Session IV. Airborne Doppler Radar / Industry

Airborne Doppler Radar Research at Rockwell International

Roy Robertson, Rockwell International

NASA / FAA

FOURTH COMBINED AIRBORNE WINDSHEAR

REVIEW MEETING

APRIL 14-16, 1992

ROCKWELL INTERNATIONAL
COLLINS AIR TRANSPORT DIVISION

ROY E. ROBERTSON

DESIGN EXCELLENCE CUSTOMER SATISFACTION℠

Rockwell International
Collins Commercial Avionics

TOPICS

COLLINS 1991 WINDSHEAR FLIGHT PROGRAM

SYSTEM CONSIDERATIONS

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FLIGHT PROGRAM OBJECTIVES

- **DETERMINE FEASIBILITY OF RADAR WINDSHEAR DETECTION**
- **PERFORMANCE ASSESSMENT**

  3-WAY DATA CORRELATION:
  - AIRBORNE RADAR
  - GROUND RADAR (TDWR)
  - AIRCRAFT DATA

- **DETERMINE WINDSHEAR PRODUCT REQUIREMENTS**

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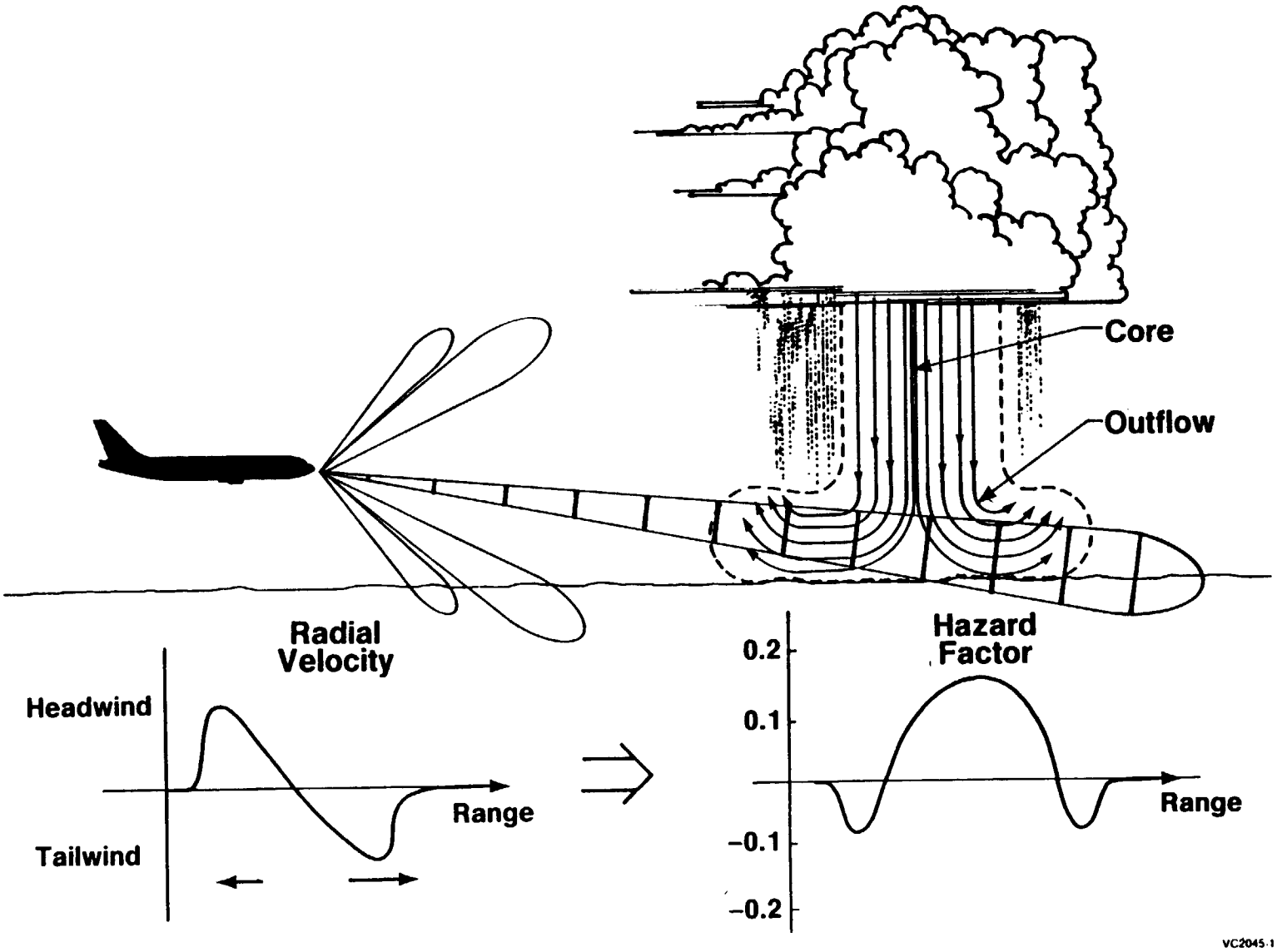
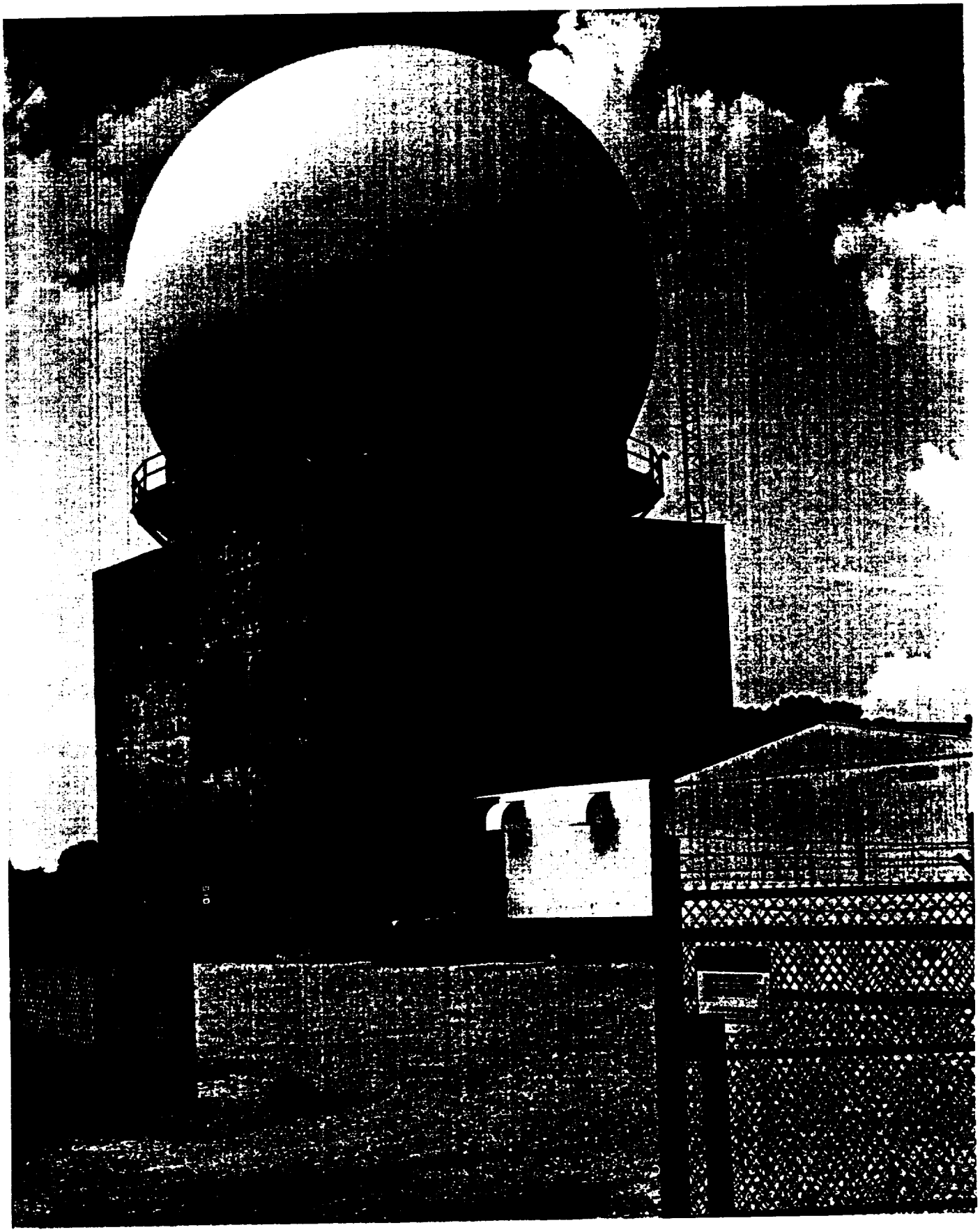
RADAR WINDSHEAR DETECTION



