DOCKET NO.: SA-517
EXHIBIT NO. 13D

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

DON BATEMAN WITNESS PRESENTATION
(41 Pages)

Guam B747

NTSB Public Hearing

Don Bateman

Purpose Of Ground Proximty Warning Systems (GPWS)

Provide pilot with timely visual and aural alert-warnings for inadvertent flight into terrain using existing aircraft sensors such as the downward looking radio altimeter , air data signals, and glideslope deviation.

Airline Experience With GPWS

- **GPWS Installed on Over 12,500 Jet Aircraft**

  Approx. **100** Not Equipped

- **1975 to 1997**

  125 Million departures in the U.S.&Canada

  230 Million departures World Wide

- **U.S. & Canada CFIT Risk**

  Lowered from 0.85 to 0.03 per Million departures or 28 Times

  It Presently Remains at 0.44 for FAR 129 Operations

Ground Proximty Warning System (GPWS)

- **Input Signals:**

  Radio Altimeter

  -Descent Rate /Airspeed

  -Landing Gear Position

  -Landing Flap Position

  -Glideslope

  -Radio Altitude Setting

(4)

GPWS (cont'd)

Outputs Visual & Aural

Soft Alerts: *"sinkrate' 'don't sink'*

'too low-terrain' 'glideslope'

Hard Warning: *'Terrain!' 'Pull Up!'*

Advisories: *'1000' '500' '100' etc*

(67)

Limitations Of GPWS

- Short Warnings for Flight Into Precipitous Terrain
- No Alert or Warning for Stable Flight Into Terrain, When in Full Landing Configuration, and No Glideslope Signal
- Altitude Callouts are Referenced to Altitude Above Ground, Not Runway.

GPWS Regulatory Requirements

- GPWS is Required on all U.S. Aircraft With 10 Passenger Seats or more Operating Under FAR 121,125, and 135
- GPWS is Not Required For Foreign Aircraft Operating Into Or Out of the U.S. under FAR 129. However, ICAO under Annex 6, Recommends that All States carry an Operating GPWS and most, States including South Korea ,Comply.

12 CFIT Accidents for FAR 121/129 Operators 1985 to 1997 (12 Years)

1997	Agana, Guam	B747-300	229 Fatalities
1996	Lima, Peru	DC-8/72	-----
1995	Cali,Columbia	B757-200	165 Fatalities
1995	Windsor Locks	MD-80	-----
1995	San Salvador	B737-200	65 Fatalities
1990	Unakaleet, Alaska	B737-200	----
1989	Kuala Lumpur	B747-100	4 Fatalities
1989	Santa Maria, Azores	B707-300	144 Fatalities
1989	Tegucigalpa, Honduros	B727-200	131 Fatalities
1989	Paramaribo, Suriname	DC-8/62	170 Fatalities
1987	Kansas City	B707-300	4 Fatalities
1985	La Paz, Bolivia	B727-200	29 Fatalities

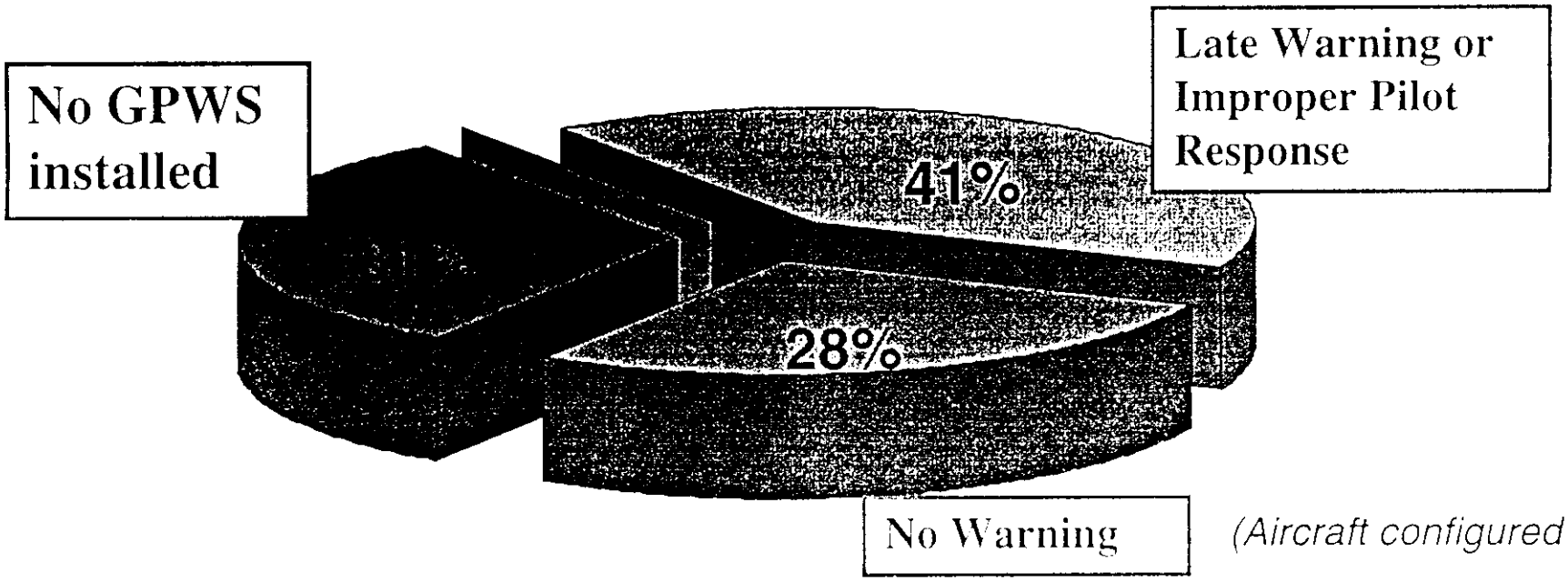
1997 Airline CFIT Losses
Western Built Jet Aircraft

- Agana, Guam B747 230 fatalities
- Medan, Indonesia A300 234 fatalities
- Sylhet, Bangladesh F28 No fatalities

9

COMMERCIAL JET AIRCRAFT ACCIDENTS

1988 - 1995



EGPWS Design Requirements were based on addressing GPWS weaknesses while maintaining GPWS safety benefits

Purpose Of Enhanced GPWS

- Provide the pilot with improved situational awareness of significant terrain or obstacles with relationship to the aircraft
- Provide timely alert for flight into preciptous terrain or flight into terrain or water short of the runway end
- Utilize existing sensors such as the FMS-IRS or GPS,and using the existing cockpit Weather Radar or EFIS Map Displays.

Enhanced GPWS

Input Signals

- Same signals as GPWS
- Position data FMS/IRSor GPS
-Track, Heading, Ground Speed
-Altitude MSL
- Display Range

Colour Display

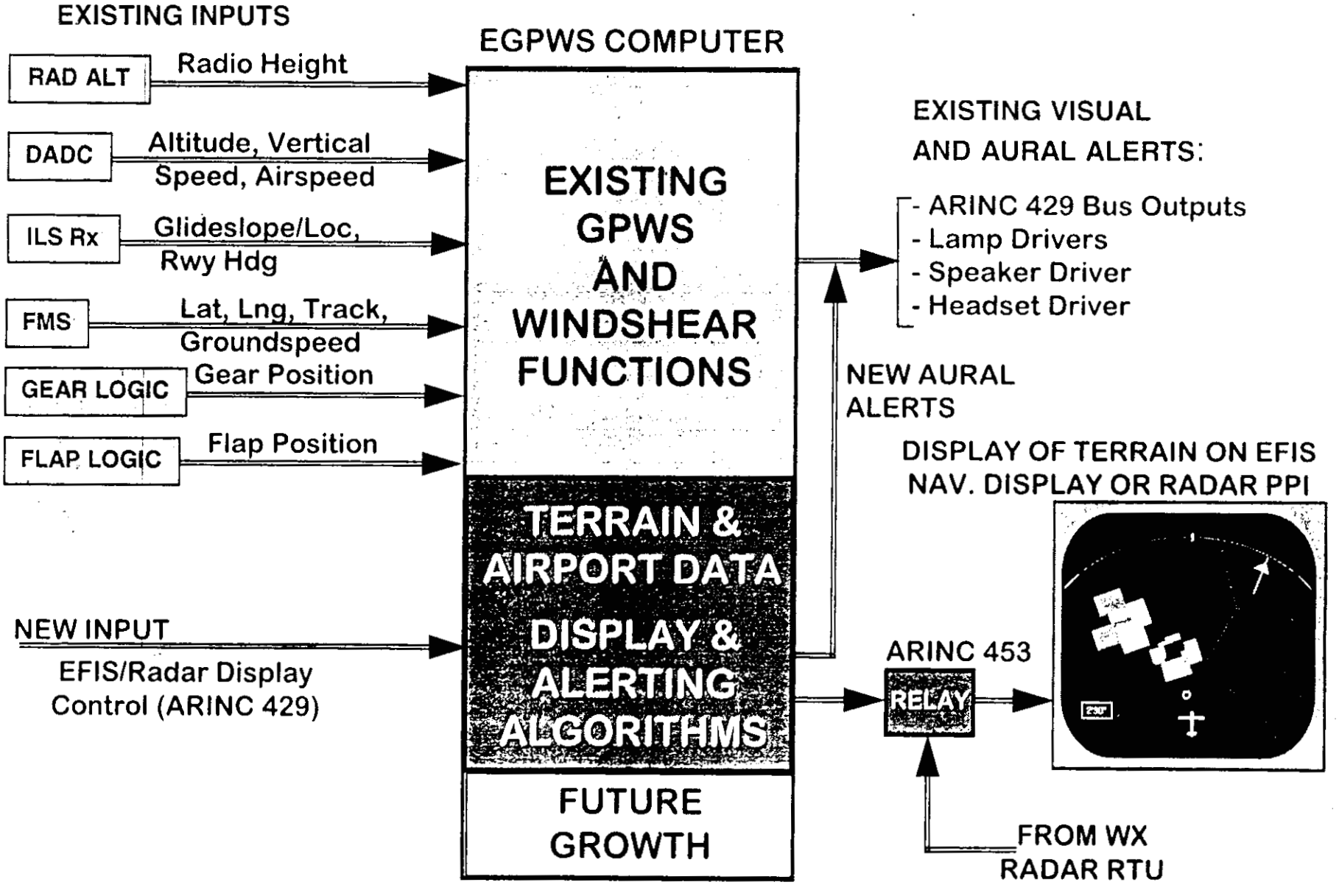
- EFIS or Weather Radar

EGPWS (con'd)

