Docket No. SA-509

Exhibit No. 5-K

NATIONAL TRANSPORTATION SAFETY BOARD

Washington D.C.

MIT Lincoln Laboratory ASR-9 Study

ASR-9 SIX LEVEL WEATHER CHANNEL AND DOPPLER WEATHER RADAR

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LEXINGTON, MA

mew/pas/9/14/94

LINCOLN LABORATORY WEATHER SENSING GROUP
MAJOR PROGRAMS

- TERMINAL DOPPLER WEATHER RADAR (TDWR)
- AIRPORT SURVEILLANCE RADAR (ASR-9)
  - SIX-LEVEL WEATHER REFLECTIVITY CHANNEL
  - WIND SHEAR PROCESSOR (WSP)
- ENHANCED LOW LEVEL WIND SHEAR ALERT SYSTEM (LLWAS-III)
  - TDWR/LLWAS-III INTEGRATION
- INTEGRATED TERMINAL WEATHER SYSTEM (ITWS)

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OUTLINE

- ASR-9 SIX LEVEL WEATHER REFLECTIVITY CHANNEL
  - DESCRIPTION
  - TECHNICAL AND OPERATIONAL EVALUATIONS
  - SIMULATIONS FOR 2 JULY 1994 AT CLT
- FAA DOPPLER WEATHER DATA TECHNOLOGY
  - TDWR
  - ASR-9 WSP
  - ITWS

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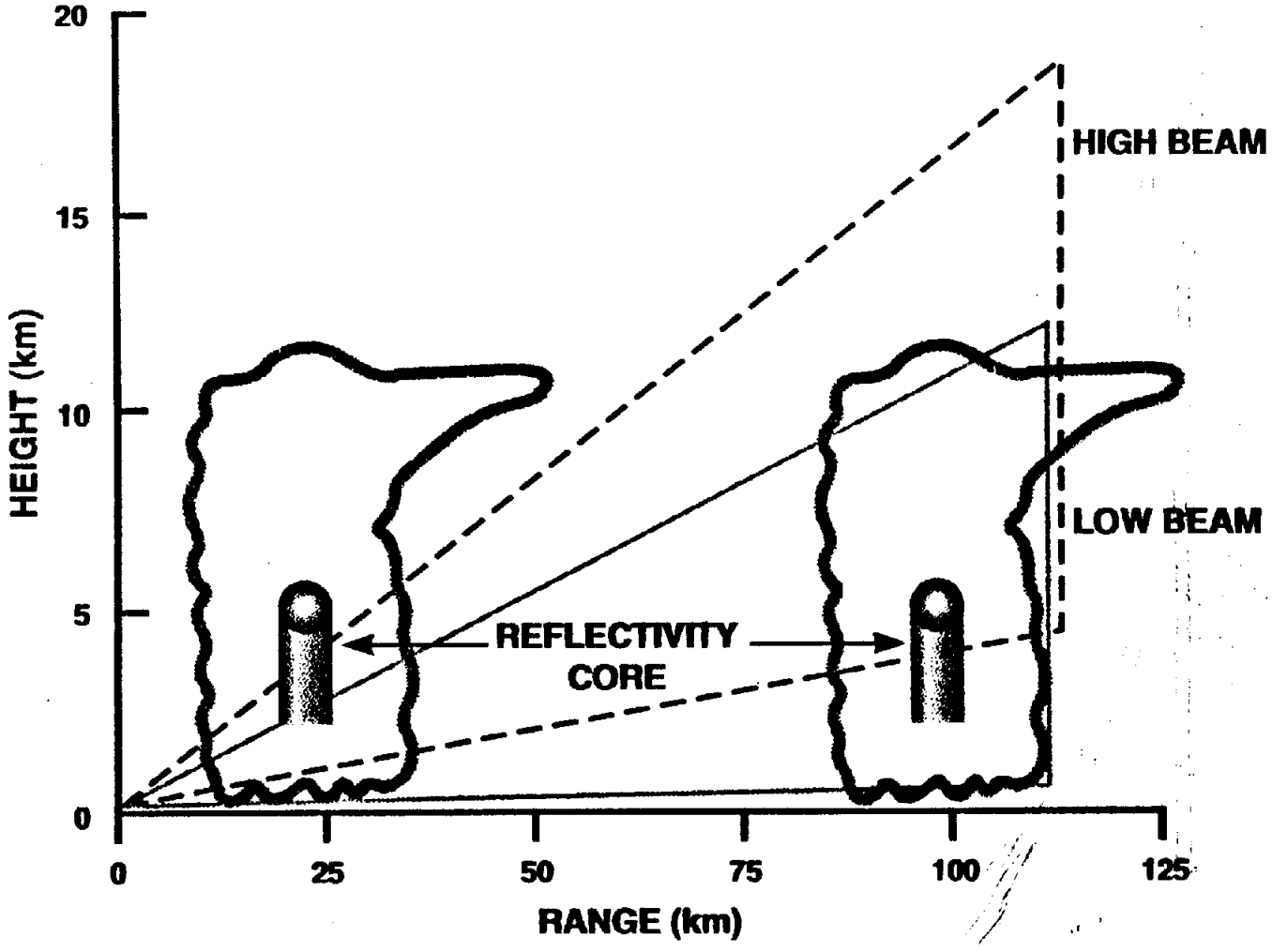
ASR-9 BEAM COVERAGE