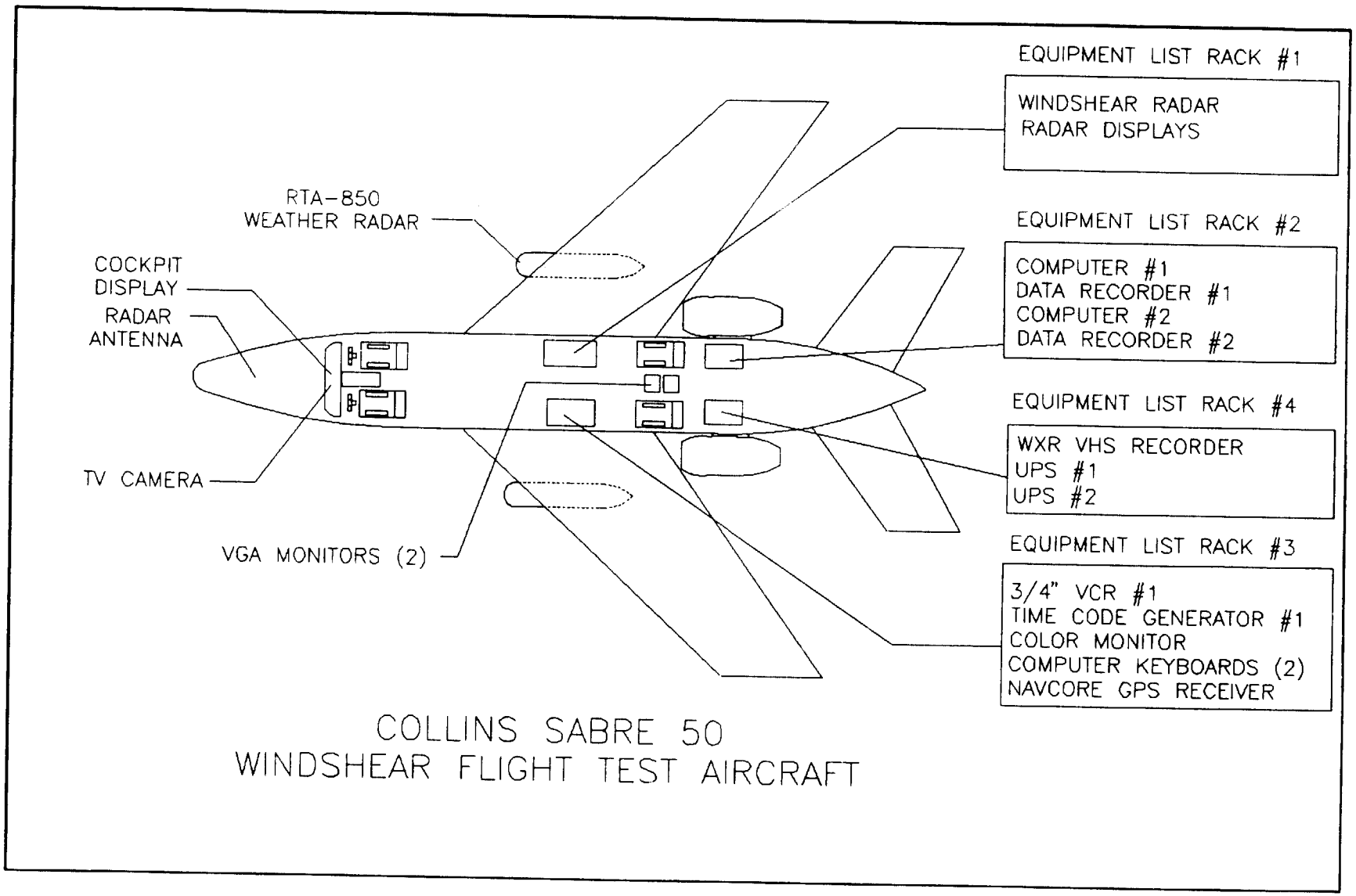
FLIGHT PROGRAM PREPARATION

- **GROUND SUPPORT**
  - SITE SELECTION
  - GROUND RADAR
  - FLIGHT COORDINATION
- **AIRCRAFT**
  - EQUIPMENT
  - PERFORMANCE
- **OPERATION**
  - PROCEDURES
  - TRAINING
  - SAFETY CRITERIA
  - ATC



AIRCRAFT READINESS

- **INSTRUMENTATION AND RECORDING**
  - WINDSHEAR RADAR
  - POSITION (GPS)
  - RADIO ALTITUDE
  - ATTITUDE ACCELERATION
  - AIR DATA
  - NAVIGATION DATA
  - TIME CODE
  - COCKPIT VIDEO CAMERA
- **AIRCRAFT MODIFICATIONS**
  - ANGLE OF ATTACK INDICATOR
  - STALL WARNING SYSTEM, STICK SHAKER
  - CONTINUOUS IGNITERS
  - TCAS
  - LARGER ENGINES
- **PERFORMANCE TESTS**
  - CLIMB, ACCELERATION (F=APPROX 0.19)


EQUIPMENT LIST RACK #1
WINDSHEAR RADAR
RADAR DISPLAYS
RTA-850
WEATHER RADAR
COCKPIT
DISPLAY
RADAR
ANTENNA
EQUIPMENT LIST RACK #2
COMPUTER #1
DATA RECORDER #1
COMPUTER #2
DATA RECORDER #2
EQUIPMENT LIST RACK #4
WXR VHS RECORDER
UPS #1
UPS #2
TV CAMERA
VGA MONITORS (2)
EQUIPMENT LIST RACK #3
3/4" VCR #1
TIME CODE GENERATOR #1
COLOR MONITOR
COMPUTER KEYBOARDS (2)
NAVCORE GPS RECEIVER
COLLINS SABRE 50
WINDSHEAR FLIGHT TEST AIRCRAFT

FLIGHT OPERATIONS

- **GROUNDSIDE**
  - WEATHER MONITORING - AIRCRAFT LAUNCH DECISION
  - LOCATE MICROBURST FORMATION
  - HAZARD ASSESSMENT
  - RADIO EVENT COORDINATES TO AIRCRAFT
  - CONTINUOUS FLIGHT MONITORING
  - DATA LOGGING/RECORDING

- **AIRCRAFT**
  - GROUND WEATHER RADAR COMMUNICATIONS
  - NAVIGATION SETUP
  - ATC COORDINATION
  - HAZARD ASSESSMENT
  - OBSTACLE CLEARANCE
  - DATA RECORDING
  - RADAR OPERATION
  - PENETRATION FLIGHTS

CUSTOMER SATISFACTION℠

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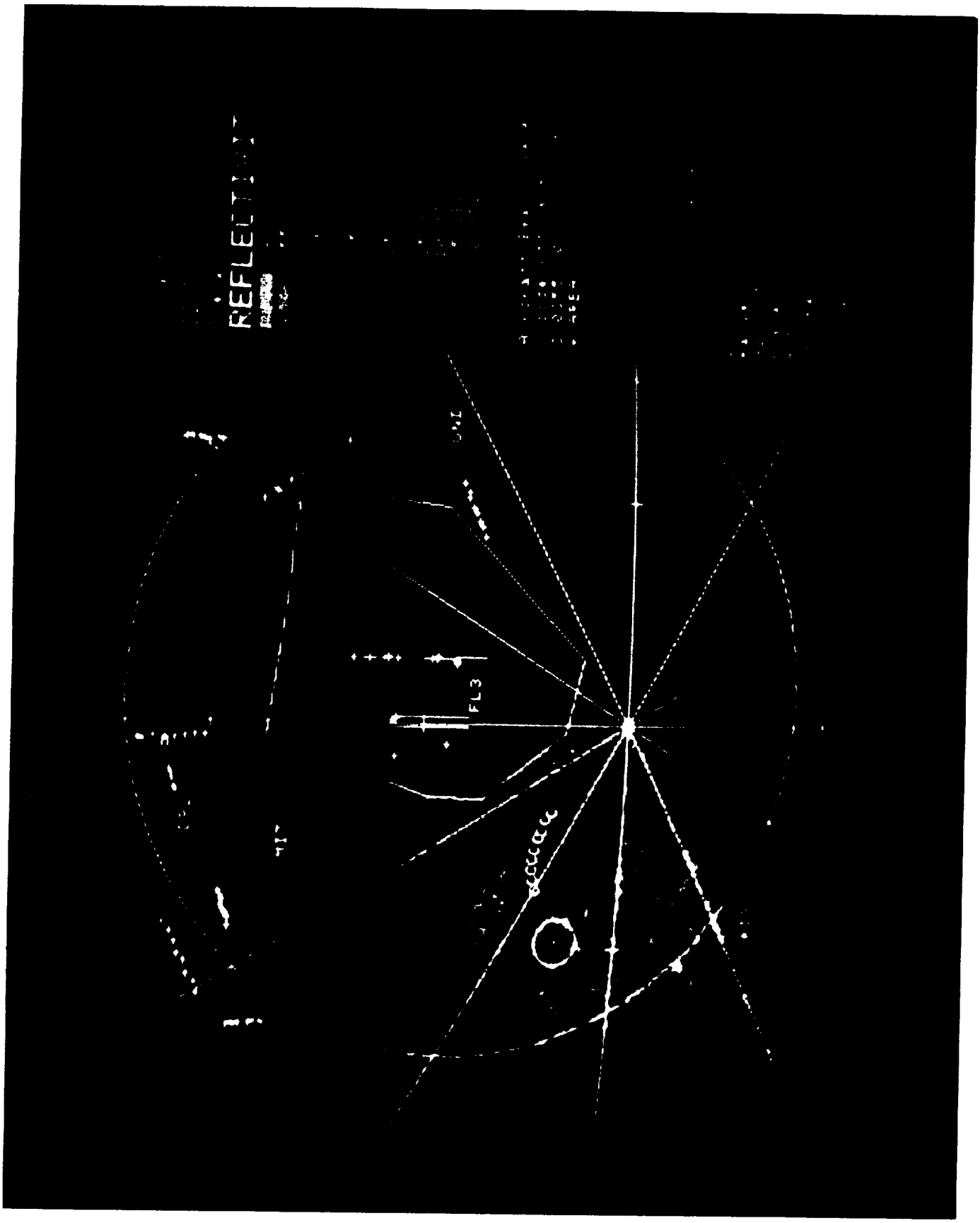