World Wide Data

- Airport Runway Ends
- Terrain Data
- Man Made Obstacles

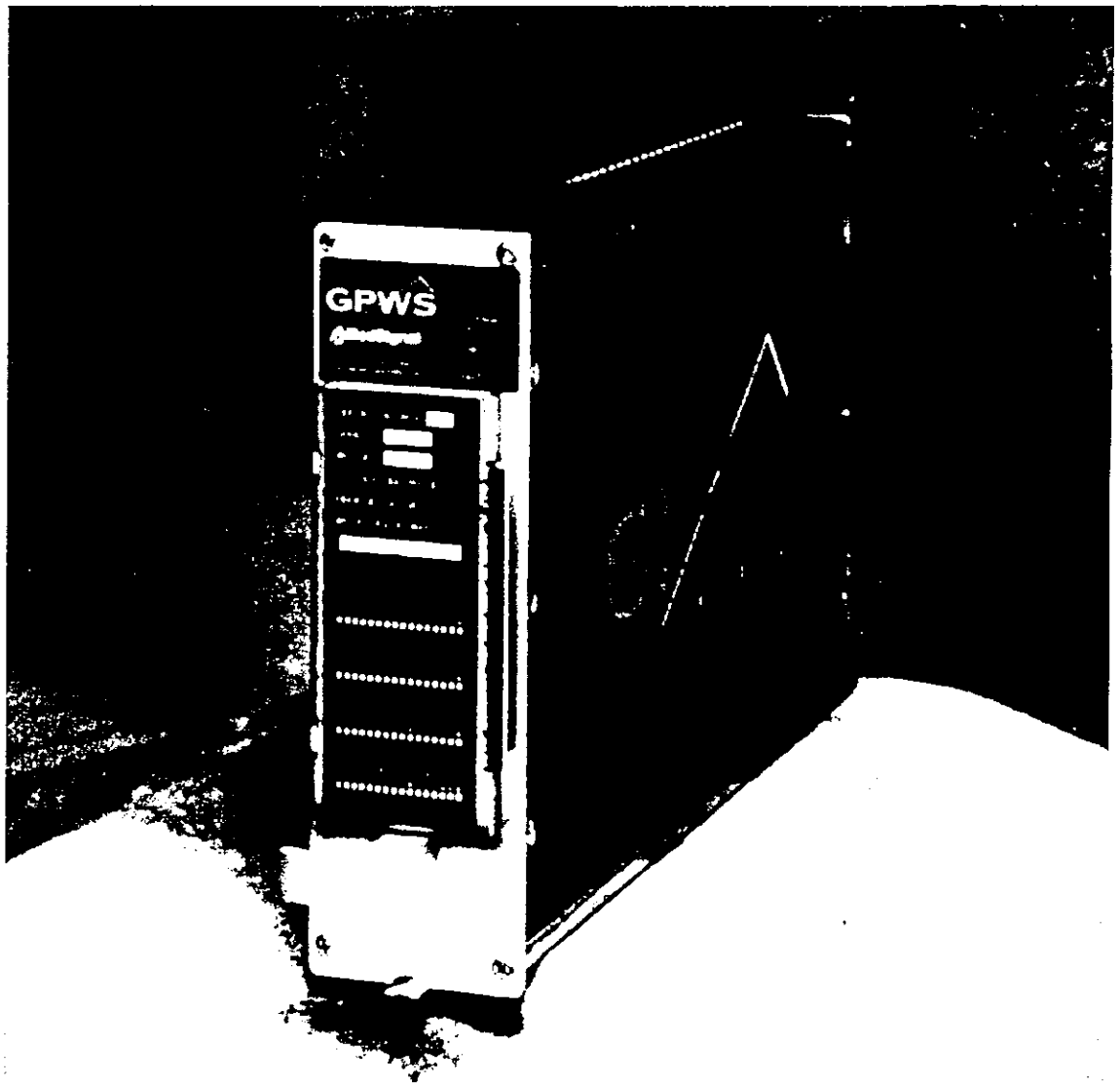
EGPWS SYSTEM

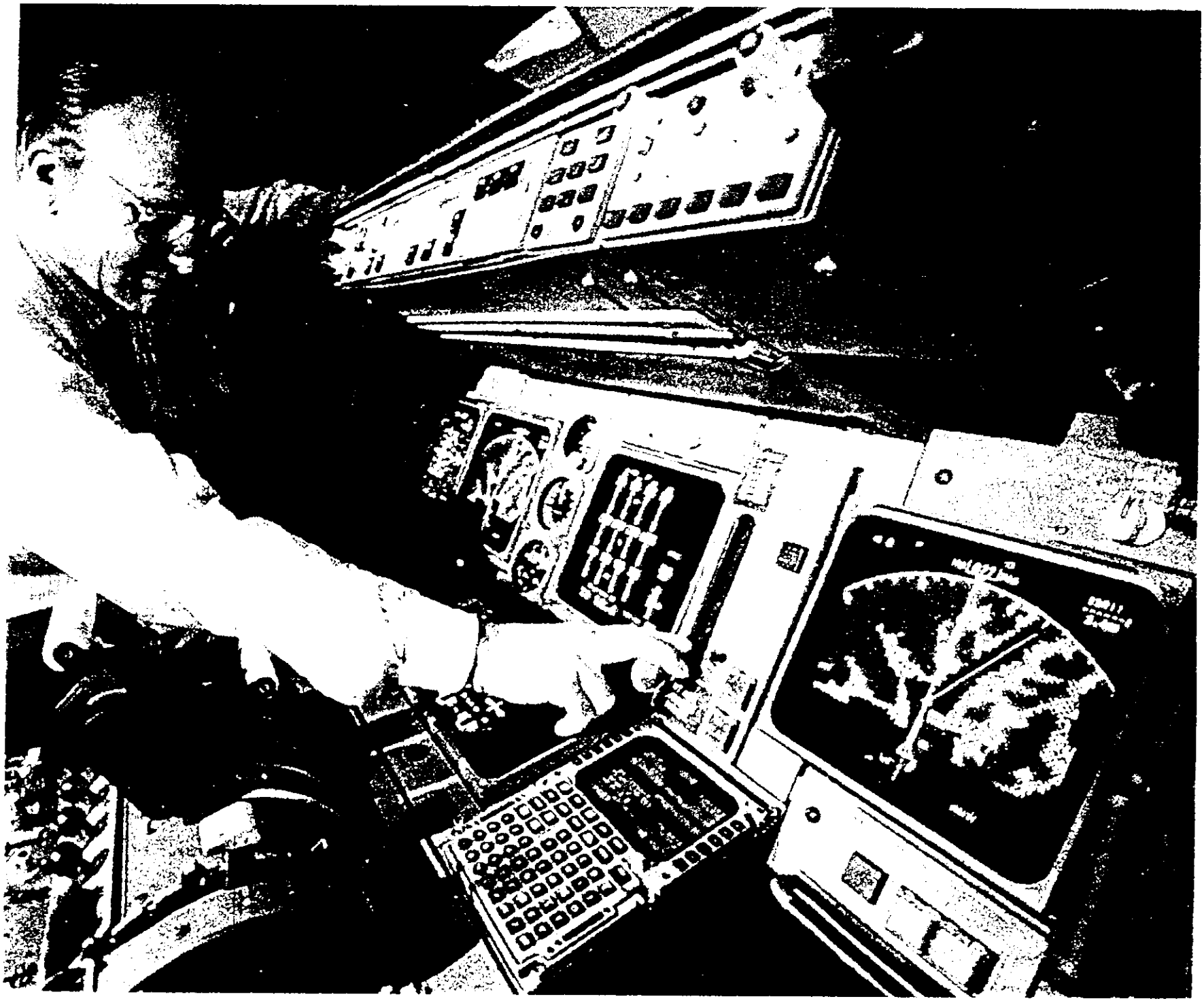


AlliedSignal

ENHANCED GPWS

- SAME FORM FACTOR AS EXISTING GPWS.
- UTILIZES EXISTING PROVISIONS
- EXISTING GPWS FUNCTIONS MAINTAINED/IMPROVED
- DATABASE: PCMCIA ACCESSABLE