ASR-9 BEAM COVERAGE

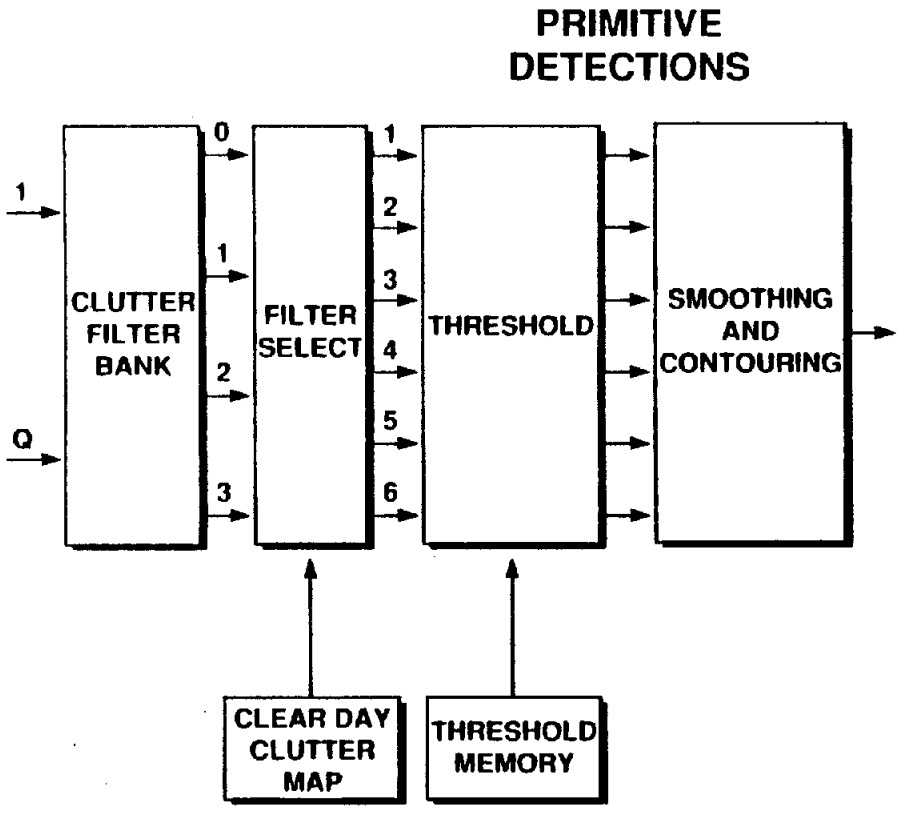


248190-1B

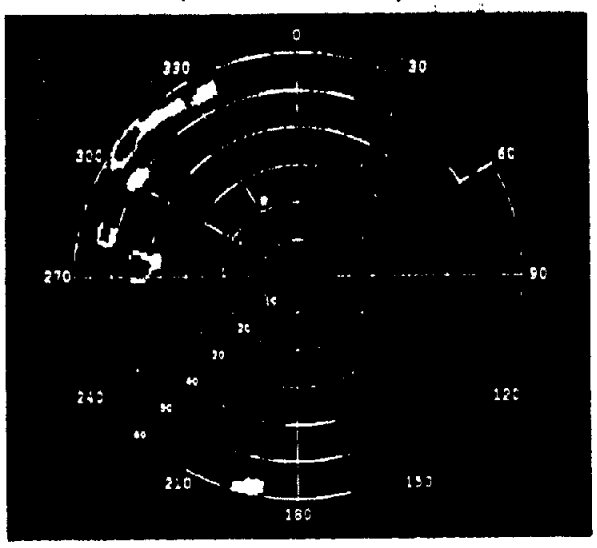
NWS STANDARD REFLECTIVITY LEVELS

LEVEL	REFLECTIVITY (dBZ)	RAINFALL CATEGORY
1	18-30	LIGHT
2	30-41	MODERATE
3	41-46	HEAVY
4	46-50	VERY HEAVY
5	50-57	INTENSE
6	>57	EXTREME

ASR-9 SIX-LEVEL WEATHER REFLECTIVITY CHANNEL



ARTS DISPLAY
(Level 2 And 5)



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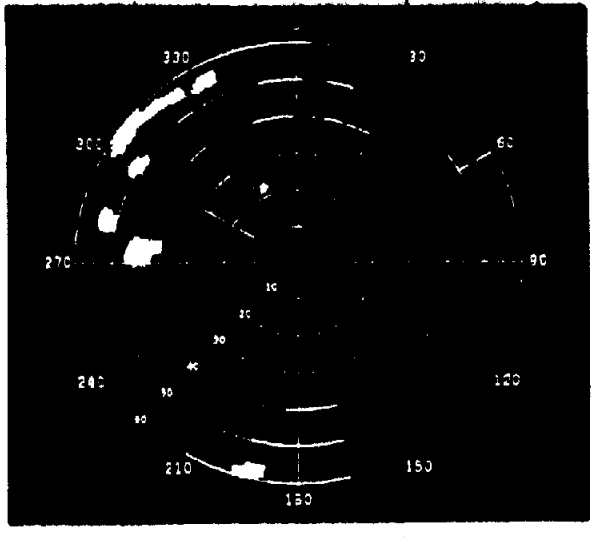

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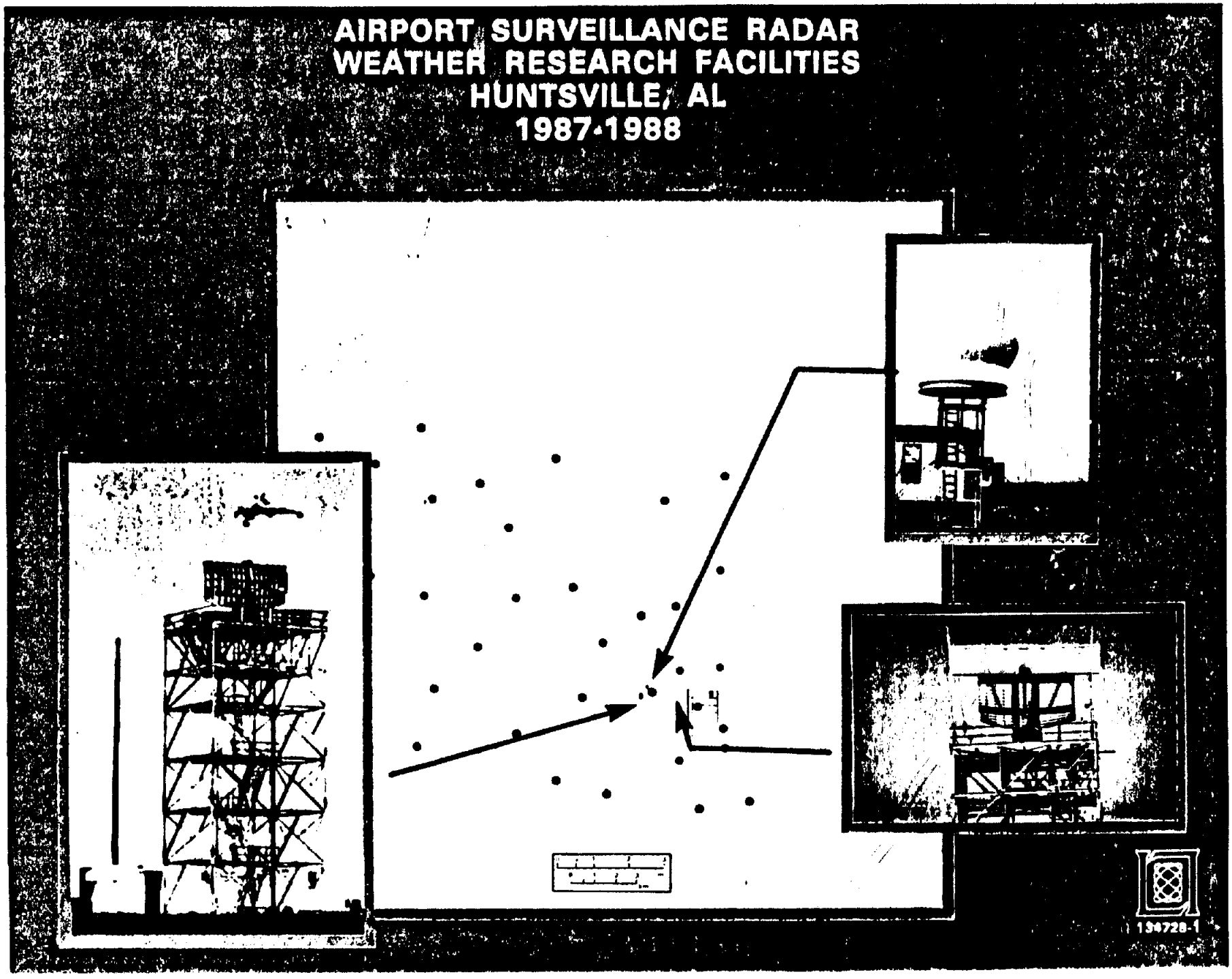
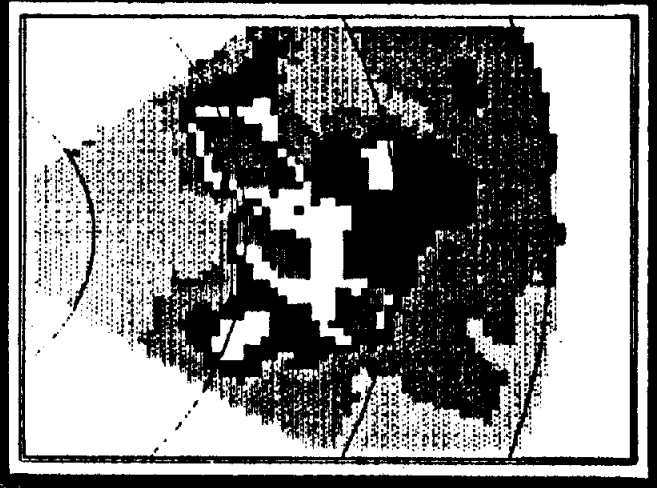