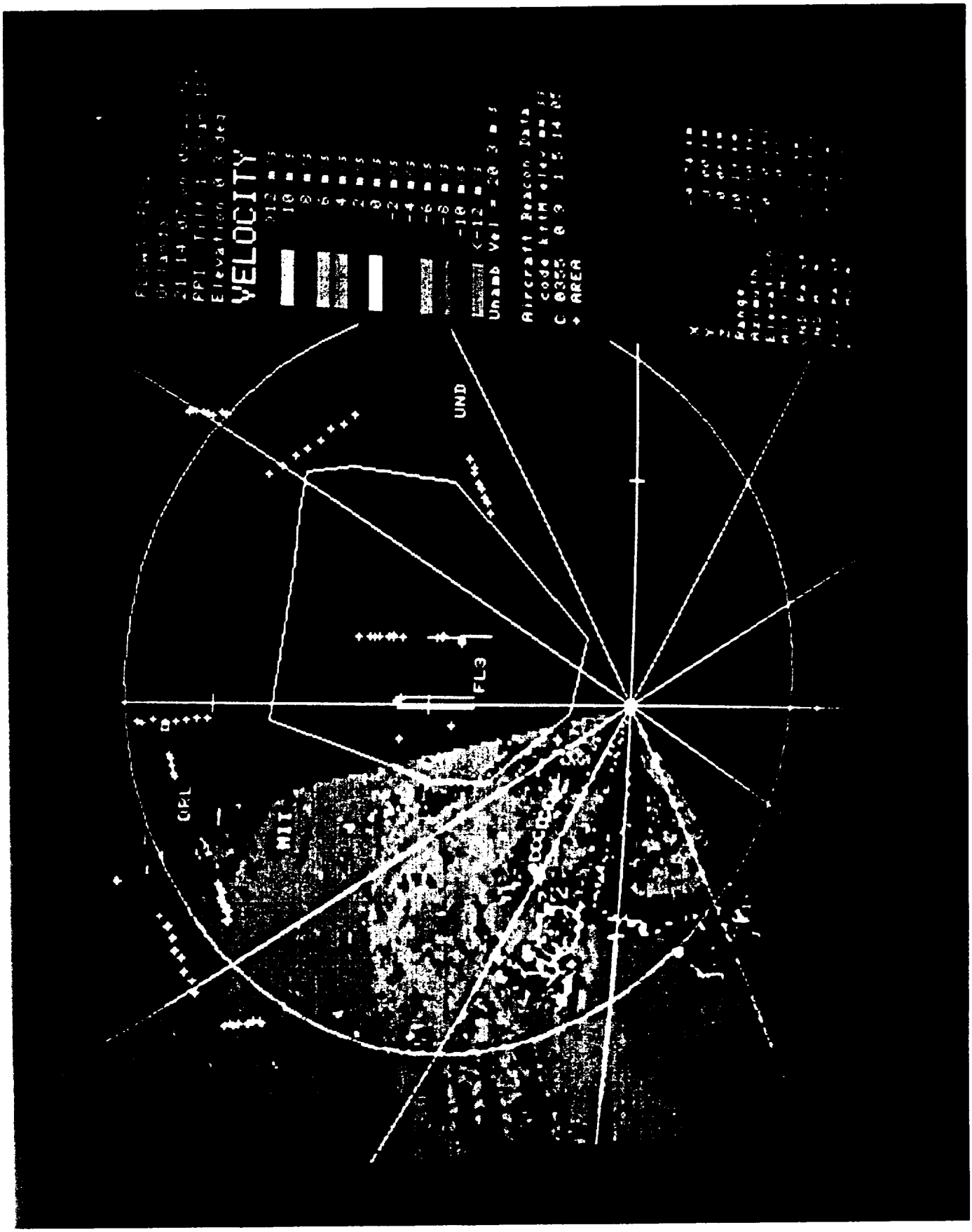

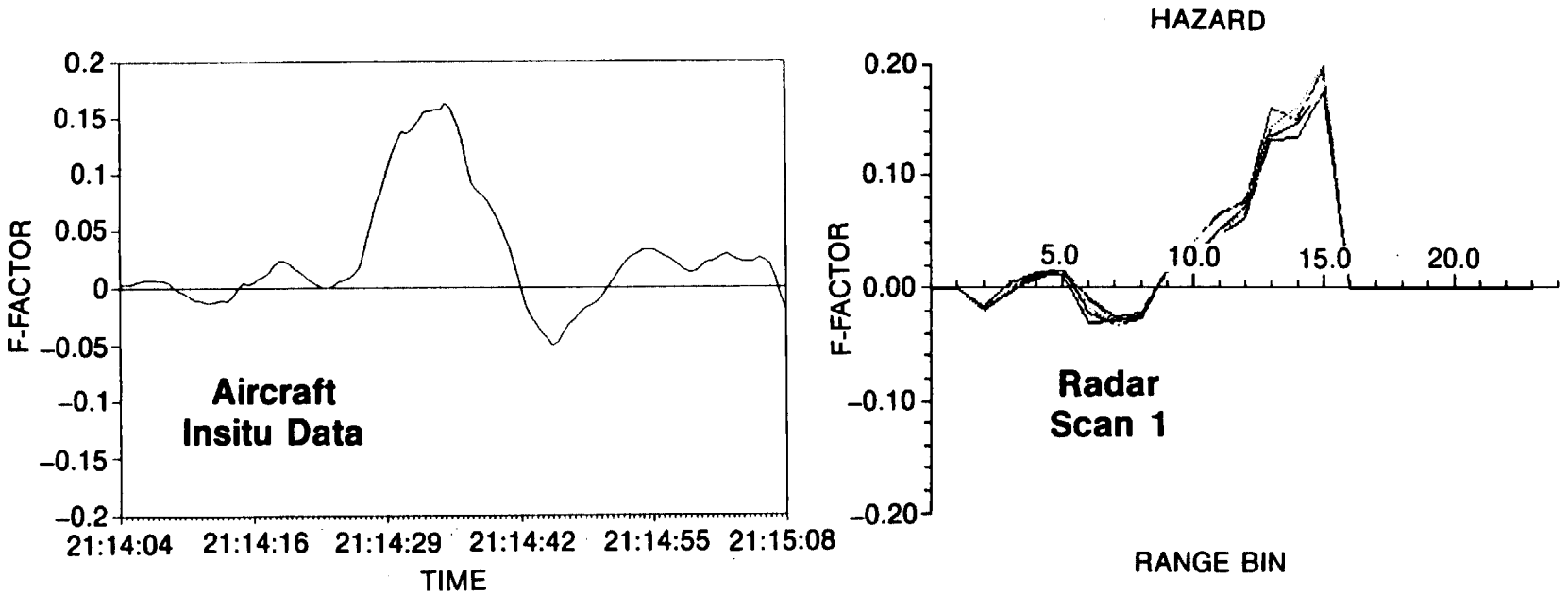
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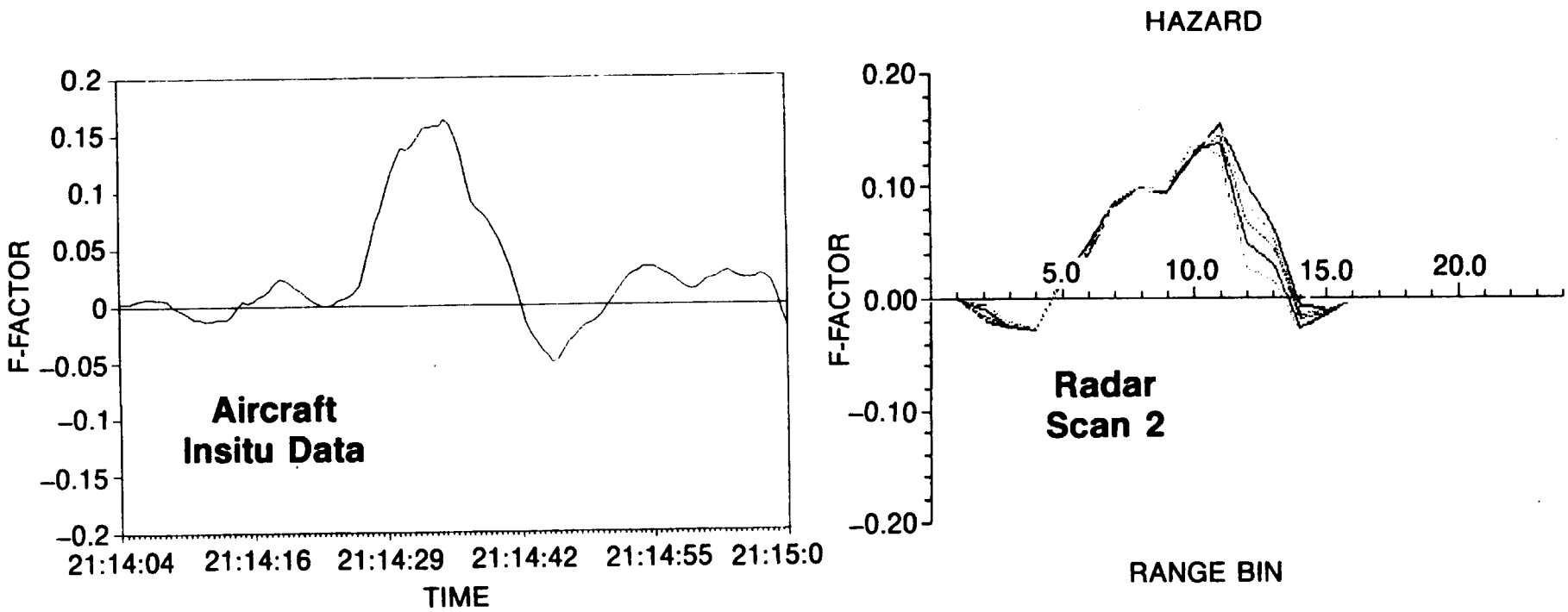
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
F-FACTOR
Aircraft
Insitu Data
21:14:04
21:14:16
21:14:29
21:14:42
21:14:55
21:15:08
TIME
0.20
0.10
0.00
−0.10
−0.20
F-FACTOR
5.0
10.0
15.0
20.0
Radar
Scan 1
RANGE BIN