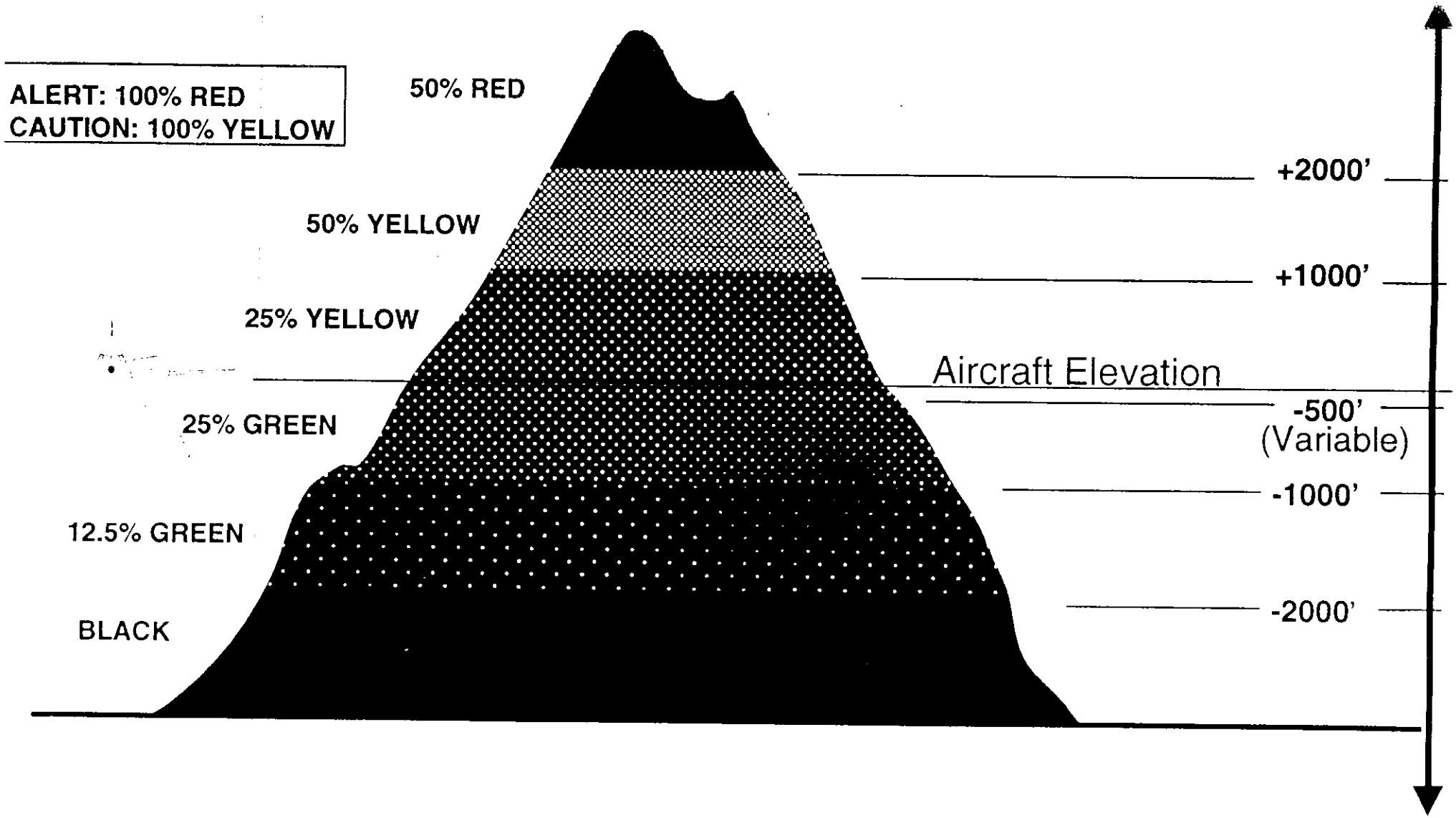




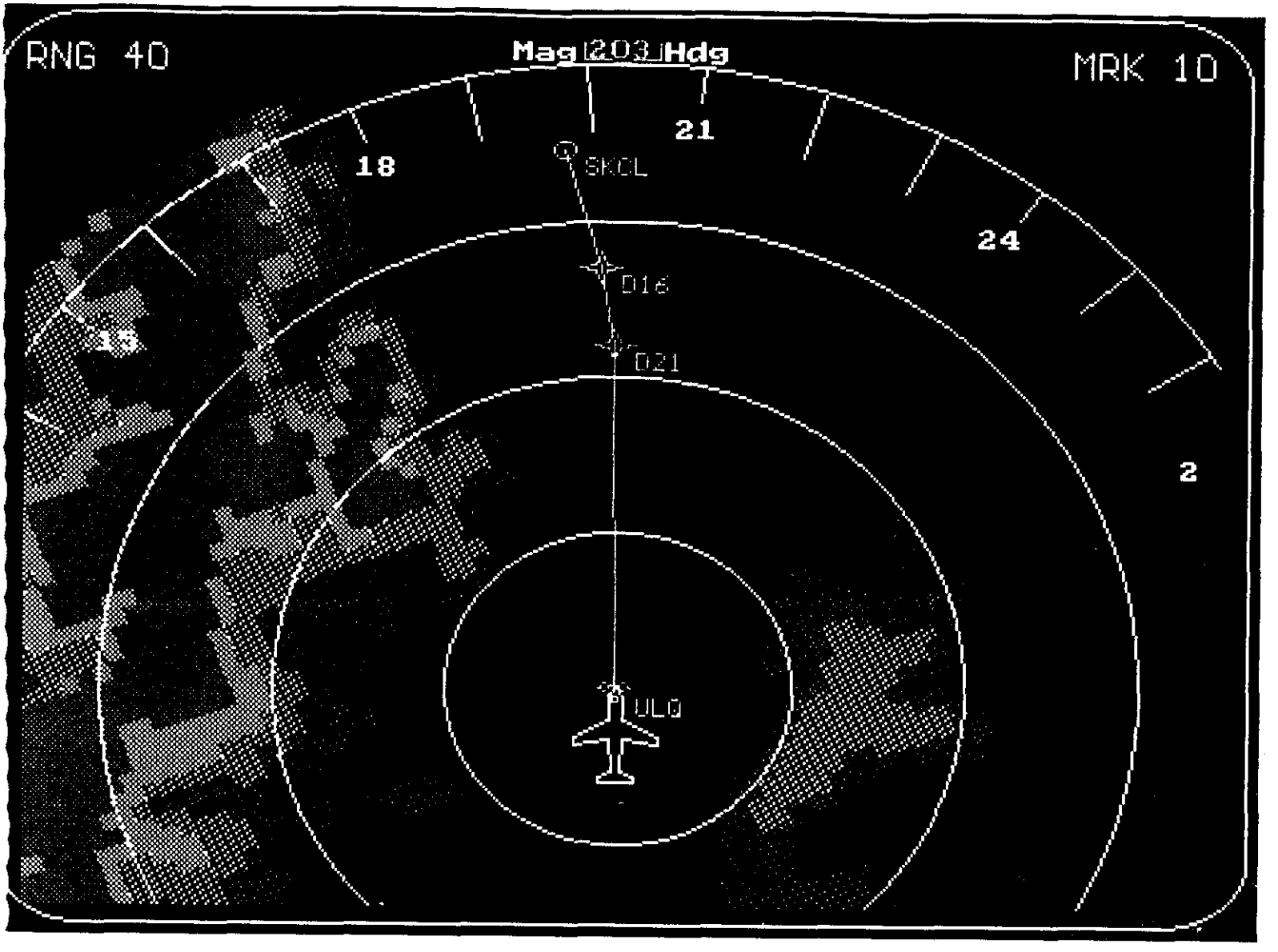
AlliedSigna

EGPWS DISPLAY COLOR CODING

(SIMPLIFIED)