AIRPORT SURVEILLANCE RADAR
WEATHER RESEARCH FACILITIES
HUNTSVILLE, AL
1987-1988
136728-1

ASR-9 WEATHER CHANNEL EMULATION

ACTUAL ASR-9 REPORT



FAN BEAM EMULATION

PENCIL BEAM SIMULATION

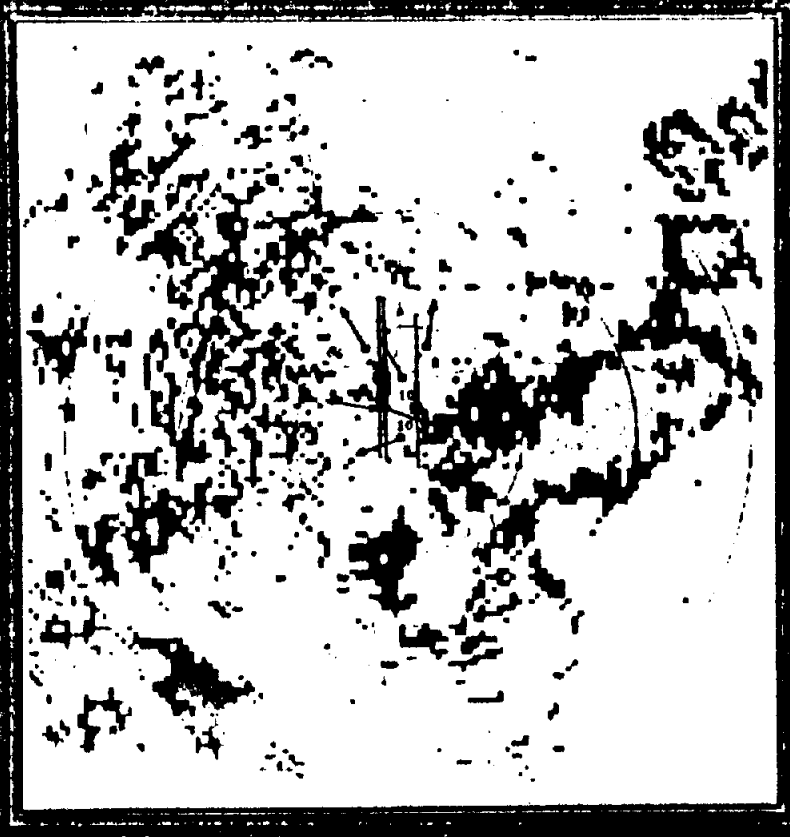
134224-1

RESULTS
Huntsville, 1988 ASR-9 Field Test

- Data analyzed from 19 weather events:
  - Air mass thunderstorms – 5 events
  - Stratiform precipitation – 2 events
  - Squall line – 4 events
  - Frontal – 8 events

- ASR-9 vs. Truth Radar Simulations
  - 97% Agreement Within One NWS Level
  - 79% of Levels Agreed Exactly

ANOMALOUS PROPAGATION CENSORING



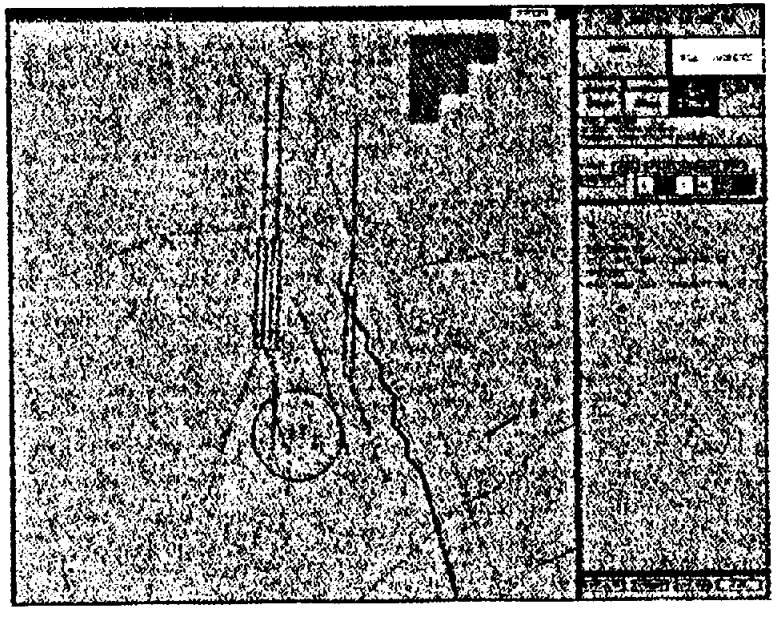
AP CENSOR OFF

AP CENSOR ON

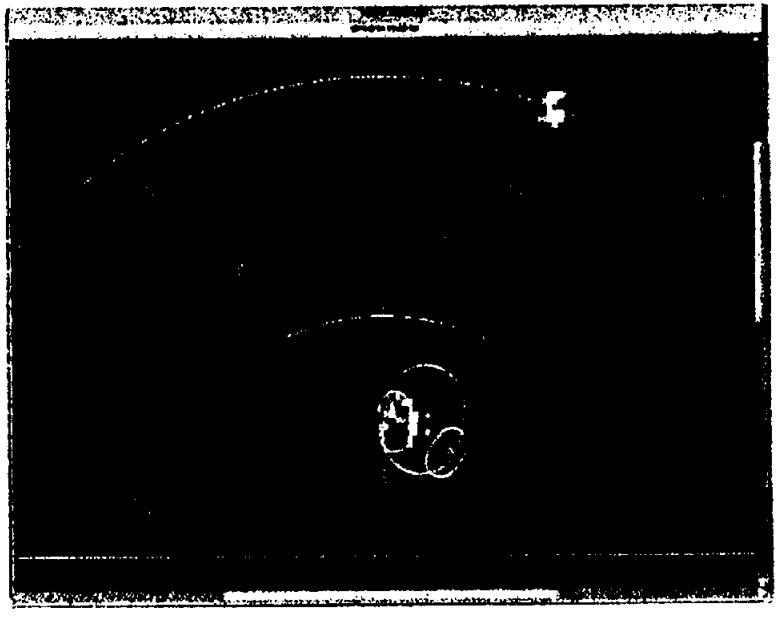
184505-1

STORM REFLECTIVITY MEASUREMENTS FROM ASR-9 WEATHER CHANNEL AND TDWR

ORLANDO, JULY 14, 19:53 Z



ASR-9



TDWR

247897-1P

United States General Accounting Office

GAO

Report to the Chairman, Committee on Science, Space, and Technology, House of Representatives

