATION WHICH YIELDED EXCELLENT DATA

91 WIND SHEAR DEPLOYMENT

OPERATIONAL SITES/KEY PARTICIPANTS

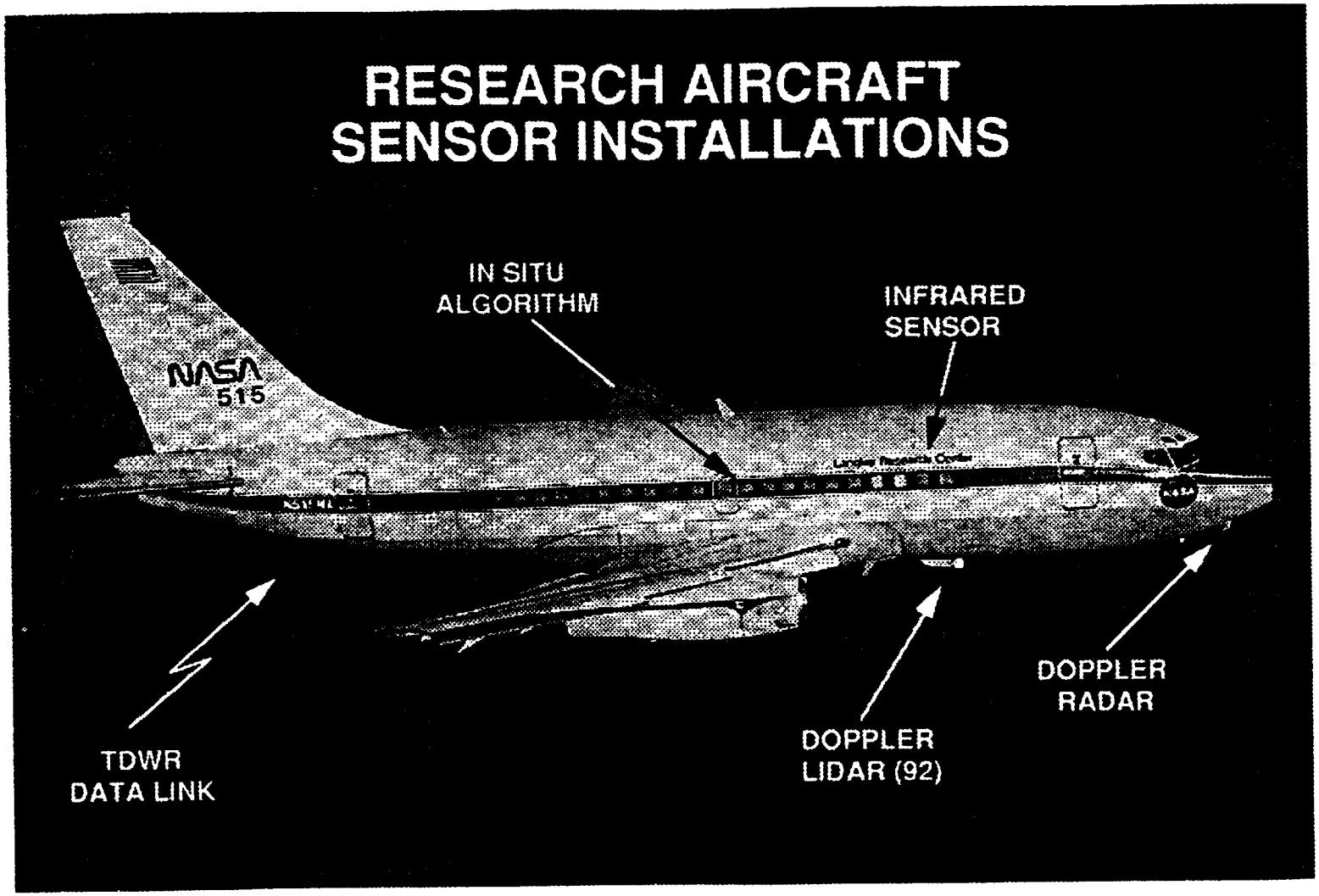


OPERATIVE WIND SHEAR DETECTION SYSTEMS

91 FLIGHT EXPERIMENTS

AIRBORNE TECHNOLOGY	FEATURES / CAPABILITY
• PULSED DOPPLER MICROWAVE RADAR	• ADVANCED HARDWARE PERFORMANCE • EXCELLENT CLUTTER REJECTION • REAL-TIME HAZARD DISPLAY
• INFRARED RADIOMETER	• REAL-TIME DETECTION ALGORITHM • THERMAL FEATURE IDENTIFICATION • SUCCESSFUL MICROBURST DETECTION
• IN SITU TRUTH MEASUREMENT	• ADVANCED ALGORITHM PERFORMANCE EXCEEDS FAA REQUIREMENTS • EXCELLENT GUST REJECTION CHARACTERISTICS • MANEUVER MOTION IMMUNITY
• TDWR / AIRCRAFT DATA COMMUNICATION AND DISPLAY	• NASA HAZARD ALGORITHM • DATA LINK COMMUNICATION • EHSI DISPLAY OF HAZARD