AlliedSign



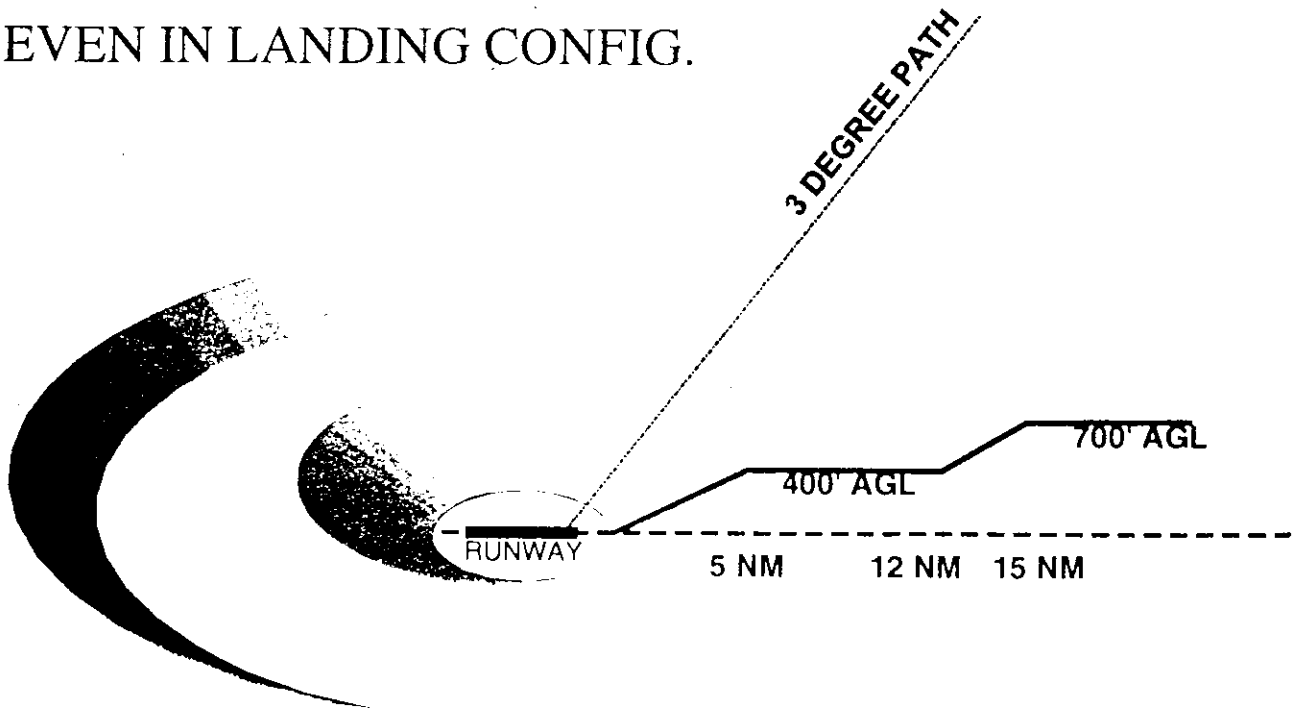
EGPWS TERRAIN SITUATIONAL DISPLAY

NORMAL APROACH (VORDME 19)
TO CALI, COLUMBIA

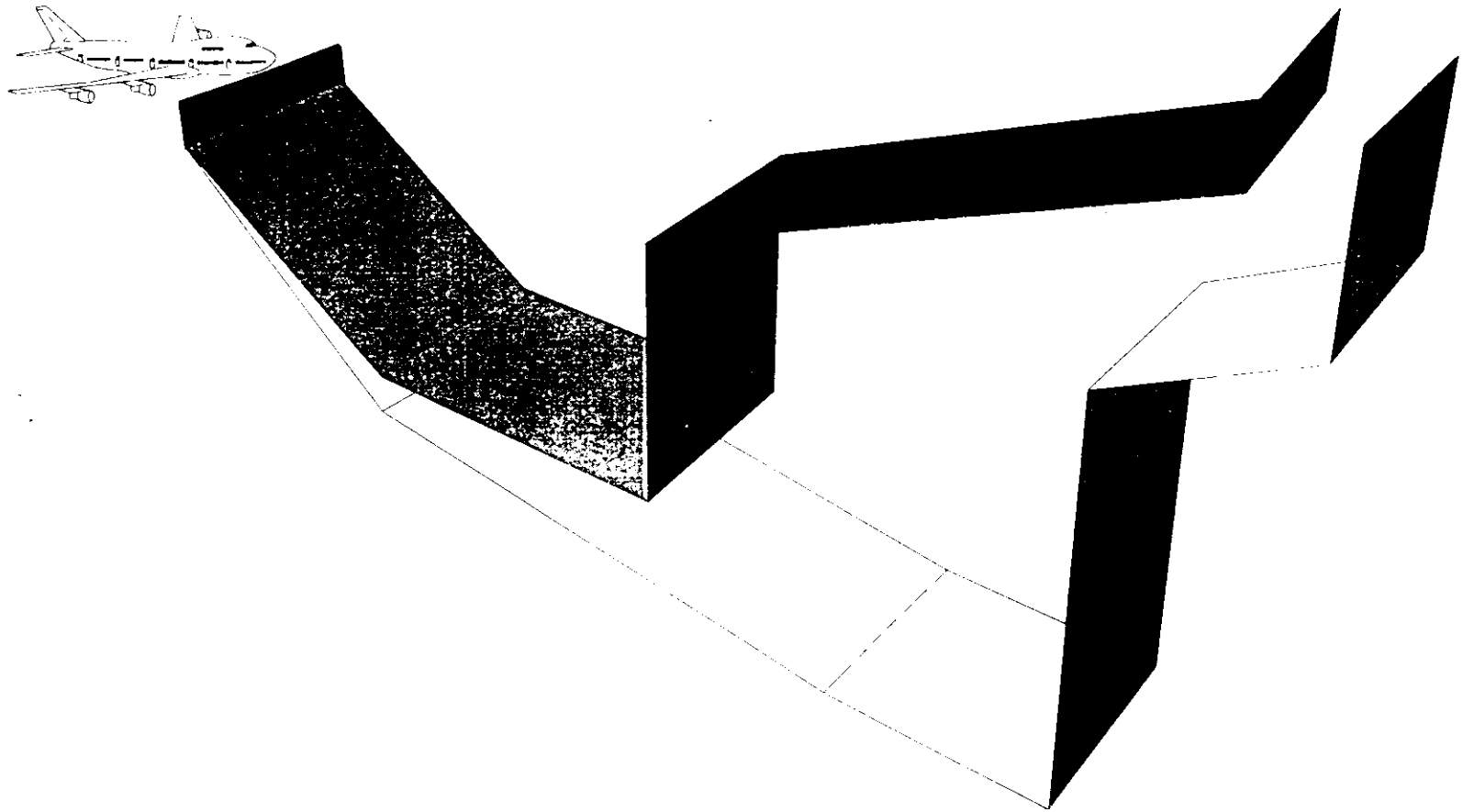
AIRCRAFT INBOUND AT TULUA VOR AT 9000 MAT MSL

TERRAIN CLEARANCE FLOOR

- AIRCRAFT POSITION / HEADING VS.
- AIRPORT LOCATION DATABASE, TO GIVE
- PROTECTION EVEN IN LANDING CONFIG.

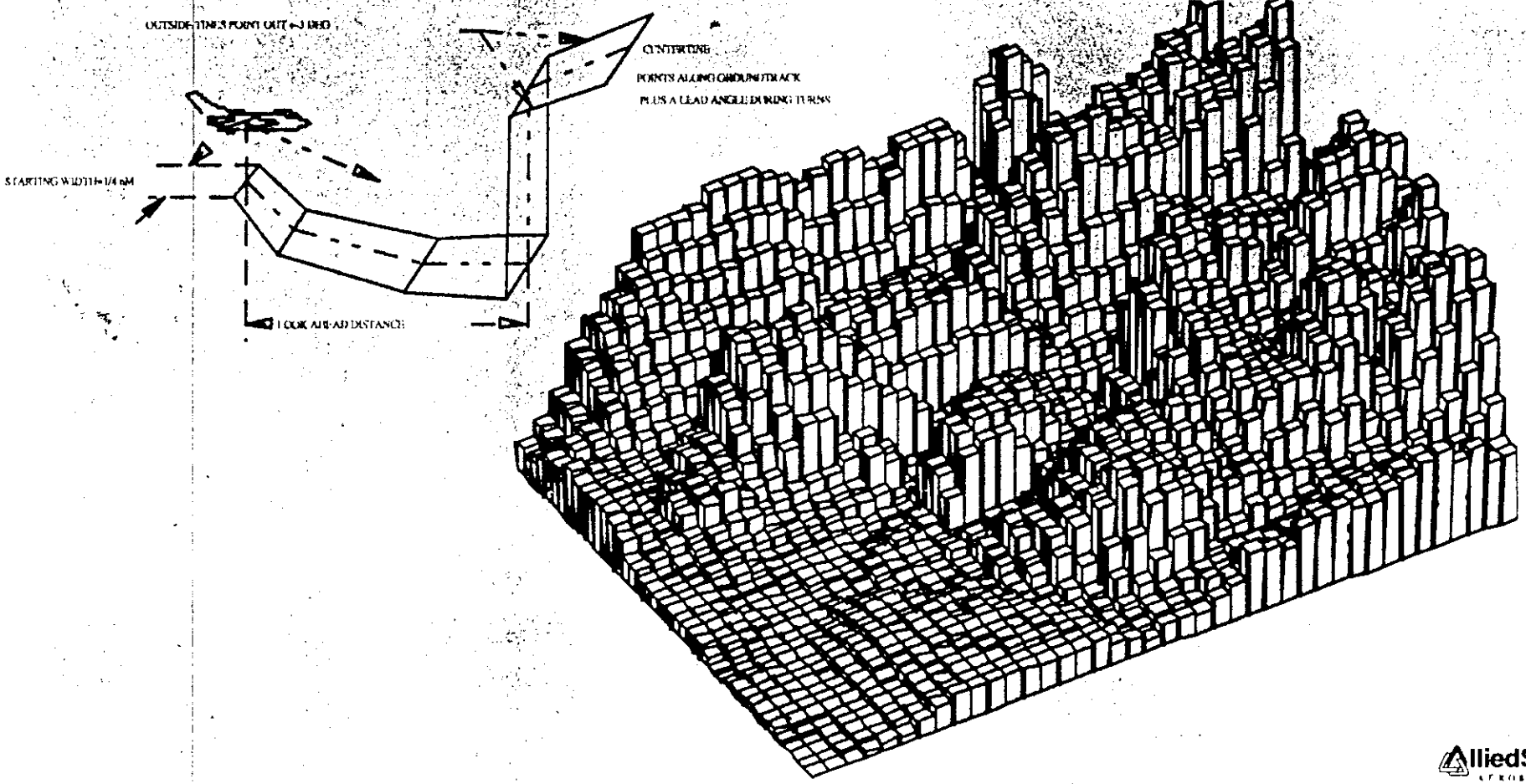


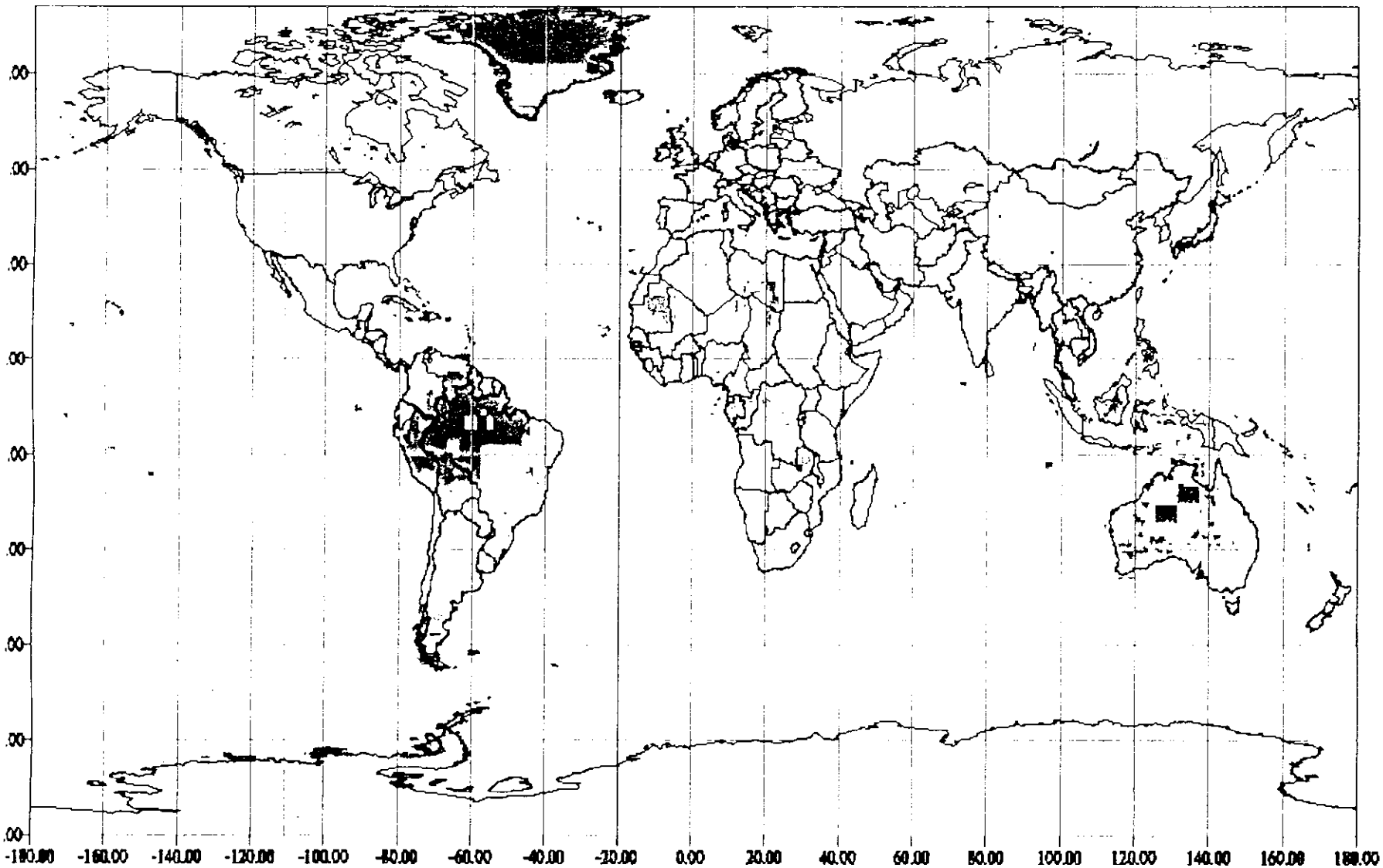
TERRAIN ALERTING ALGORITHMS



AlliedSignal

LOOK AHEAD INTO TERRAIN





EGPWS Terrain Database

Build 1.2 409
3/05/97

Terrain Data Bases

- Inherently Imperfect But Useful For Non-Critical Applications
- Integrity Level Not Sufficient For Useage In Critical Systems
- Critical Systems Require Independent Real Time Validation