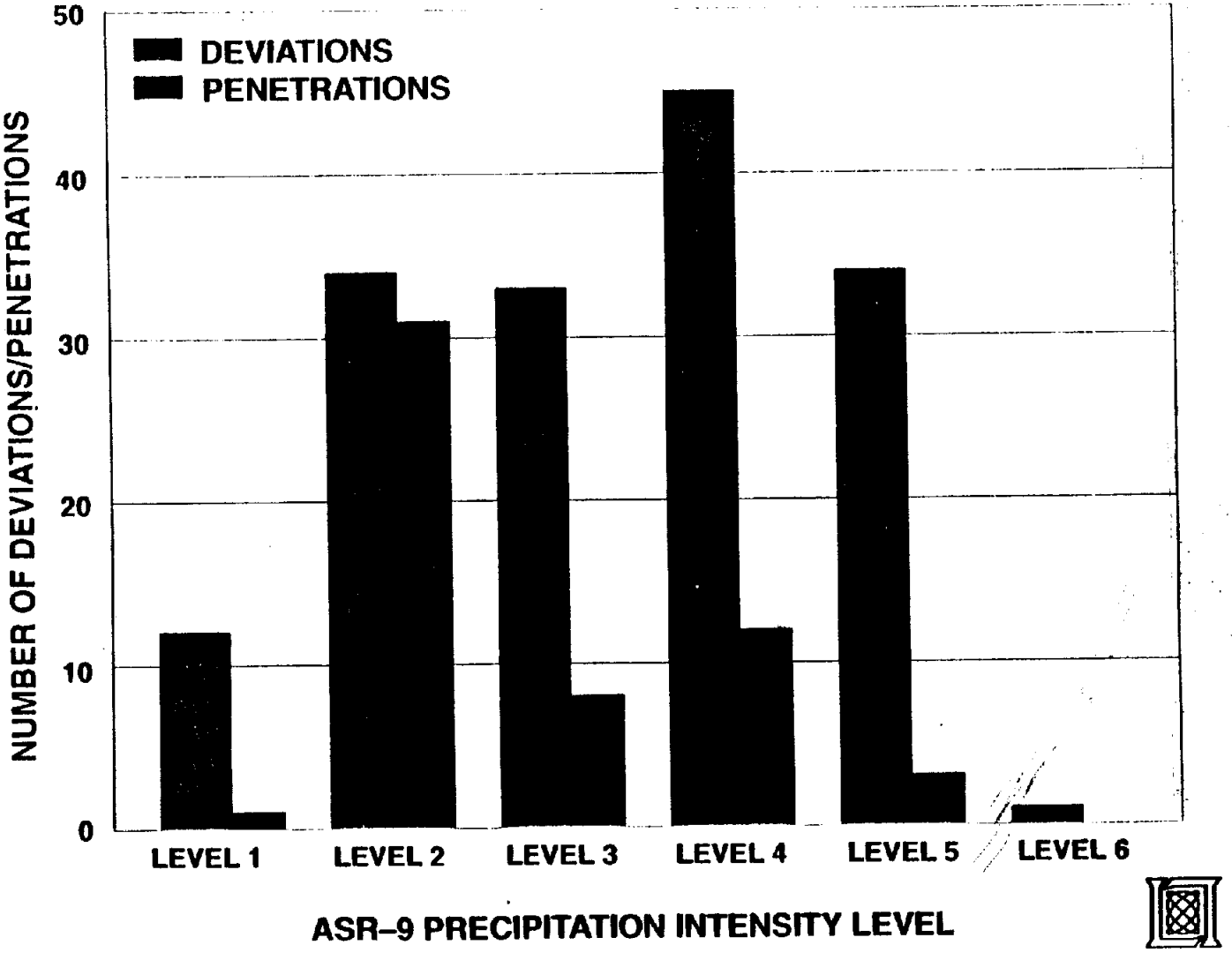
October 1989

AVIATION WEATHER

FAA Needs to Resolve Questions Involving the Use of New Radars

- **FAA has not established formal procedures for sending ASR-9 weather data from air traffic controllers to pilots, although the first radar is now operational and additional radars will soon be deployed. FAA believes that before implementing formal procedures, controllers need to experience basic changes in the system's precipitation detection capabilities. Moreover, a policy question regarding whether to route aircraft around storms using ASR-9 weather data will not be answered until FAA learns more about precipitation effects on aircraft and the work load effects on controllers.**

AIRCRAFT DEVIATIONS / PENETRATIONS
ORLANDO, FL



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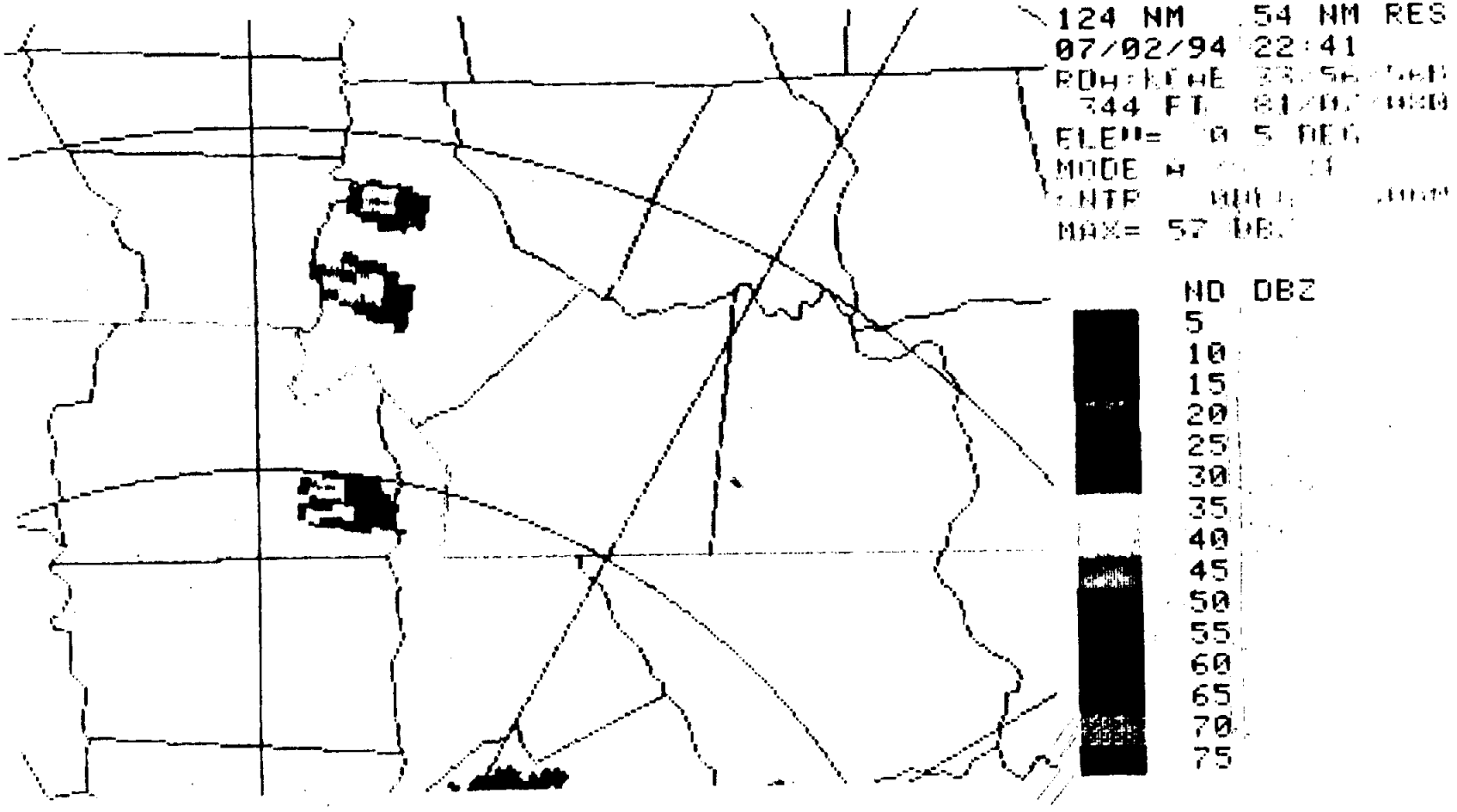
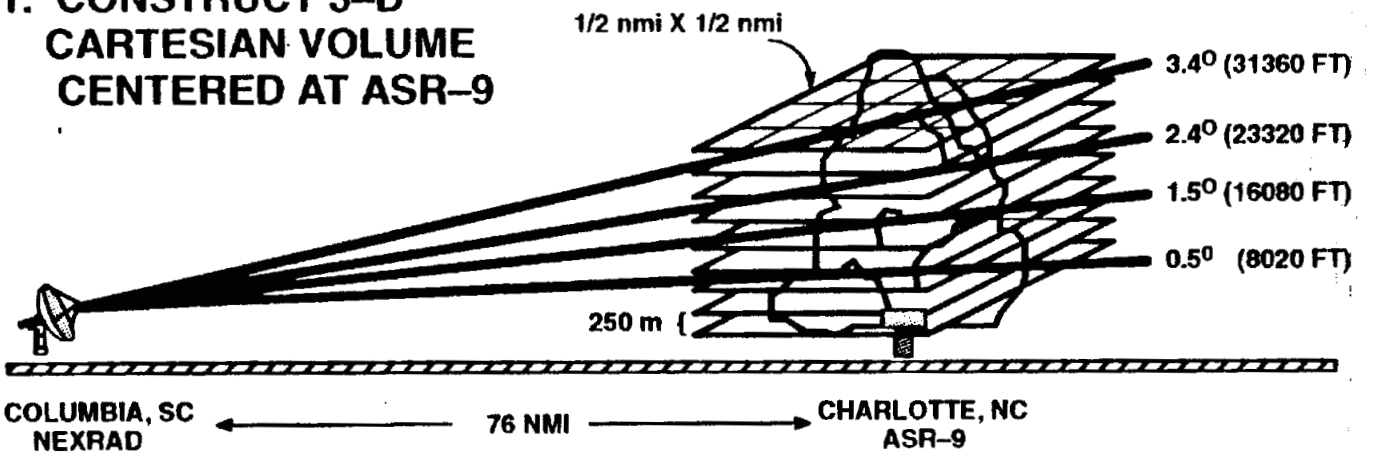
NEXRAD SURFACE SCAN AT TIME OF ACCIDENT