HAZARD
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0.1
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-0.05
-0.1
-0.15
-0.2
F-FACTOR
Aircraft
Insitu Data
21:14:04
21:14:16
21:14:29
21:14:42
21:14:55
21:15:0
TIME
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F-FACTOR
5.0
10.0
15.0
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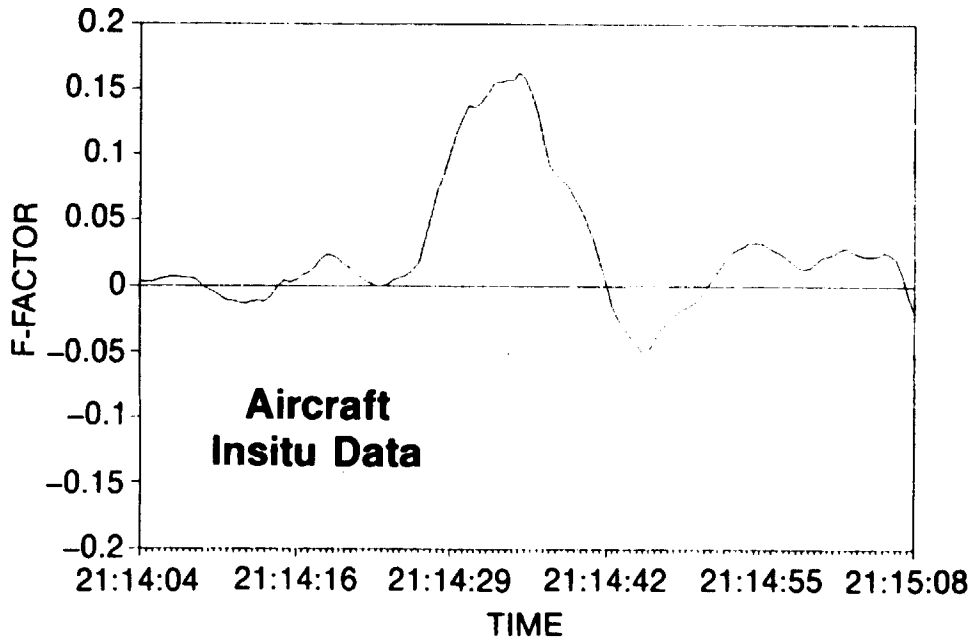