Guam -GPWS Mark VII

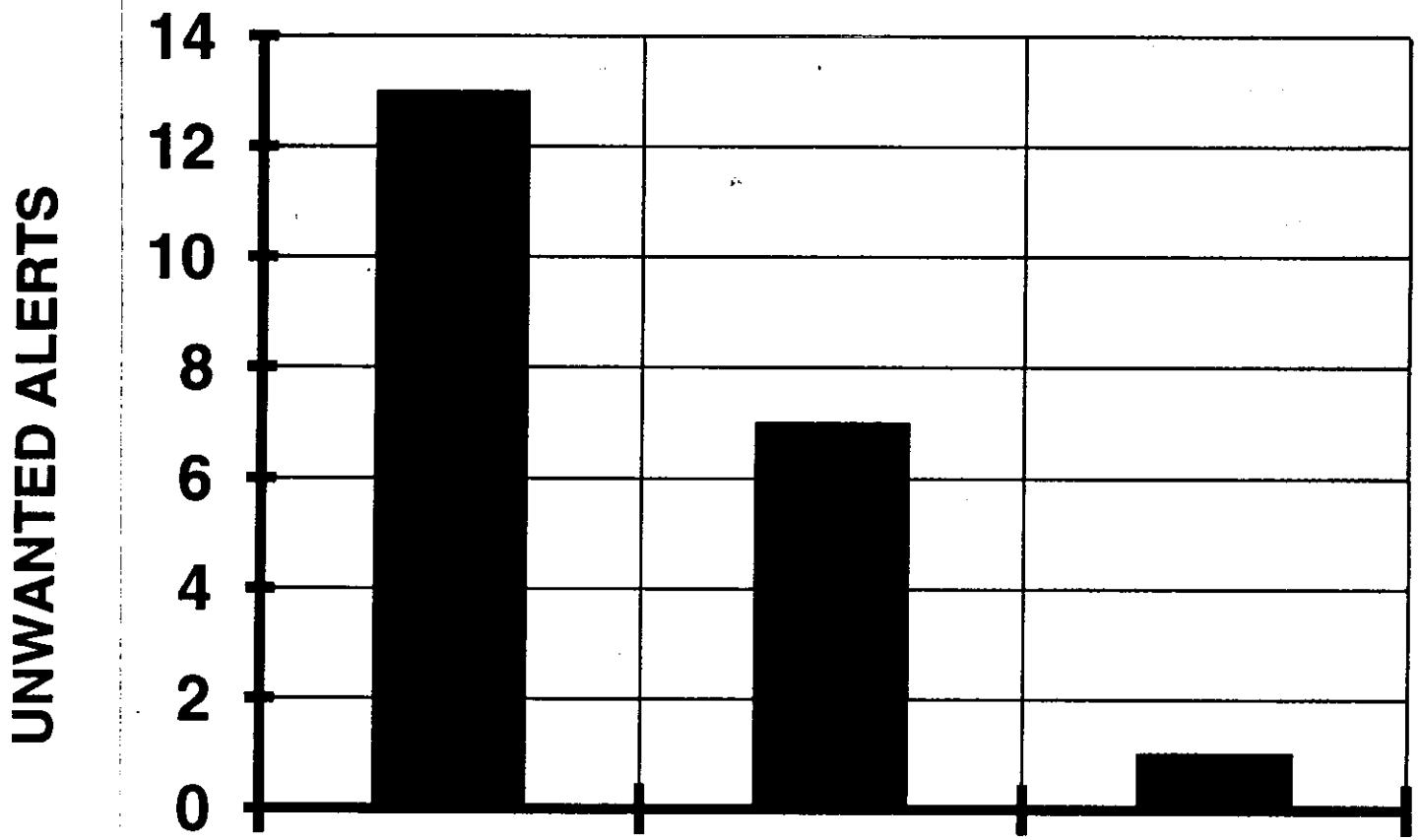
Original Mark II GPWS replaced and updated with Mark VII giving additional performance

- Windshear Detection and Alerting
- Radio Altitude Callouts
- Better Immunity to Unwanted Alerts

24

REDUCTION IN GPWS UNWANTED ALERTS

BRITISH AIRWAYS A320 FLEET



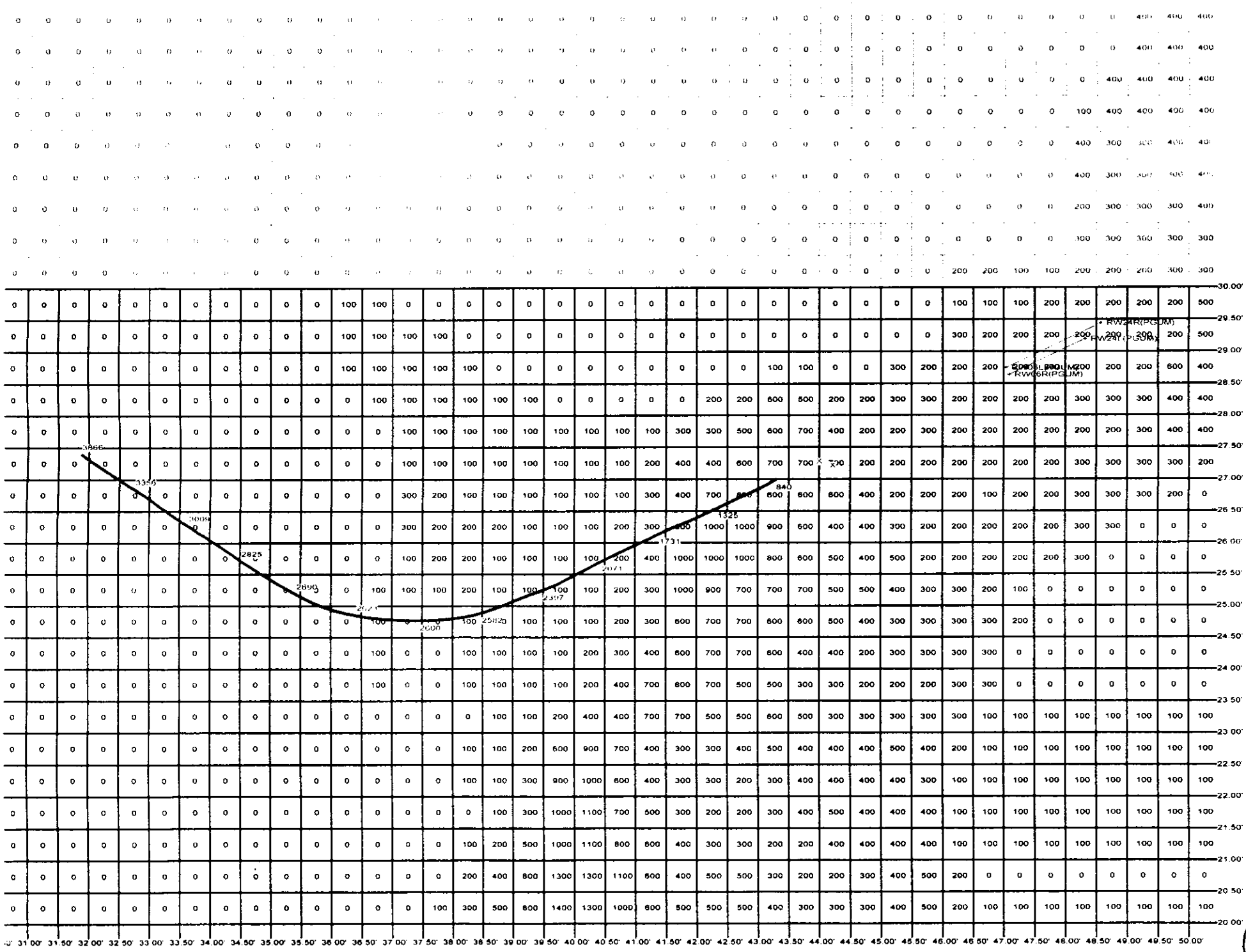
35

Guam- GPWS Simulation Tests

- A flight path profile constructed from FDR data and a radio altitude (derived from aircraft altitude and a topographical charts) was used to perform a simulation of the Mark VII performance.
- The single 'sinkrate' correlated within a 0.5 second to the actual recorded time.

Guam - Mark VII GPWS

- With Aircraft in Landing Configuration, and Stable Descent Into Terrain Short Of the Runway, with No Glideslope, there would be No Warning or Alerts
- Radio Altitude Callouts Probably Reinforced Pilot's Situational Perception of Distance to DME on the Runway. Unfortunately, the DME was not on the Runway.
- Smart '500' with Procedure Apparently Not Used