WIND SHEAR AIRBORNE SENSORS PROGRAM



WIND SHEAR AIRBORNE SENSORS PROGRAM

1991 TEST RESULTS SUMMARY

- ACQUIRED OUTSTANDING HIGH RESOLUTION MEASUREMENTS OF MICROBURST DYNAMICS AND STRUCTURE
- ACCOMPLISHED FIRST EVER IN SITU DETECTION SYSTEM CORRELATION WITH INDEPENDENT MEASUREMENTS
- ACCOMPLISHED FIRST EVER AIRBORNE RADAR DETECTION OF HAZARDOUS WIND SHEAR
- HIGH QUALITY CLUTTER MEASUREMENTS PROVIDE BASIS FOR NATIONAL CERTIFICATION STANDARDS
- DEMONSTRATED PERFORMANCE BENEFITS AND UTILITY OF TDWR DATA LINK CONCEPT

WIND SHEAR AIRBORNE SENSORS PROGRAM

1992 FLIGHT TESTS EXPECTATIONS

- PULSED DOPPLER LIDAR SYSTEM ON BOARD
- FULL SENSOR COMPLEMENT INSTALLED
- SIGNIFICANTLY ENHANCED RADAR PROCESSOR INSTALLED
- IR INSTRUMENT INCLUDES 1991 'LESSONS LEARNED'
- TDWR DATA LINK ENHANCED
- FLIGHT OPERATIONS TO INCLUDE 1991 'LESSONS LEARNED'
- LOCAL, ORLANDO, AND DENVER TEST SITES
- END-TO-END WIND SHEAR DETECTION PERFORMANCE EVALUATION
  - COMMON HAZARD PROCESSING
  - UNIFIED ALERTS
  - INTEGRATED DISPLAY

Q: Bob Otto (Lockheed) - A potential recommendation for carrying out a sensor comparison program would be to use all candidate sensors (TDWR, reactive, radar, IR, etc.) to determine F-factor as a function of space and time for the same microburst event. A reference or ground truth needs to be decided upon. It may be TDWR or reactive data properly processed. Then the sensors can be evaluated and compared. A parametric evaluation can be done for wet and dry, different microburst spatial sizes and temporal duration, different microburst strengths and various parameters of the event. Please comment on this recommendation and tell what the actual plan will be.

A: Roland Bowles (NASA Langley) - The easy answer is that we don't write those plans, but we certainly feel sensitive to the need to help the FAA put together a technical rationale. That is our job. We are not going to dictate how you are going to get your systems approved, but we are going to be in the background along with the other programs operating out of the FAA like the Lincoln and the NCAR program. Wherever we can get relevant and pertinent data to bare on the subject we are going to get it.

Q: Bob Otto (Lockheed) - I have attended all of the wind shear conferences that you have had and each time I come here I see a great deal of progress being made. I have this vision that at some point we are going to be able to take all the data from all the different sensors for the same type of microburst events and compare all these different sensors and say this sensor works best in this regime, this sensor works best for that regime. In other words, trying to accumulate enough scientific data and try to make a valid comparison among all these different sensors. I think NASA is in a unique position to do that sort of thing. I am just asking if that is what you really want to do or should do in order to satisfy the program objectives?

A: Roland Bowles (NASA Langley) - Our job was basically three fold: a) Define the relevant technologies appropriate to airborne hazard detection and avoidance. b) Out of that admissible list, decide through priority structure what we think the system requirement is going to end up to be and realize in hardware and software those candidates and c) fly them off and compare against suitable environments that we can call truth. I don't call TDWR ground truth. I call TDWR another estimate of what is out there. But I'll tell you what I do think the truth is, I believe it is the airplane. Newton as alive and well. That is why we are stressing a great deal using our In Situ data. Brac showed some results that were extremely encouraging. The data that he showed yesterday had the antenna looking down two degrees below the horizon. There were range gates out there in the ground. In fact, the strongest event we incurred was right over top of the interstate in Orlando. So we had plenty of stuff around to reject or mess it up. When the radar took a snapshot and made a prediction 8 kilometers out and subsequently the airplane flew through that environment and you compare the results, we can even see the latency in the reactive alert due to the gust rejection filtering and it is right on the money. That was based on a snapshot 30 to 40 seconds earlier. So that is one means by which you can judge the validity in the prediction. We do not see anything coming off of the TDWR that is inconsistent with what we are seeing in the air, when we fly in the vicinity or an appropriate neighborhood of the event.

Now, we did fly through icons last year where there just wasn't anything in them. That is another problem that I think Steve is going to address tomorrow. I think this is a good question. I look at it as, what would be the appropriate mix that industry would have to place on the FAA doorstep between flight results, simulation results, and those test procedures that will be outlined in the Interim Standards document and or a TSO, if we ever get to one. I think it is the mix that is important. But, it is going to cost the industry money. Knowing Kurt and his people, I don't think anyone is going to be able to back in on this one. There is a lot of homework to be done. I think we are on the right track. The NASA laser, built by UTAS and integrated by Lockheed, is going to get a good ride. I guarantee you it will get a fair objective comparison. This year we have refined the algorithms throughout the airplane and have been pulling all the data together on a common basis of measurement and display. There are a lot of events that we threw away last year that we will take this year. If things cooperate reasonably well we are going to have a good summer and it will get a fair ride.