Radar
Scan 2
RANGE BIN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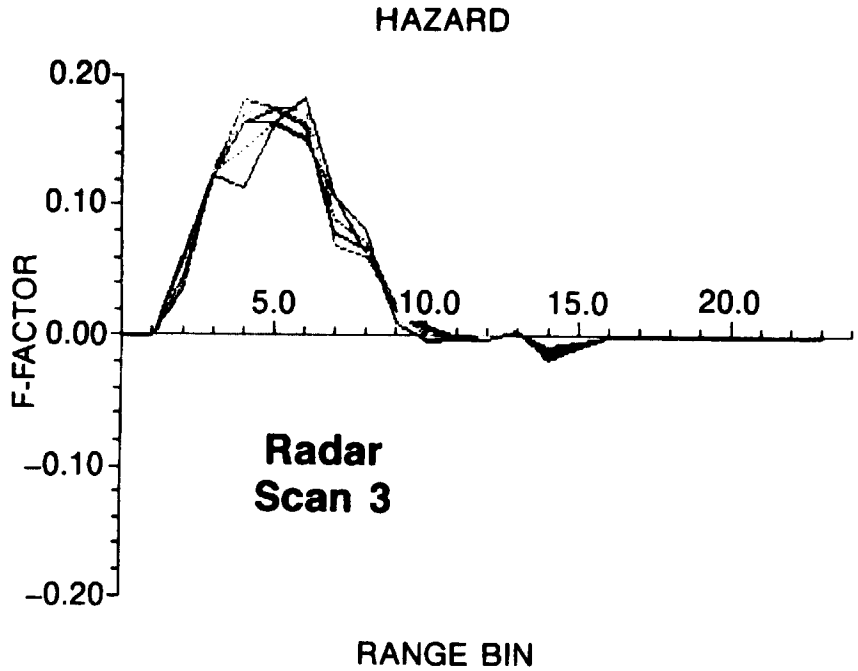
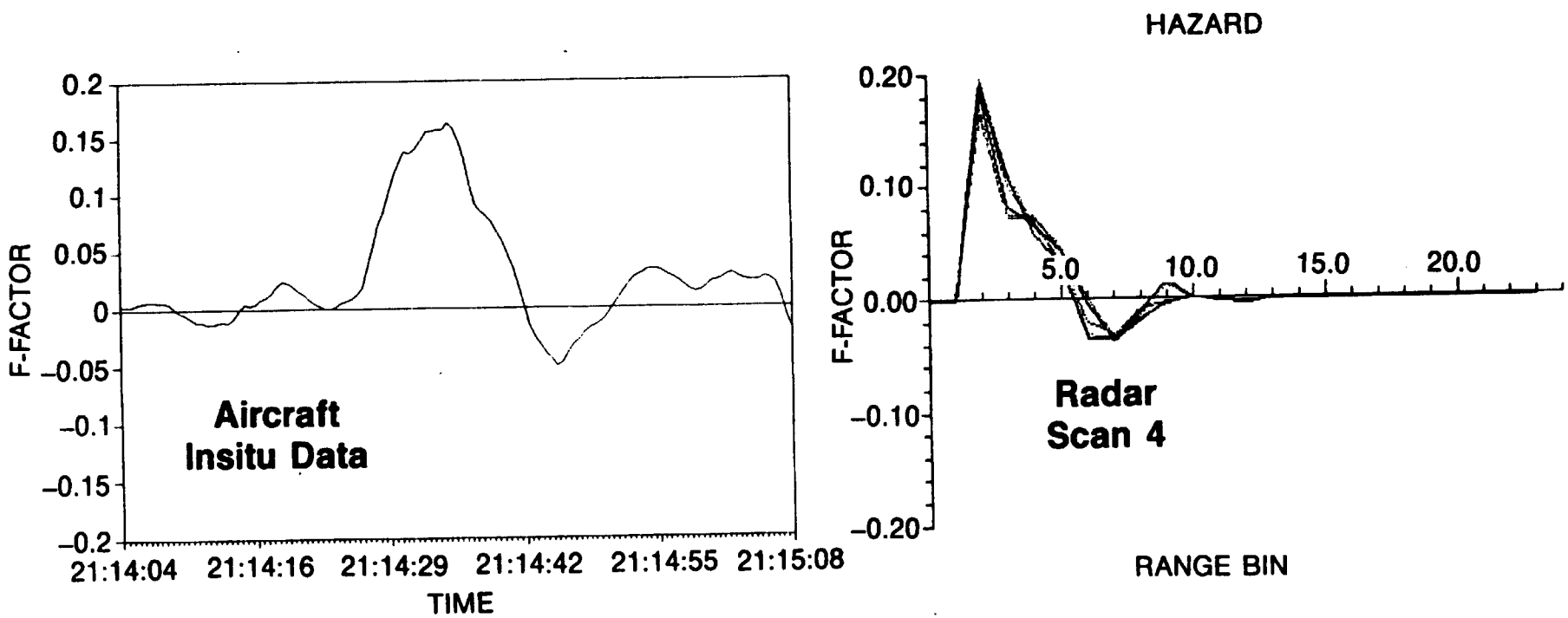
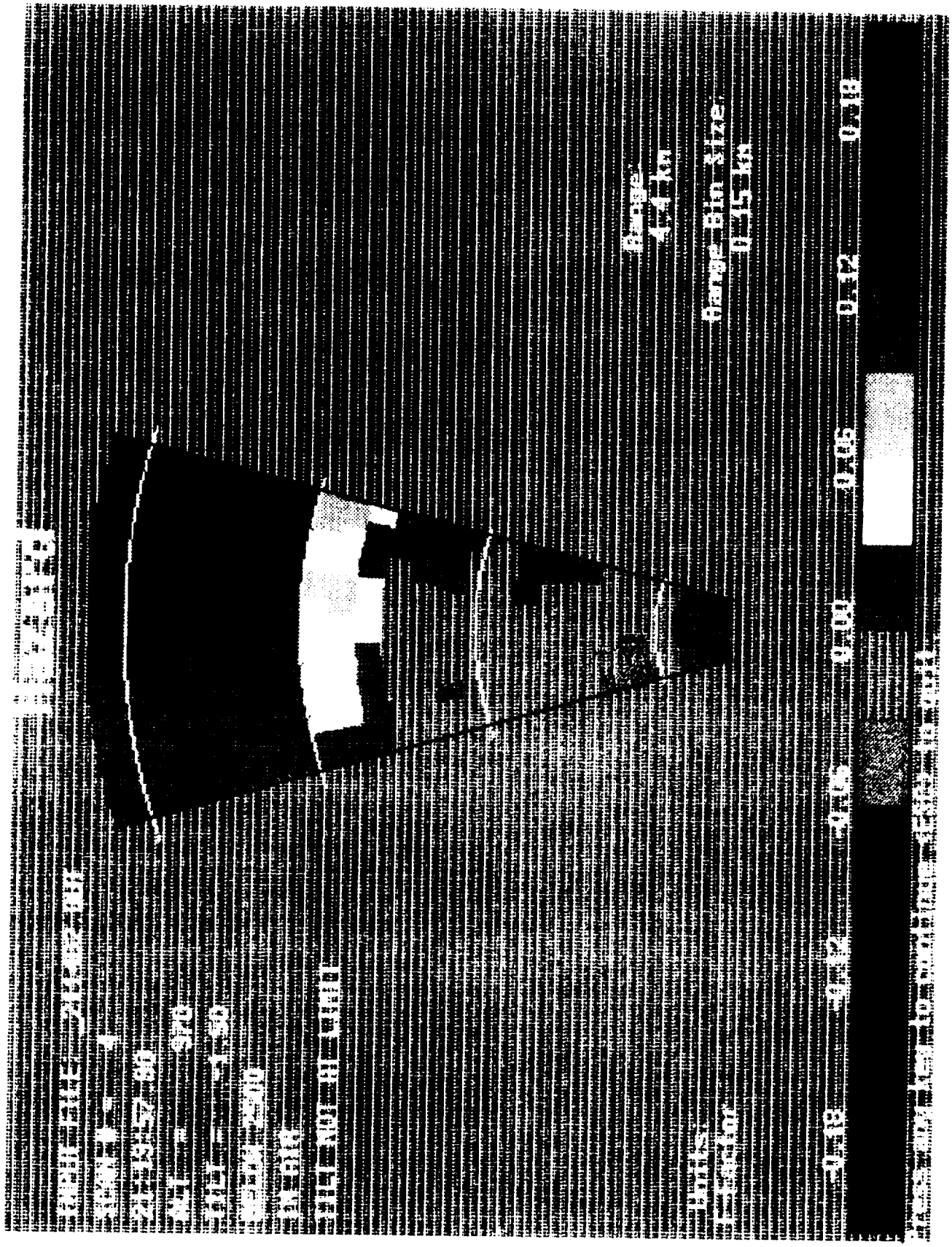
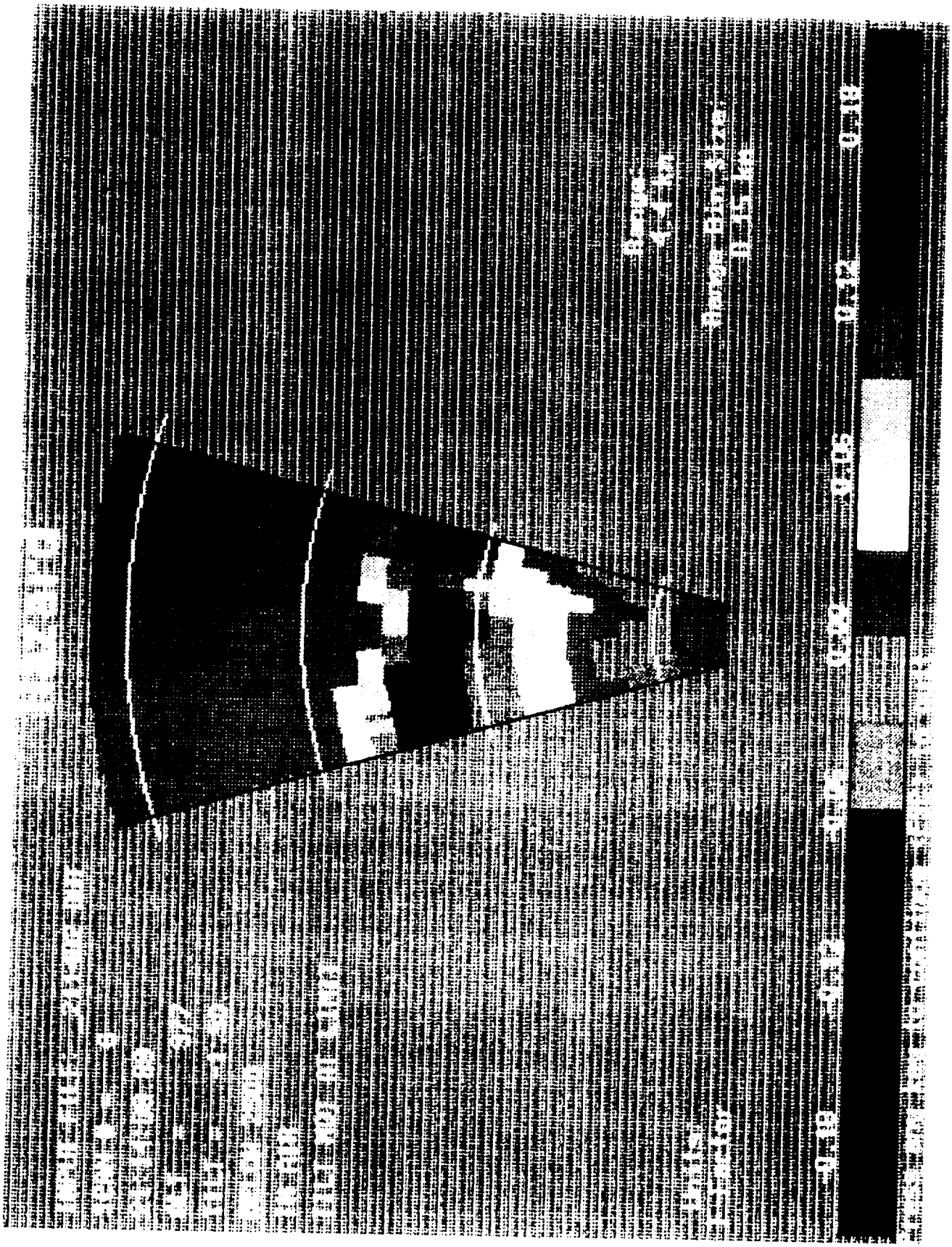
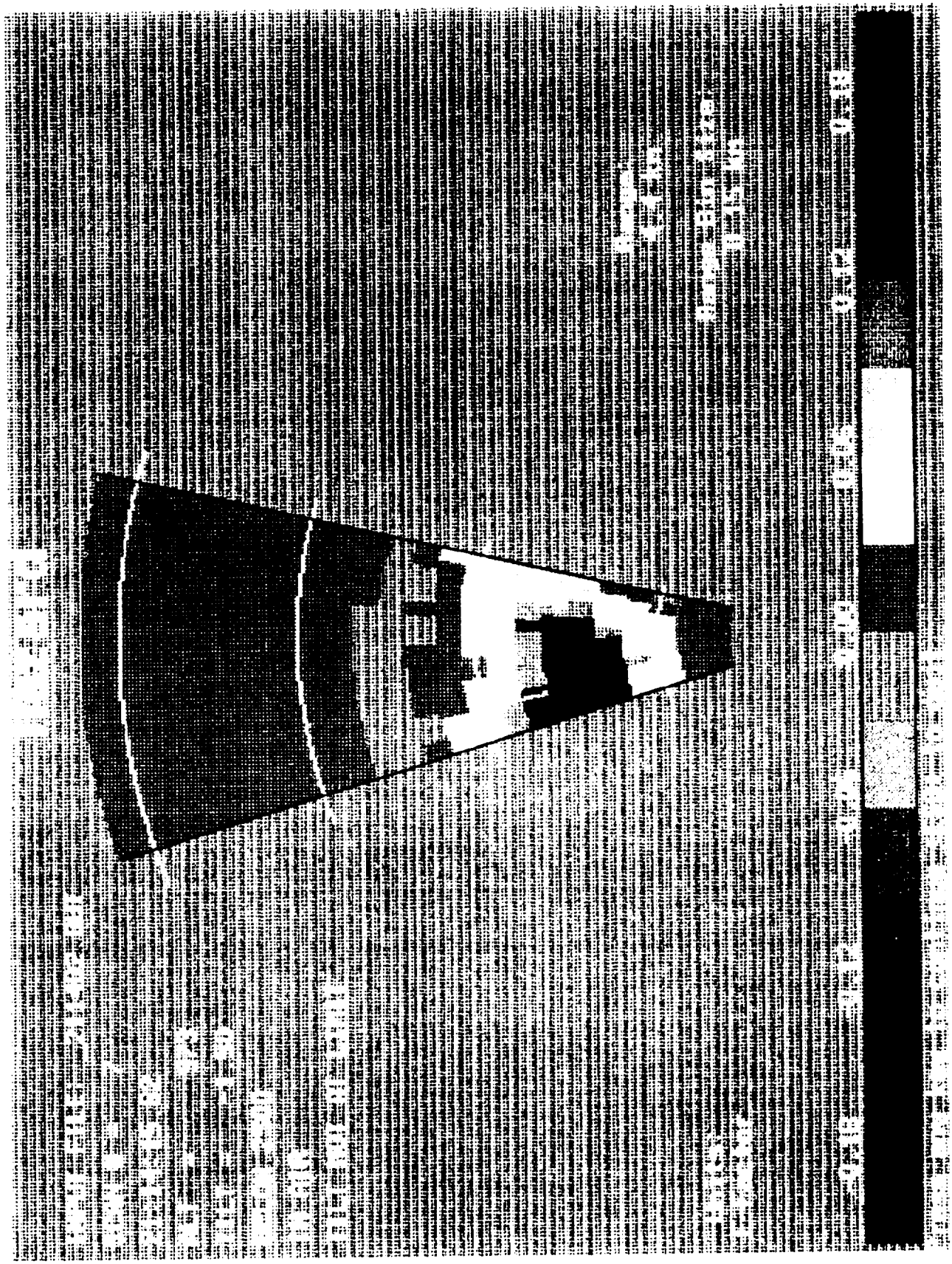
F-FACTOR
Aircraft
Insitu Data
21:14:04
21:14:16
21:14:29
21:14:42
21:14:55
21:15:08
TIME