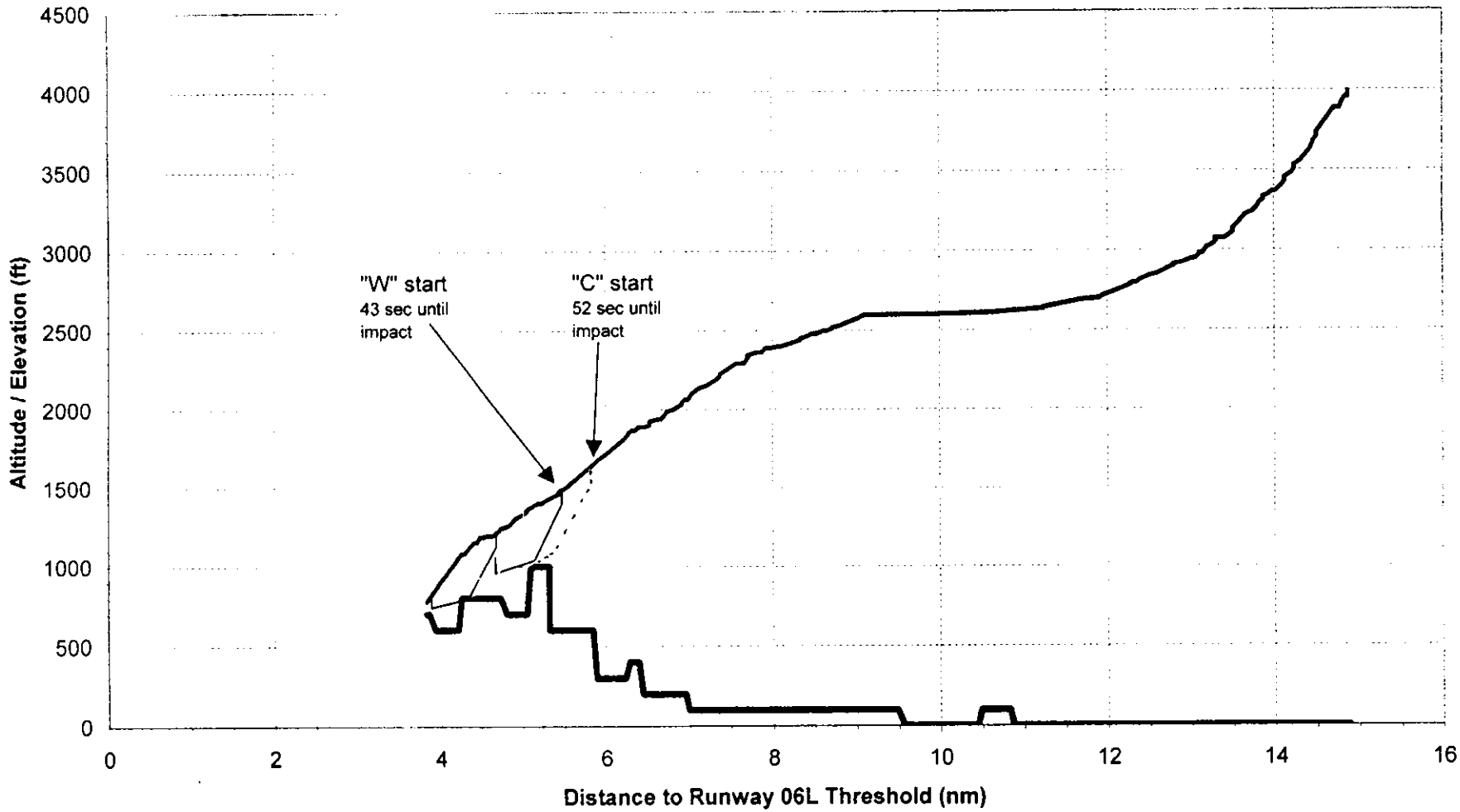


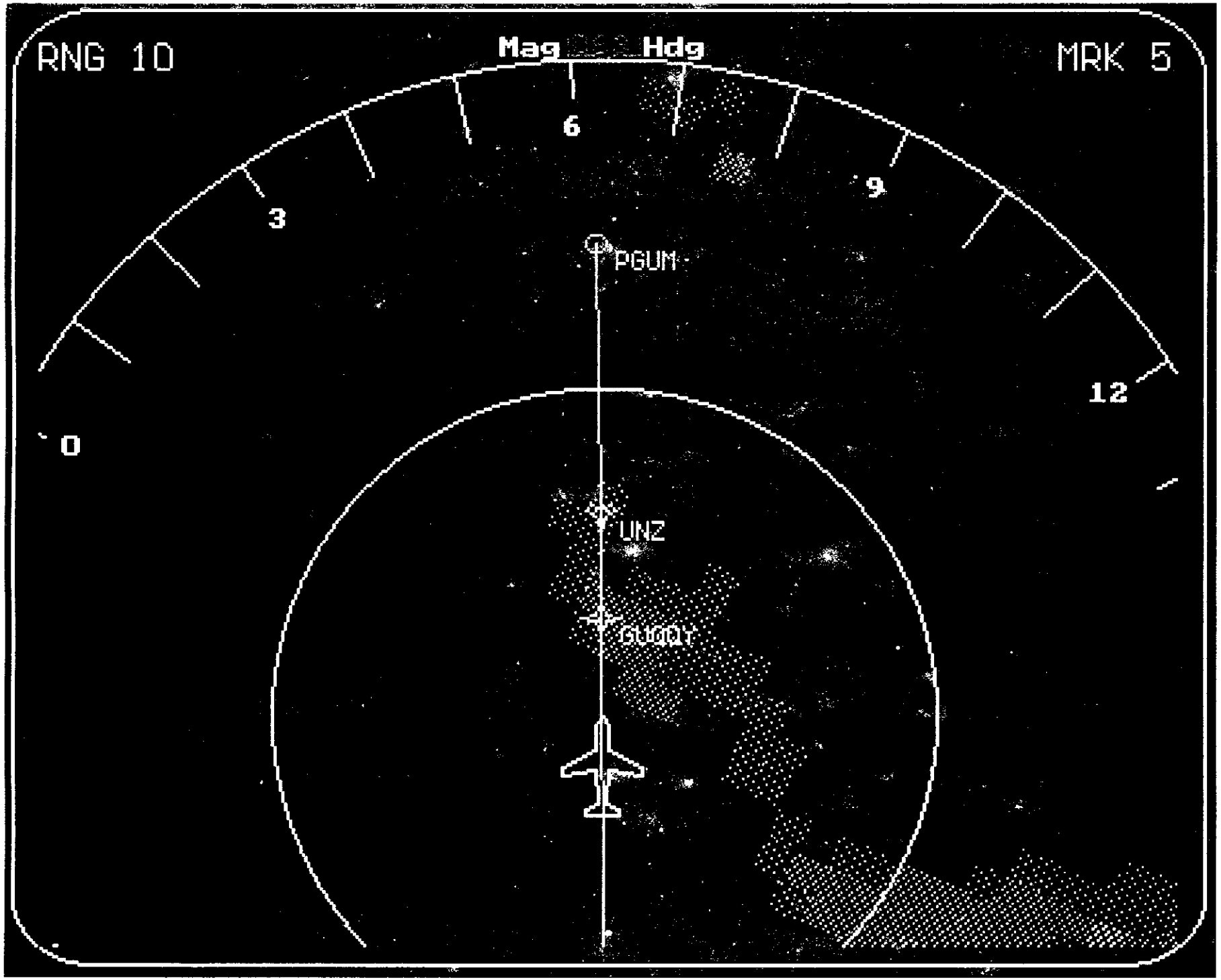
[redacted]

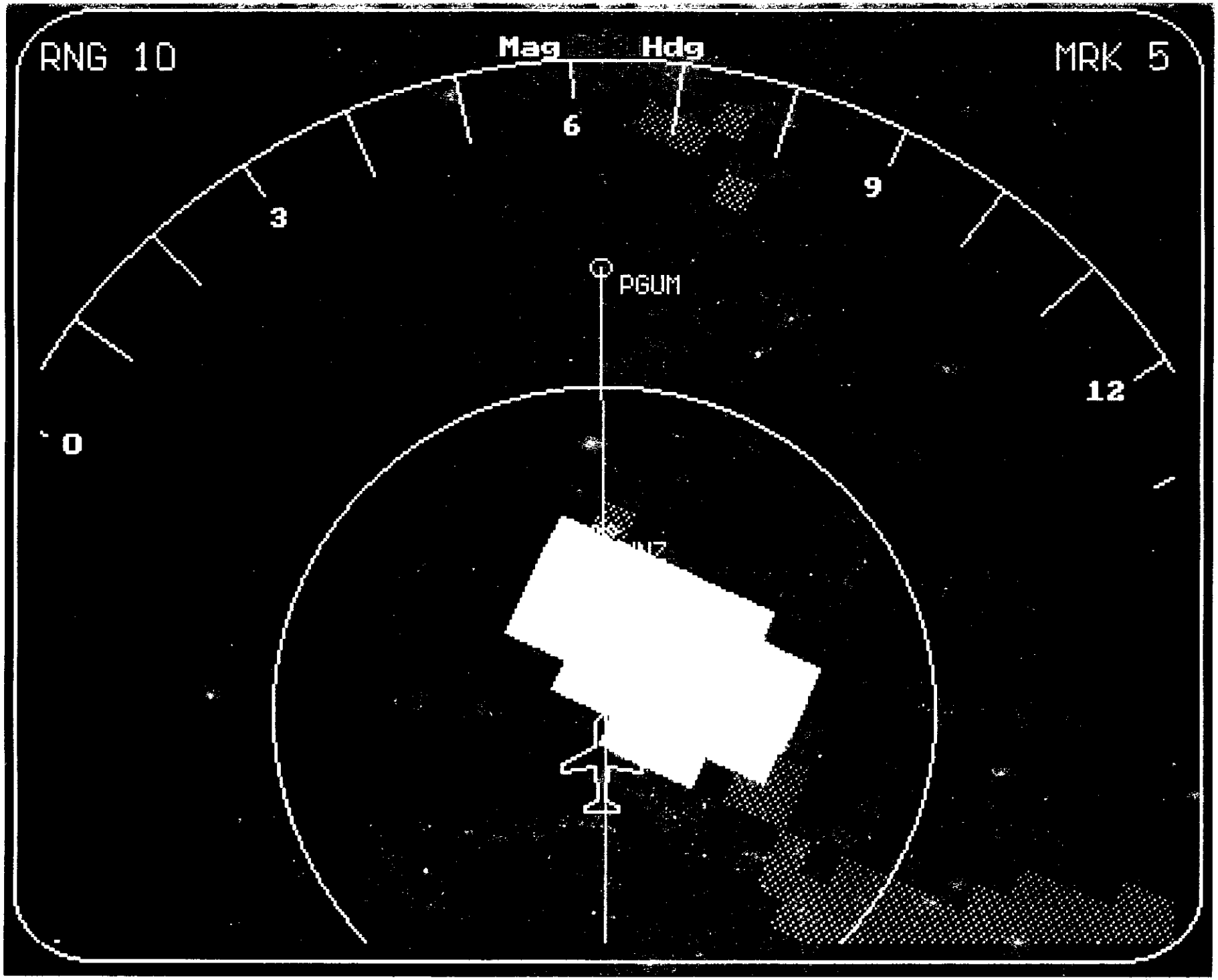
Scale: 0.510 in. per nmile (0.444 in per mile, 30.623 in per deg lat, 0.700 cm per km)
Track 1: ac970804.DAT