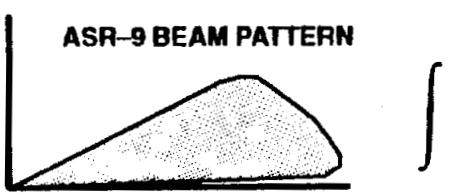


ASR–9 WEATHER CHANNEL SIMULATION

1. CONSTRUCT 3–D CARTESIAN VOLUME CENTERED AT ASR–9



2. VERTICAL INTEGRATION



3. CONVERT INTEGRATED DBZ TO NWS 6–LEVEL INTENSITY

4. TWO–STAGE SPATIAL SMOOTH

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SIMULATION LIMITATIONS

- NEXRAD DATA RESOLUTION
  - LOWEST BEAM CENTERED AT 2.4 KM
  - 2.5 KM VERTICAL RESOLUTION
  - 6 MINUTE VOLUME SCAN

- SIMULATION PERFORMED IN CARTESIAN COORDINATES TO FACILITATE DATA TRANSLATION INTO ASR-9 COORDINATE SYSTEM
  - ASR-9 PERFORMS SPATIAL SMOOTHING ON A RANGE-AZIMUTH COORDINATE GRID

- SIMULATION DOES NOT INCLUDE GROUND CLUTTER AND ASR-9 CLUTTER SUPPRESSION PROCESSING
  - POSSIBLE EFFECTS WOULD BE CENSORING OR DOWNWARDS BIAS IN REPORTED WEATHER LEVELS IN AREAS OF HEAVY GROUND CLUTTER