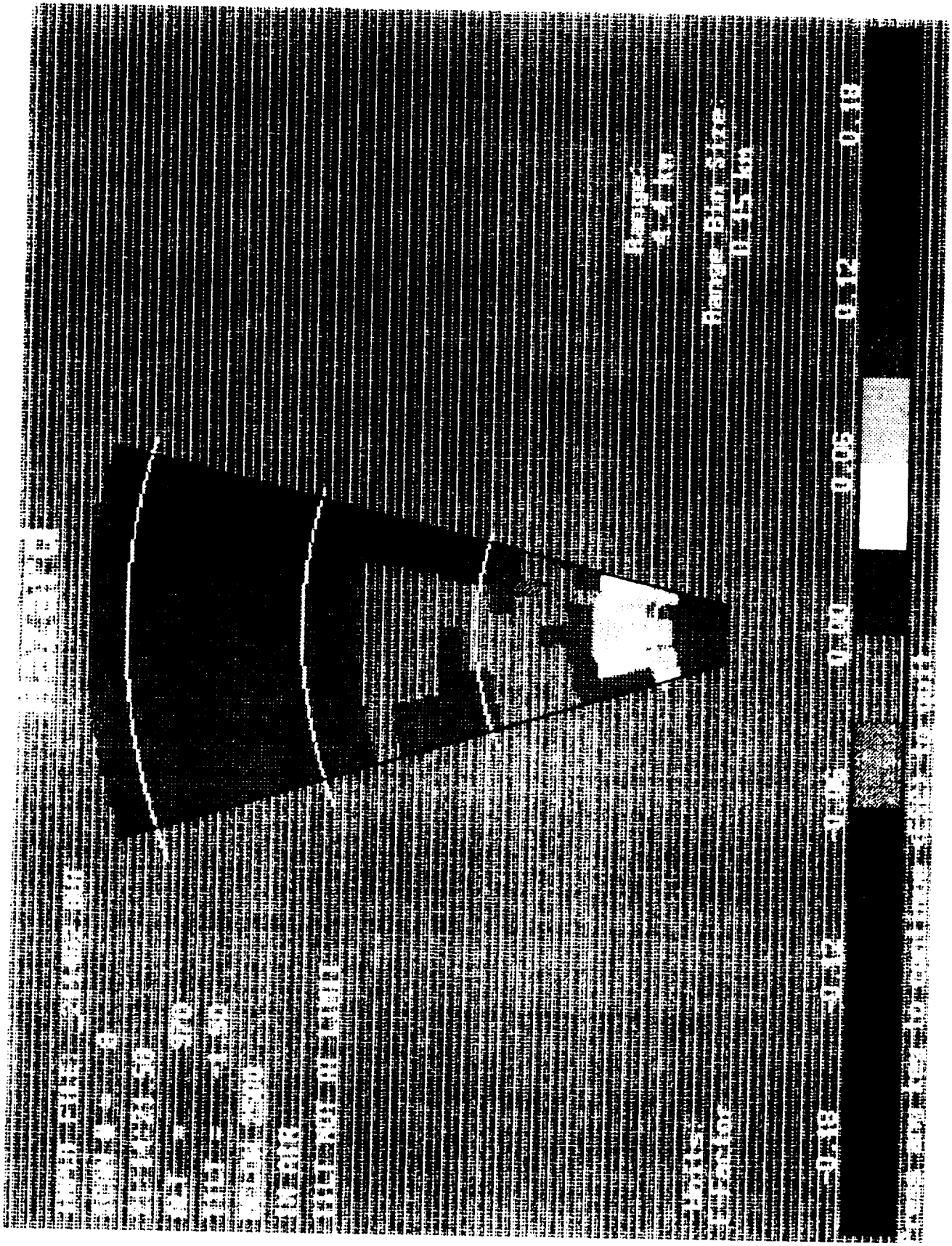

HAZARD
0.20
0.10
0.00
−0.10
−0.20
F-FACTOR
5.0
10.0
15.0
20.0
Radar
Scan 3
RANGE BIN


HAZARD
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
F-FACTOR
Aircraft
Insitu Data
21:14:04
21:14:16
21:14:29
21:14:42
21:14:55
21:15:08
TIME
0.20
0.10
0.00
−0.10
−0.20
F-FACTOR
5.0
10.0
15.0
20.0
Radar
Scan 4
RANGE BIN









FLIGHT PROGRAM

CONCLUSIONS:

- EXCELLENT CORRELATION
  - AIRBORNE RADAR
  - AIRCRAFT INSITU
  - GROUND RADAR (TDWR)
- RADAR WINDSHEAR DETECTION IS FEASIBLE
- NEED FLIGHT DATA ON DRY EVENTS