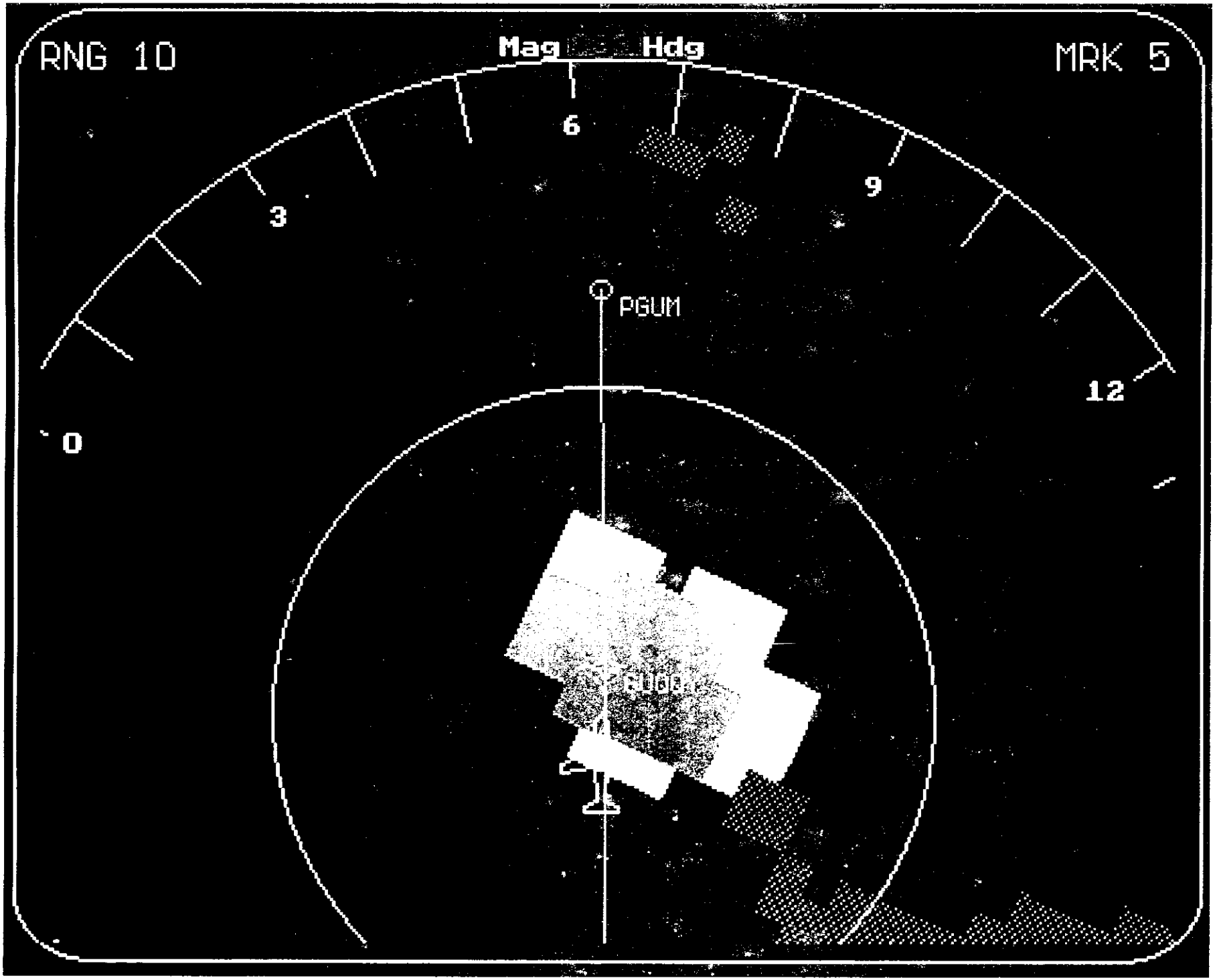
28

Agana, Guam
Accident: Aug. 04 1997
KAL 801 B747-300
Flight Path Profile




RNG 10
Mag Hdg
MRK 5
6
3
9
PGUM
12
0
UNZ
GUAM


RNG 10
Mag
Hdg
MRK 5
6
3
9
12
0
PGUM


RNG 10
Mag
Hdg
MRK 5
6
3
9
12
0
PGUM

EGPWS Status

- Over 250 Jet Aircraft Flying World Wide and the Number Growing to Over 1,000 by end of this Year 1998
- Certification Exists On Over 12 Aircraft Types
- All US Airline Aircraft to be Fitted By Year 2003
- Orders for Over 4,600 Aircraft

GPWS

EXPEDITING CERTIFICATION

- AlliedSignal MOU
  - Memorandum of Understanding (MOU) process will be in place 1st Quarter 1998
- Instant STC
  - Prevents requirement for system deactivation
  - Requires very close coordination between applicant and FAA

34

A Review Of Pacific Rim Airports With Off Airport DME

- A review of 88 International Airports around the Pacific Rim, only 6 (7%) had a single DME located off the airport, and of those only 2 (3%) were without a Glideslope approach aid.

A Rarity- - *It is a rarity for Pacific Rim airports with an instrument approach procedures, to have the only procedural DME located off the airport, and with also No operating glideslope*

Approximately 98% of all instrument procedures flown into Pacific Rim International Airports have a DME on the airfield or have an operating Glideslope aid.

An Insidious CFIT 'Trap':

The only DME navigation aid located off the airport, and no glideslope aid

There have been many incidents where the flight crew may have inadvertently assumed that the DME was on the airfield.

Two such examples:

- Lagos, Nigeria B747
- St.John, B.C. DHC-8

FT ST JOHN, BC

FT ST JOHN

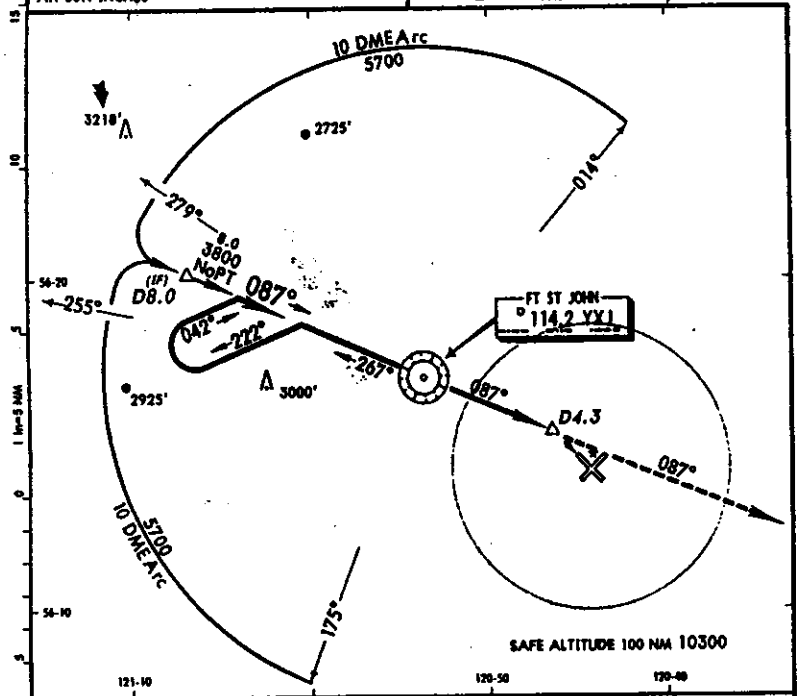
VOR Rwy 11

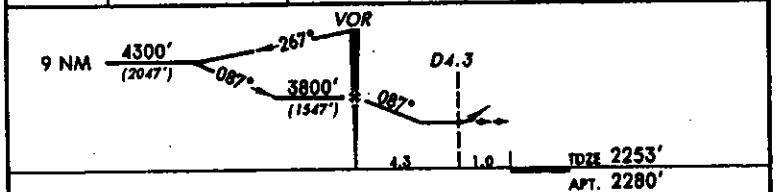
VOR 114.2 YXJ

EDMONTON Center 132.6
*FT ST JOHN Tower 118.5
*Ground 121.9
*FT ST JOHN Radio MF 118.5 when Twr inop.
Alt Set: INCHES

4300'
MSA YXJ VOR

Apt. Elev 2280'





MISSED APPROACH: Climb to 4300' outbound on YXJ VOR R-087. Return to YXJ VOR.

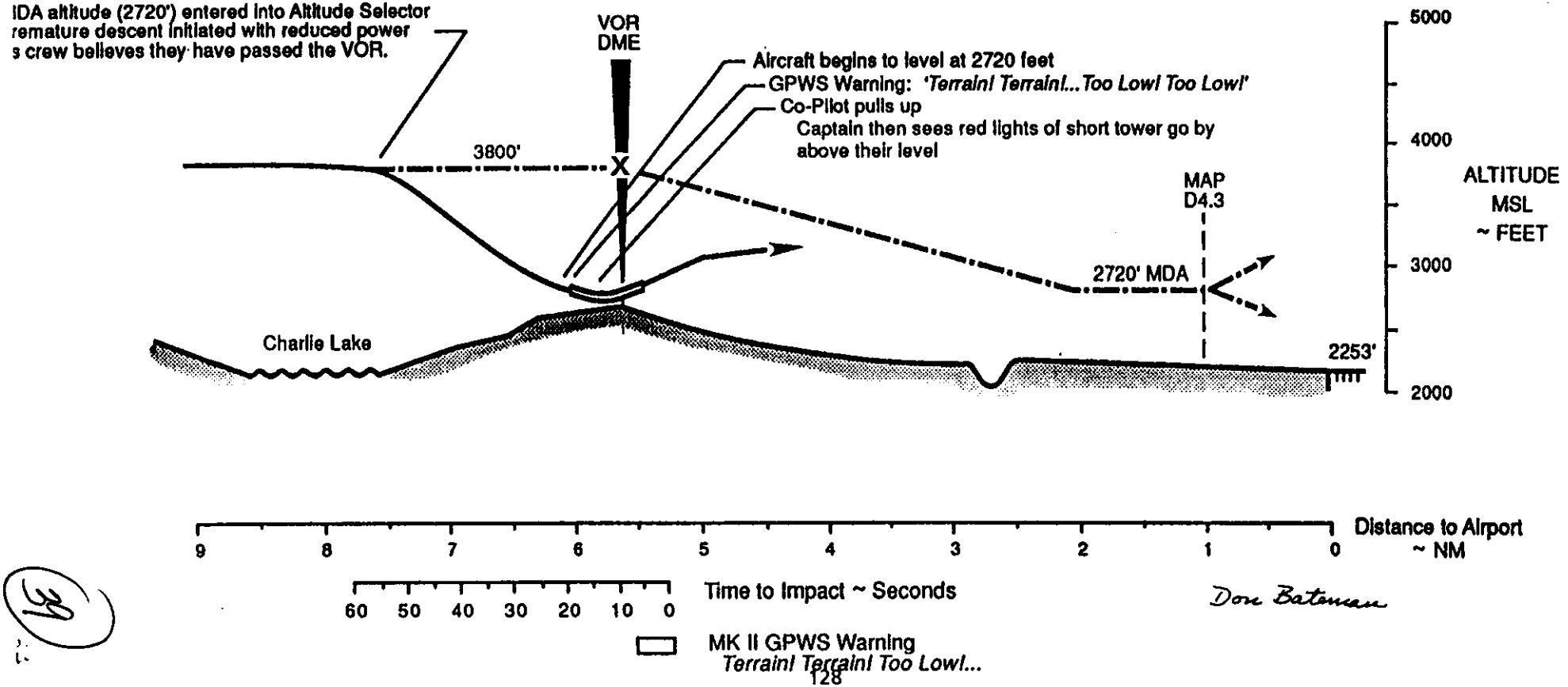
STRAIGHT-IN LANDING RWY 11		CIRCLE-TO-LAND	
MDA(H) 2720' (467')			
ALS out		Max Kts	MDA(H)
A, B, C, D	1¼	90	2780'(500')-1½
		120	2780'(500')-2
		140	2780'(500')-2
		165	2880'(600')-2