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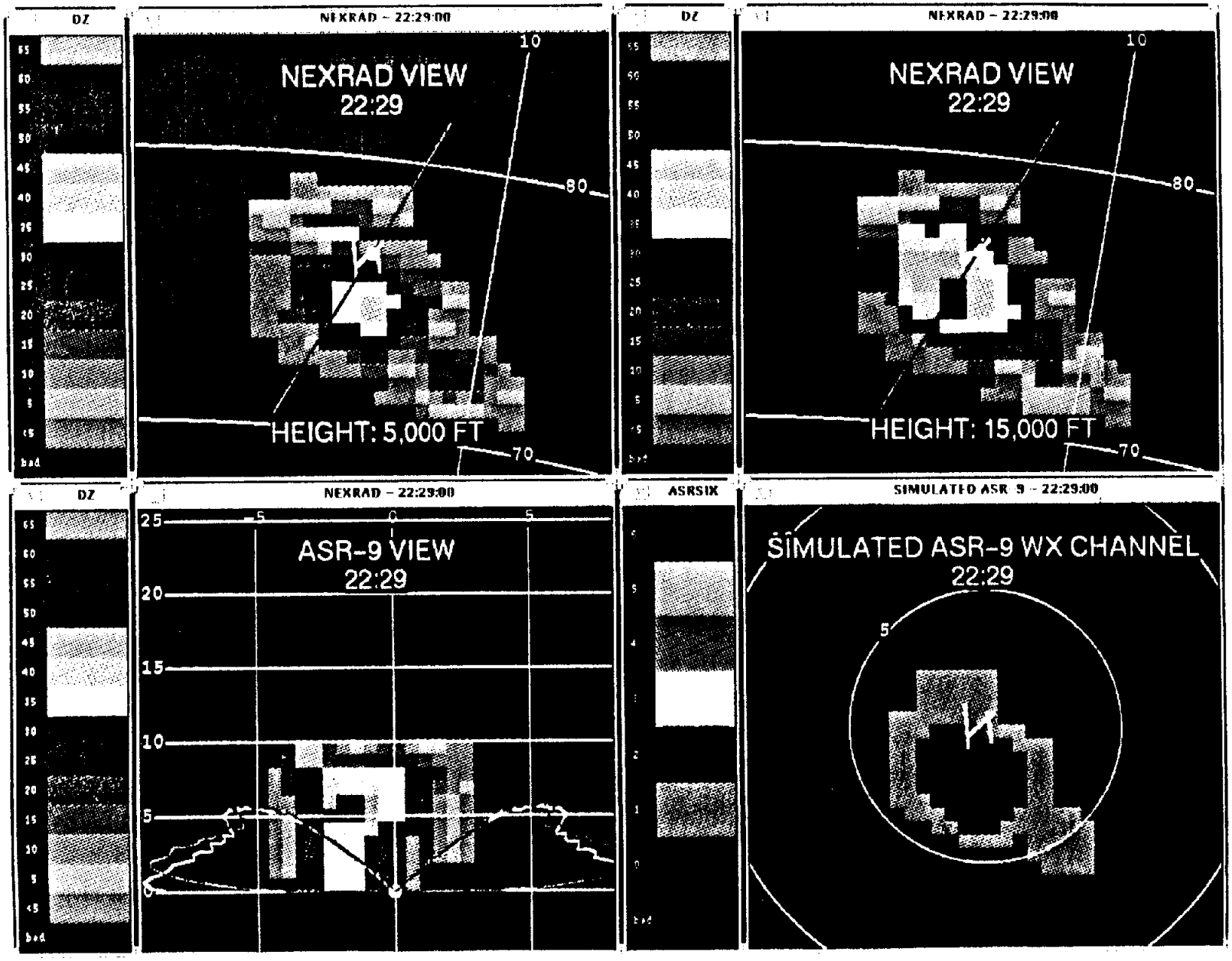
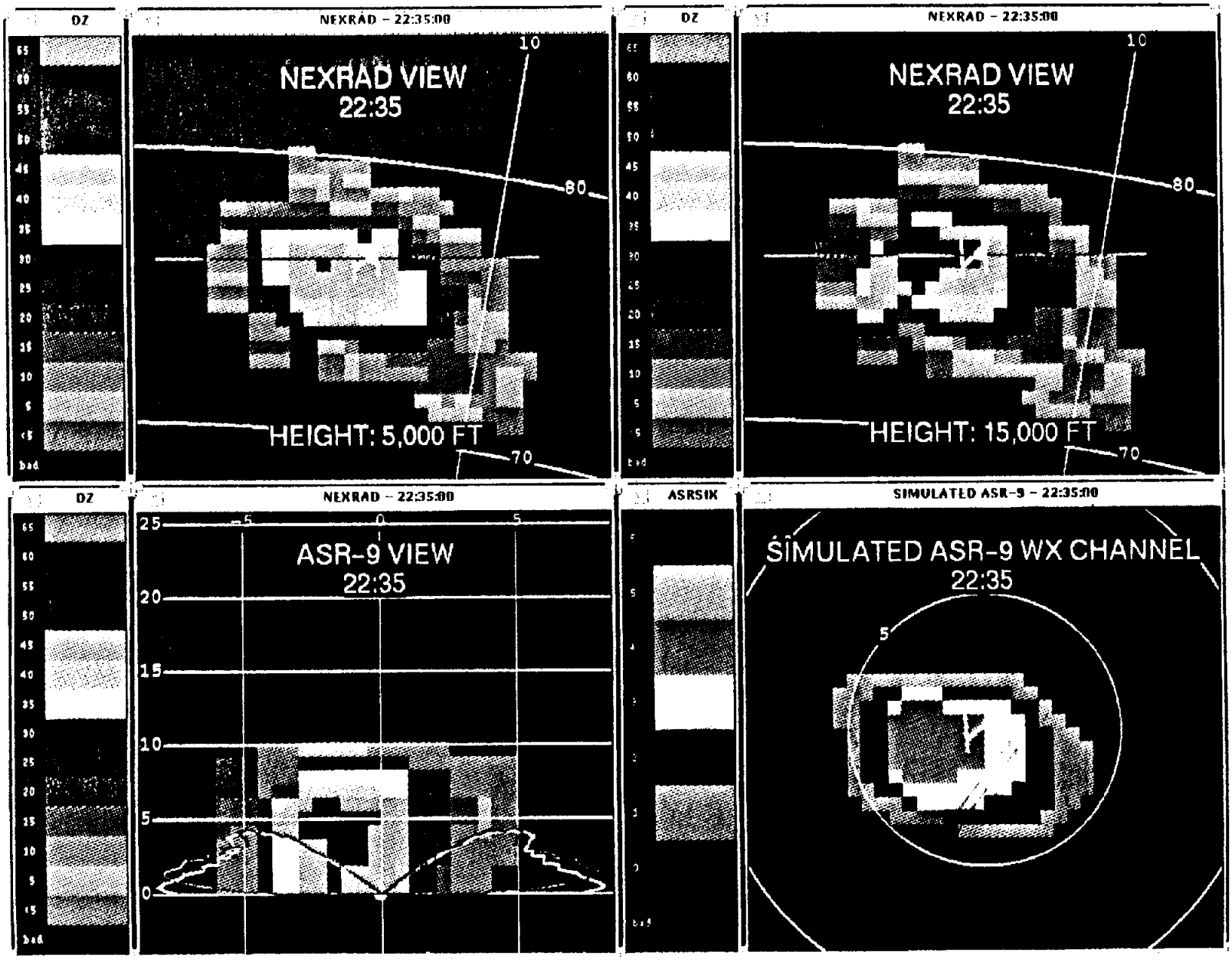
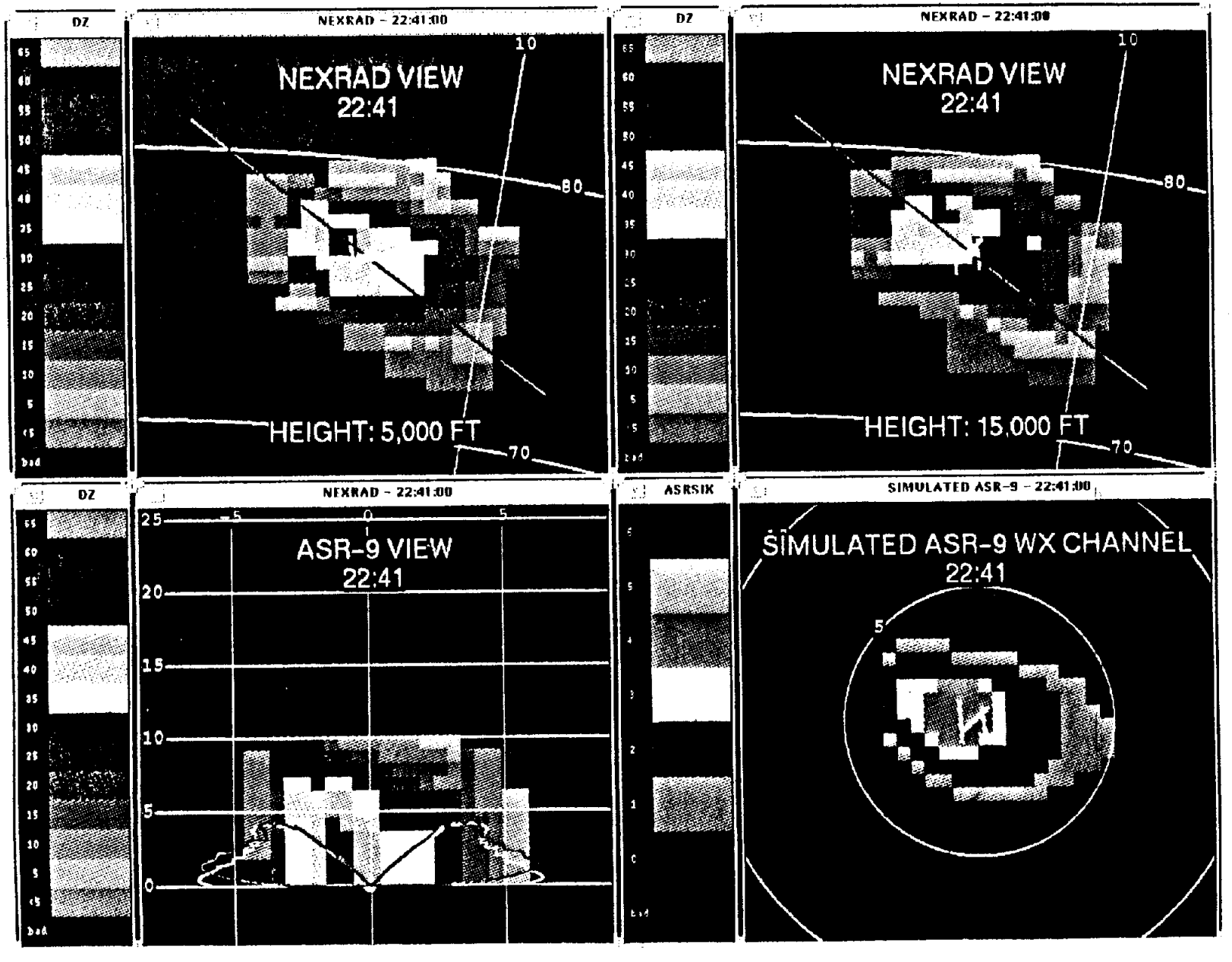
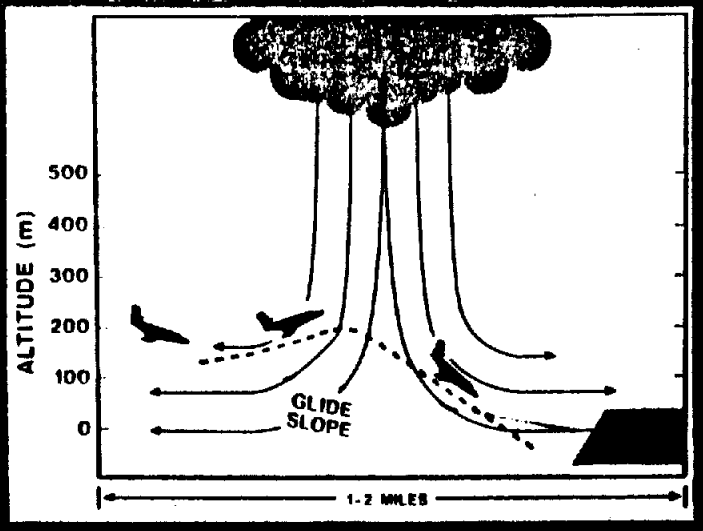