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SYSTEM CONSIDERATIONS

WARNING STRATEGY

- TWO LEVELS OF ALERTING
  - CAUTION <5 NAUTICAL MILES ±25° COVERAGE
  - WARNING <1.5 NAUTICAL MILES
- PRIMARY CREW ALERT
  - AURAL ALERT
  - "CAUTION" OR "WARNING" INDICATOR
- WINDSHEAR DISPLAY SECONDARY
  - HAZARD ASSESSMENT / ESCAPE MANEUVER
  - AUTOMATIC OR MANUAL
  - SYMBOLIC OVERLAY ON WEATHER

CAUTION - TIME TO ASSESS HAZARD; AVOIDANCE
WARNING - GO AROUND

WINDSHEAR RADAR

DISPLAY CONSIDERATIONS:

- HAZARD FACTOR DISPLAY
  - MAY OR MAY NOT BE ASSOCIATED WITH REFLECTIVITY CORE
  - DIFFICULT TO CORRELATE WITH VIEW AHEAD

- SYMBOLIC REPRESENTATION
  - OVERLAY ON WEATHER OR HAZARD DISPLAY

CONCLUSION: WINDSHEAR SYMBOLIC OVERLAY ON WEATHER DISPLAY GIVES MOST COMPLETE PICTURE OF WEATHER SITUATION

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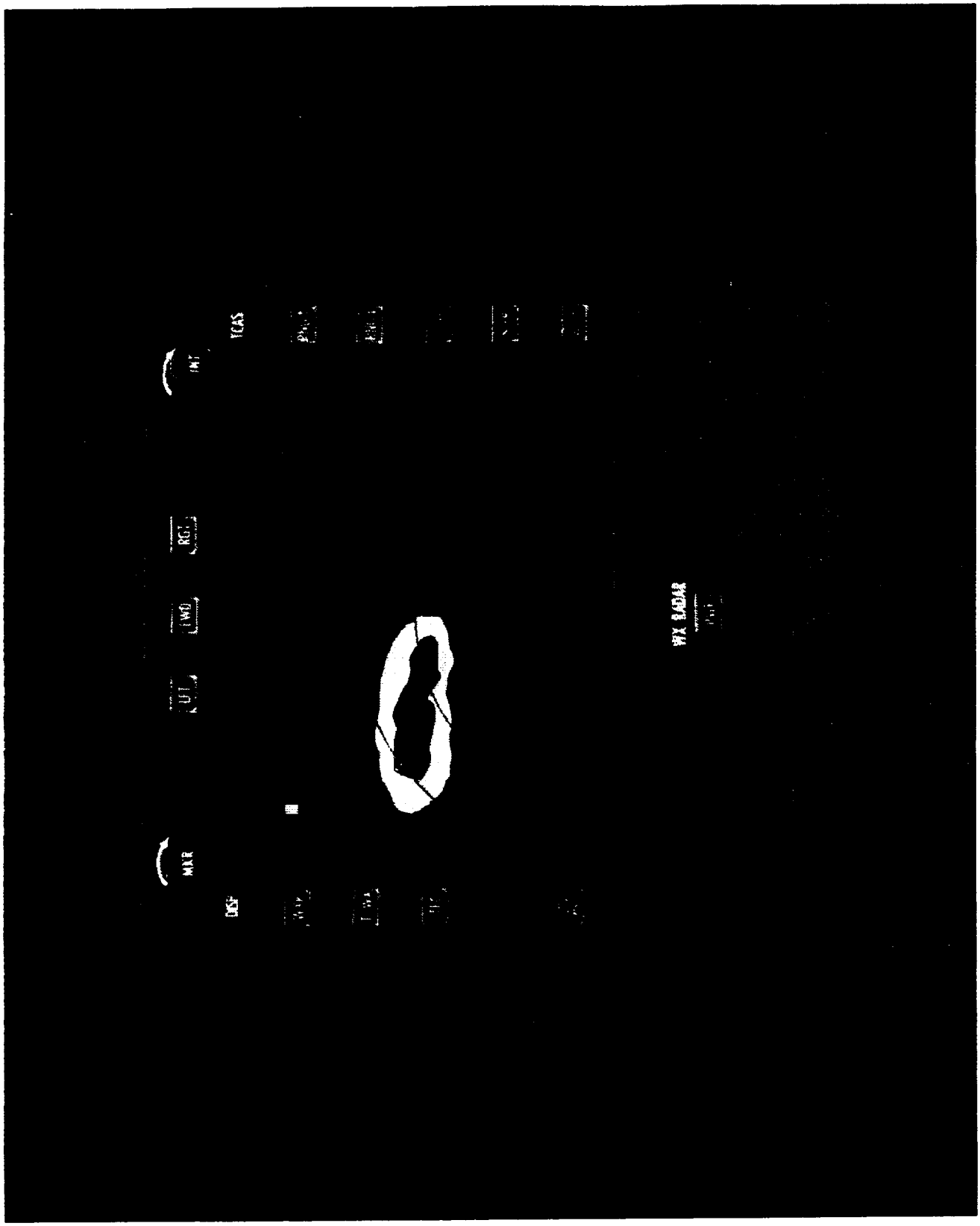