DZ
NEXRAD – 22:29:00
NEXRAD VIEW
22:29
HEIGHT: 5,000 FT
DZ
NEXRAD – 22:29:00
NEXRAD VIEW
22:29
HEIGHT: 15,000 FT
DZ
NEXRAD – 22:29:00
ASR-9 VIEW
22:29
ASRSIX
SIMULATED ASR-9 – 22:29:00
SIMULATED ASR-9 WX CHANNEL
22:29


DZ
NEXRAD – 22:35:00
NEXRAD VIEW
22:35
10
80
70
HEIGHT: 5,000 FT
DZ
NEXRAD – 22:35:00
NEXRAD VIEW
22:35
10
80
70
HEIGHT: 15,000 FT
DZ
NEXRAD – 22:35:00
ASR-9 VIEW
22:35
25
20
15
10
5
0
-5
0
5
ASRSIX
SIMULATED ASR-9 – 22:35:00
SIMULATED ASR-9 WX CHANNEL
22:35
5


DZ
NEXRAD – 22:41:00
NEXRAD VIEW
22:41
HEIGHT: 5,000 FT
DZ
NEXRAD – 22:41:00
NEXRAD VIEW
22:41
HEIGHT: 15,000 FT
DZ
NEXRAD – 22:41:00
ASR-9 VIEW
22:41
ASRSIK
SIMULATED ASR-9 – 22:41:00
SIMULATED ASR-9 WX CHANNEL
22:41

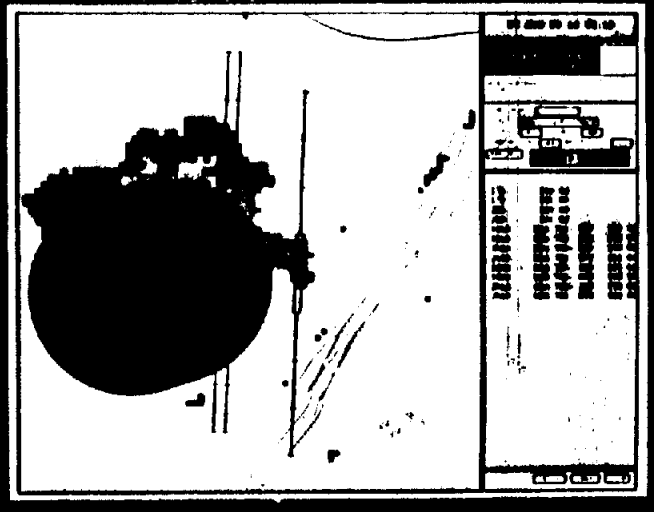
TERMINAL DOPPLER WEATHER RADAR



AIRCRAFT ENCOUNTER WITH A MICROBURST

RADIAL VELOCITY IMAGE

TDWR TEST BED



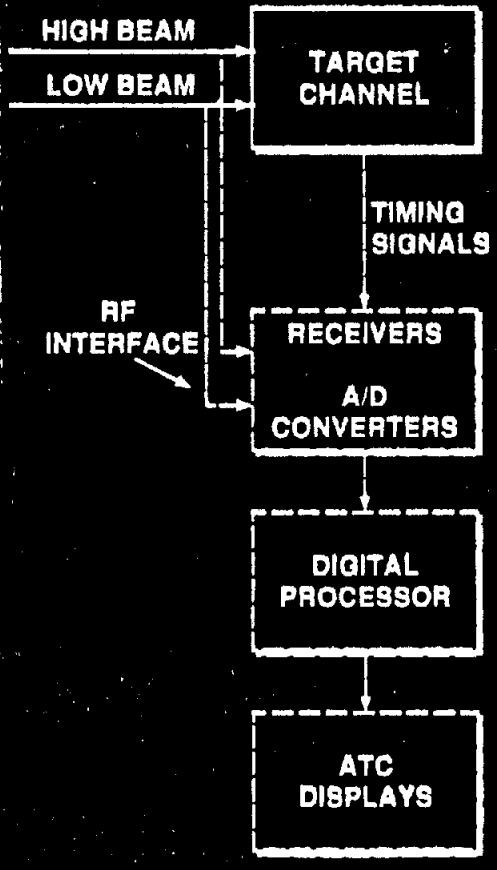
SUPERVISOR DISPLAY

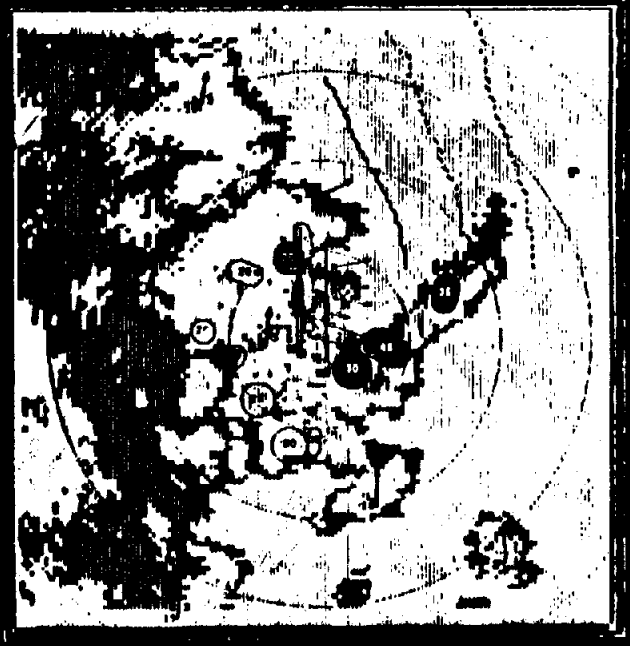
222010-1

TDWR MICROBURST DETECTION PERFORMANCE

		PROBABILITY OF DETECTION	PROBABILITY OF FALSE ALARM
HUNTSVILLE '86	ΔV > 30 KT	1.0	0.05
	ΔV > 20 KT	0.89	
DENVER '87-'88	ΔV > 30 KT	0.98	0.04
	ΔV > 20 KT	0.86	
KANSAS CITY '89	ΔV > 30 KT	0.97	0.09
	ΔV > 20 KT	0.94	
ORLANDO '90	ΔV > 30 KT	1.0	0.02
	ΔV > 20 KT	0.93	
ORLANDO '91	ΔV > 30 KT	0.98	0.02
	ΔV > 20 KT	0.94	
ORLANDO '92	ΔV > 30 KT	0.99	0.06
	ΔV > 20 KT	0.97	

ASR-9 WIND SHEAR PROCESSOR





212028-1

ASR-9 WSP MICROBURST DETECTION PERFORMANCE

		PROBABILITY OF DETECTION	PROBABILITY OF FALSE ALARM
ORLANDO '90	$\Delta V > 30$ kt	0.97	0.10
	$\Delta V > 20$ kt	0.84	
ORLANDO '91	$\Delta V > 30$ kt	0.98	0.07
	$\Delta V > 20$ kt	0.82	
ORLANDO '92	$\Delta V > 30$ kt	0.96	0.10
	$\Delta V > 20$ kt	0.87	
ALBUQUERQUE	$\Delta V > 30$ kt	0.88	0.13
	$\Delta V > 20$ kt	0.68	

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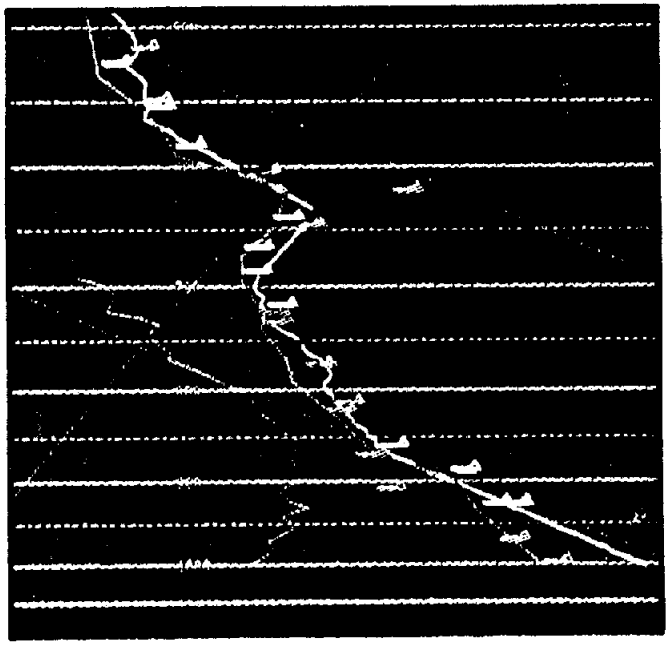
OVERVIEW OF MICROBURST PREDICTION ALGORITHM

VERTICAL ACCELERATION OF DOWNDRAFT = EVAPORATION + MELTING + WATER LOADING + PRESSURE FORCES

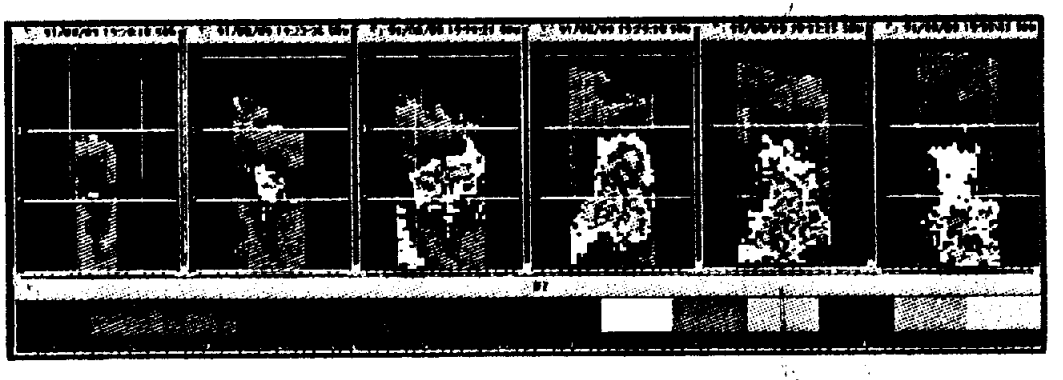
[RELATE TO OUTFLOW VIA CONTINUITY]

ESTIMATION OF SOUNDING PARAMETERS



- USE MDCRS & ASOS & SA TEMPERATURE DATA
- DERIVE TIME & SPACE WEIGHTED PROFILE
- COMPUTE MEAN LAPSE RATE & FREEZING LEVEL

DETECTION OF STORM GROWTH & DOWNDRAFT DEVELOPMENT



- LOOK FOR GROWTH (e.g., INCREASE IN VIL)
- LOOK FOR DOWNDRAFT (e.g., DROP IN CENTER OF MASS)
- ESTIMATE OUTFLOW STRENGTH USING SOUNDING
- ESTIMATE TIMING OF MICROBURST ONSET
- MAKE PREDICTIONS (MERGE W/ DETECTIONS FOR DISPLAY)
- RUN FEEDBACK (COMPARE DETECTIONS & PREDICTIONS)

SUMMARY

1.) FAA/LINCOLN LABORATORY EVALUATIONS OF ASR-9 SIX LEVEL WEATHER CHANNEL

- HUNTSVILLE OT&E VALIDATED THAT WEATHER REFLECTIVITY DEPICTION IS ACCURATE
- TWO SIGNIFICANT TECHNICAL ISSUES IDENTIFIED IN SUBSEQUENT FIELD PROGRAMS
  - ANOMALOUS PROPAGATION (Will be remedied with implementation of WSP and ITWS)
  - INTERMITTENT SUPPRESSION OF WEATHER RETURNS AT VERY CLOSE RANGE
- PROCEDURES FOR OPERATIONAL USAGE NOT WELL DEFINED

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SUMMARY (Continued)

2.) ASR-9 WEATHER CHANNEL SIMULATION FOR CLT ON 2 JULY 1994

(NEXRAD volume scans beginning at 22:29, 22:36 and 22:41)

- INDICATED MAXIMUM WEATHER LEVEL INCREASES FROM LEVEL 2 TO LEVEL 4 AS HIGH REFLECTIVITY CORE DROPS INTO BEAM
- INDICATED CENTROID OF CELL MOVES NORTHWARDS FROM 3 KM SOUTH OF AIRPORT TO A POSITION LESS THAN 1 KM WEST OF AIRPORT CENTER
  (Average speed 4 m/s or 8 kts)
- DESCENDING REFLECTIVITY CORE QUALITATIVELY CONSISTENT WITH THE DEVELOPMENT OF WET MICROBURST AT CLT

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SUMMARY (continued)

3.) DOPPLER RADAR TECHNOLOGY

- TDWR DEPLOYMENTS IN PROGRESS (Large airports)
- ASR-9 WSP DEPLOYMENTS PLANNED CIRCA 2000 (Second tier airports)
- ITWS DEPLOYMENTS PLANNED (Circa 2000)
  - WILL PROVIDE CAPABILITY FOR PREDICTIONS OF MICROBURST ~ 2 MINUTES IN ADVANCE OF ONSET

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PRESSURE (MB)	TEMPER-ATURE (C)	DEWPOINT (C)	U (M/S)	V (M/S)
327.74	-27.46	-43.60	5.73	-6.32
315.25	-29.71	-45.25	5.45	-6.16
302.95	-32.08	-46.93	5.34	-5.95
290.84	-34.56	-48.61	5.52	-6.08
278.93	-37.10	-50.32	6.02	-6.66
267.22	-39.68	-52.10	6.39	-7.31
255.73	-42.25	-53.98	6.02	-7.49
244.45	-44.85	-55.93	4.96	-7.03
233.43	-46.83	-57.57	4.96	-7.03