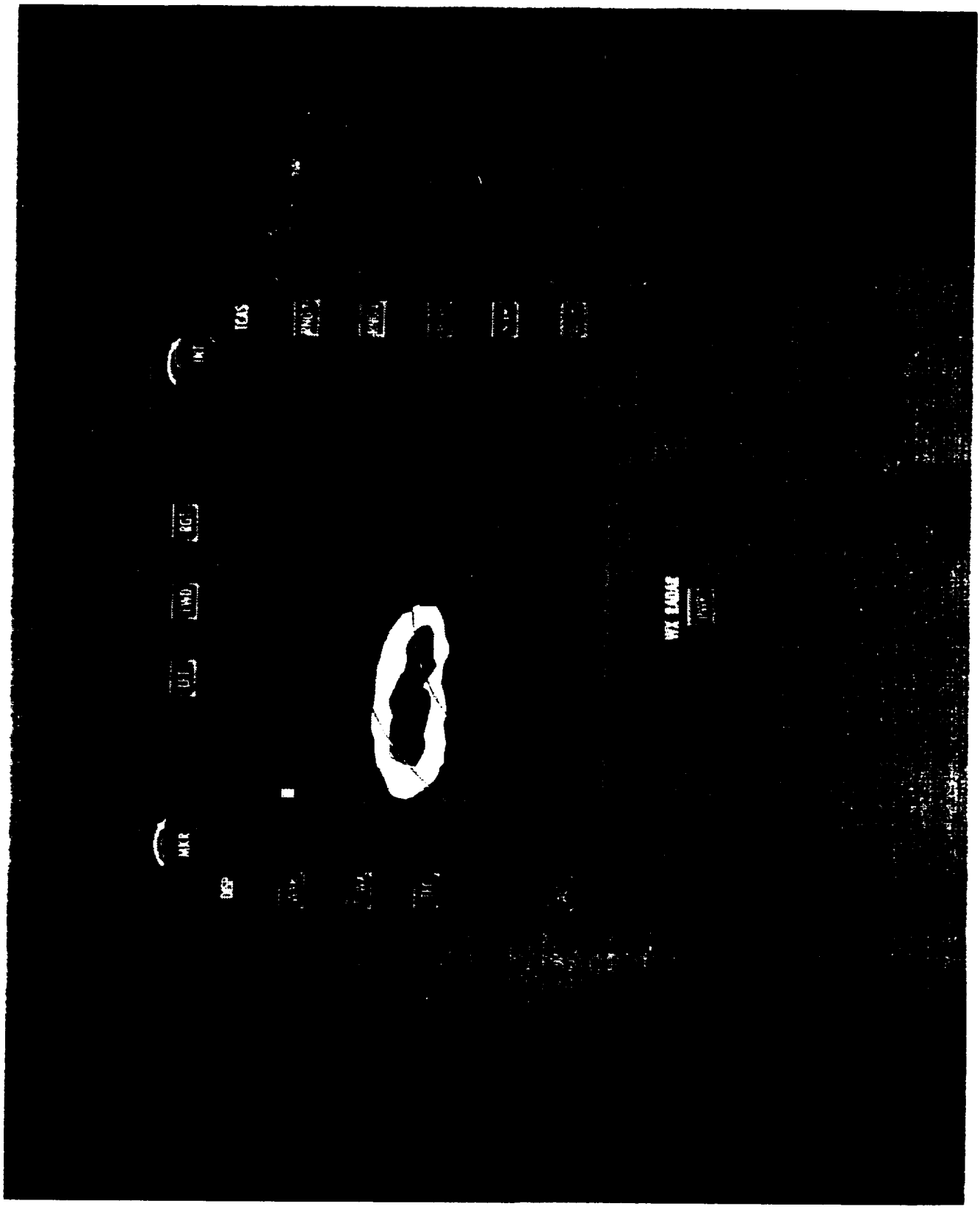

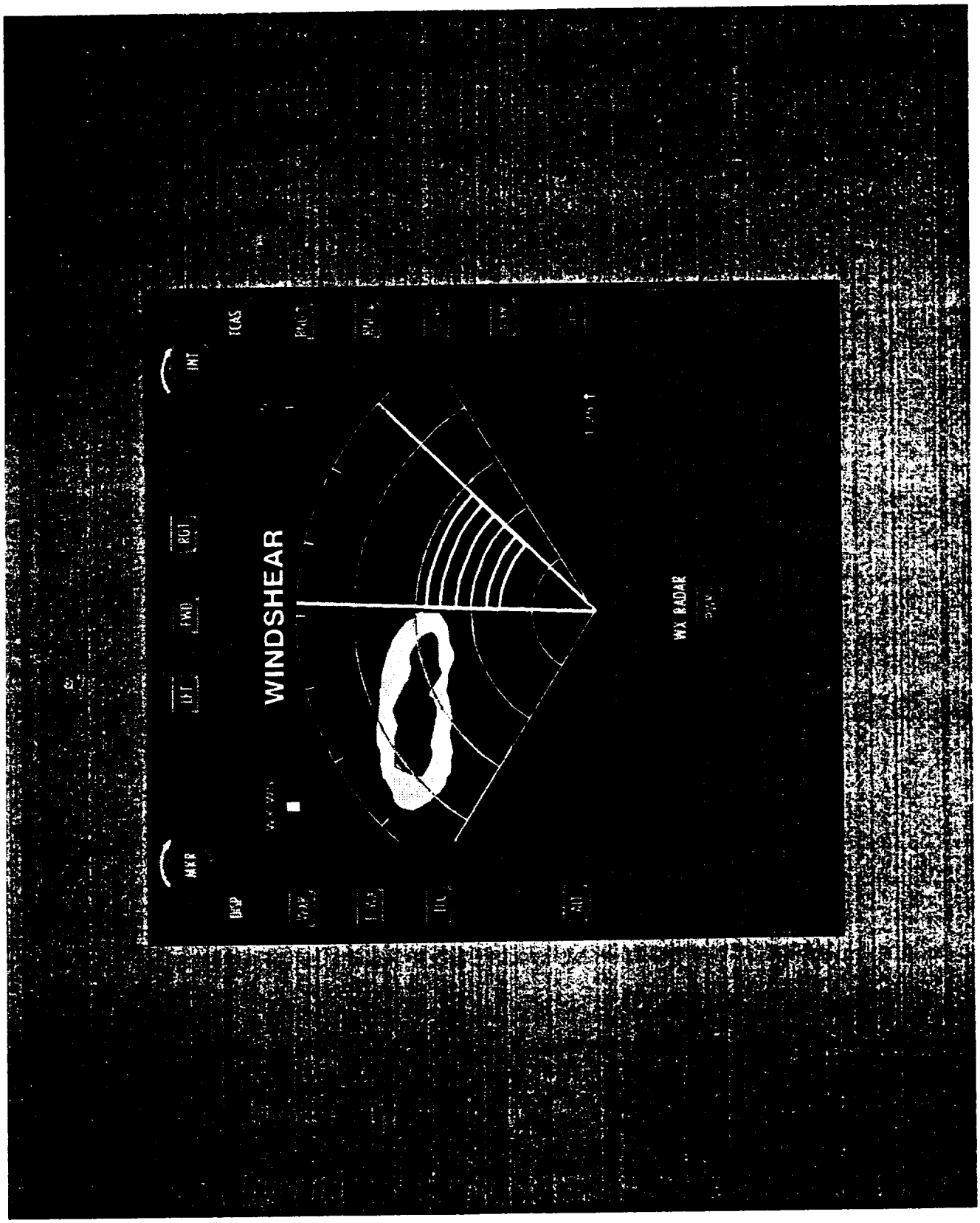

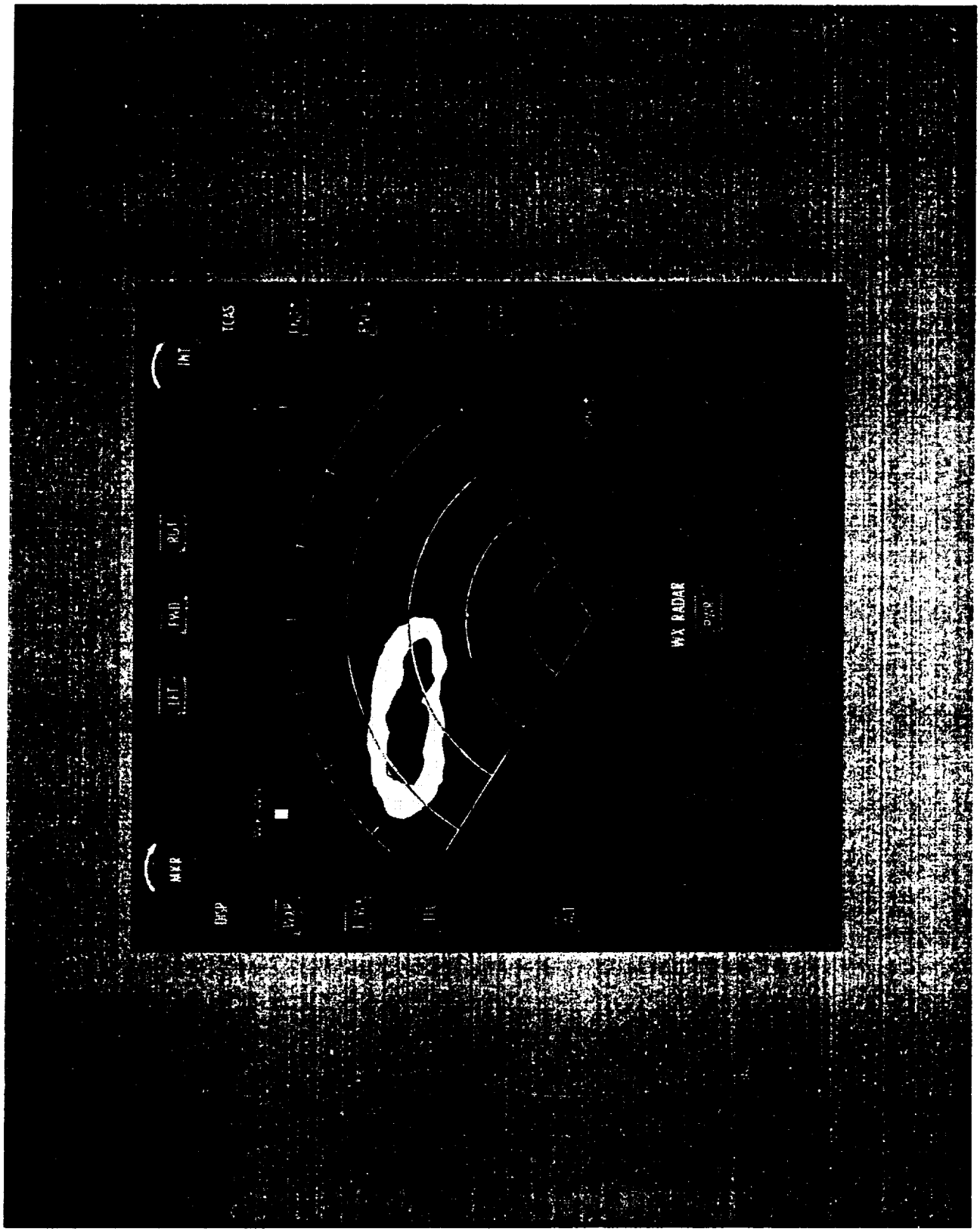

Airborne Doppler Radar Research at Rockwell International
Questions and Answers

Q: Roland Bowles (NASA Langley) - How did you estimate the downdraft, or did you estimate it in your total hazard calculation? Secondly: you post processed the airplane data through the In Situ algorithm; what did you think about the veracity of the algorithm?

Roy Robertson (Rockwell) - I will answer the second question first. Yes, we did post process the data. We collected the aircraft data from a different set of sources than what is on the B737. We had to piece together some of the In Situ inputs. The air data came from one source and the accelerometer data came from a different source, so we had to do a little work getting the filtering constant of the input data to agree. We also had some effort getting the angle of attack input calibrated. The algorithm seemed to have a fairly high sensitivity to angle of attack. Once we got those initial things worked out, we felt that the algorithm was doing very well. For downdraft estimation we used the first cut estimate that Dave Hinton had provided to the Lincoln Labs guys that had the altitude of the radar beam as a input parameter to the hazard factor calculation.

Q: Branimir Dulic (Transport Canada) - What is the price range and when will the system be in full operation, and the weight?

A: Roy Robertson (Rockwell International) - Price range? I am in engineering not marketing, so I would be stepping into some really deep problems if I said anything about that. Availability, we expect the system to be operational and finished with certification in 1993, and weight is roughly 30 pounds for the RT and something less than that for the antenna.