Gnd speed-Kts	70	90	100	120	140	160
MAP at D4.3 or VOR to MAP 4.3	3:41	2:52	2:35	2:09	1:51	1:37

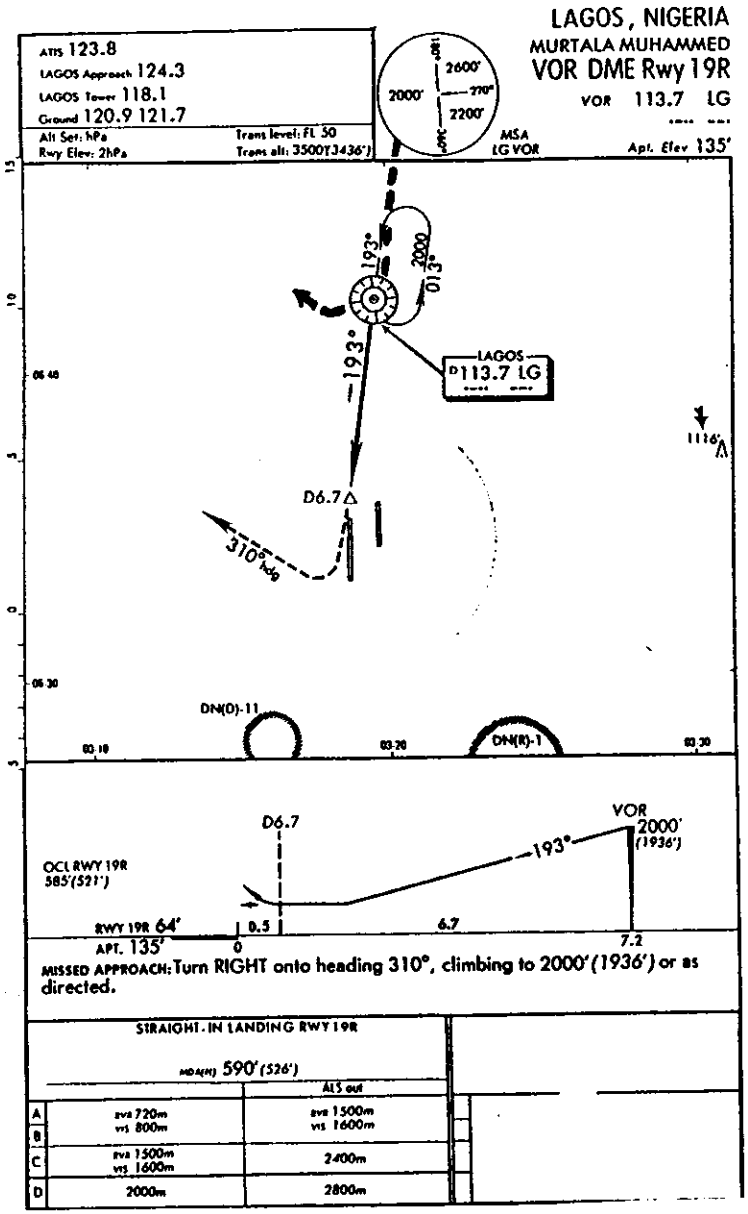
38

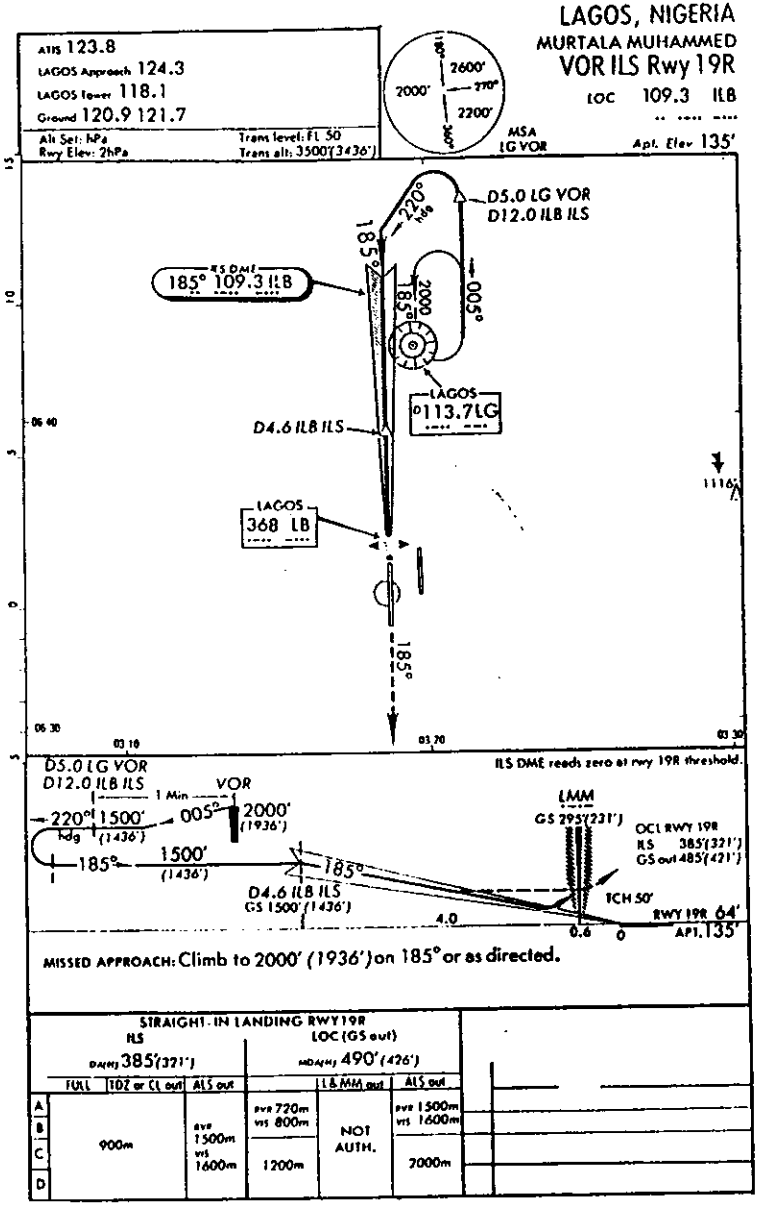
CIRCUMSTANCES:	During a VOR/DME approach to runway 11, the aircraft prematurely descended towards the MDA, before reaching the VOR (FAF). A mis-set VOR radial apparently was part of the decision to descend. A MK II GPWS warning alerted the crew in time to climb, just missing a short tower and the ground.
TIME:	Dark.
WEATHER:	1000 feet, scattered clouds, 2.5 miles visibility.
CONFIGURATION:	Landing gear down, flaps 15.
OTHER:	No injury to 23 people on-board. MK II GPWS installed and working.

Incident
Flight Path Profile
DHC-8
FT. ST. JOHN B.C., CANADA
January, 1994



Don Bateman


LAGOS, NIGERIA
MURTALA MUHAMMED
VOR DME Rwy 19R
VOR 113.7 LG
ATIS 123.8
LAGOS Approach 124.3
LAGOS Tower 118.1
Ground 120.9 121.7
Alt Set: hPa
Rwy Elev: 2hPa
Trans level: FL 50
Trans alt: 3500'(3436')
MSA
LG VOR
Apt. Elev 135'
2600'
2000'
2200'
193°
2000
013°
LAGOS
D 113.7 LG
D6.7
310° hdg
1116
DN(D)-11
DN(R)-1
OCL RWY 19R
585'(521')
VOR
2000'
(1936')
RWY 19R 64'
APT. 135'
0.5
6.7
7.2
MISSED APPROACH: Turn RIGHT onto heading 310°, climbing to 2000' (1936') or as directed.
STRAIGHT-IN LANDING RWY 19R
MDA(H) 590' (526')
ALS out
A
B
C
D
ave 720m vis 800m
ave 1500m vis 1600m
2000m
2400m
2800m


LAGOS, NIGERIA
MURTALA MUHAMMED
VOR ILS Rwy 19R
LOC 109.3 ILB
ATIS 123.8
LAGOS Approach 124.3
LAGOS Tower 118.1
Ground 120.9 121.7
Alt Set: hPa
Rwy Elev: 2hPa
Trans level: FL 50
Trans alt: 3500'(3436')
MSA
LG VOR
Apt. Elev 135'
2600'
2000'
2200'
D5.0 LG VOR
D12.0 ILB ILS
220° hdg
185°
185° 109.3 ILB
2000
005°
LAGOS
D 113.7LG
D4.6 ILB ILS
LAGOS
368 LB
1116
ILS DME reads zero at rwy 19R threshold.
1 Min
VOR
220° hdg
1500'
(1436')
005°
2000'
(1936')
185°
LMM
GS 295'(231')
OCL RWY 19R
ILS 385'(321')
GS out 485'(421')
TCH 50'
RWY 19R 64'
APT. 135'
4.0
0.6
0
MISSED APPROACH: Climb to 2000' (1936') on 185° or as directed.
STRAIGHT-IN LANDING RWY 19R
ILS
DA(H) 385'(321')
LOC (GS out)
MDA(H) 490' (426')
FULL
TDZ or CL out
ALS out
LTG MIN out
ALS out
A
B
C
D
900m
ave 1500m vis 1600m
ave 720m vis 800m
1200m
NOT AUTH.
ave 1500m vis 1600m
2000m

Some CFIT Accidents/Incidents from 1992 to 1997 (six years) where a DME was possibly Misread, Misinterpreted or a DME 'Hdd' Switch Misused

Accident/ Incident	Date	Place	Aircraft Type	Approach Procedure	Description	DME Locations	Night/ Day	GPWS
ccident	6 Aug 1997	Agana, Guam	B747-300	LOC 6L	Aircraft flown in stable descent to VOR DME 3 nm from runway	at VOR 3.3 nm from runway. No LOC DME. CS Inop	Night	MKII - No warning - Stable descent in landing configuration. Altitude callouts but NO smart '500' callout
cident	Jan. 1996	Lago, Nigeria	B747-200	LOC 19R	Aircraft flown in stable descent toward VOR DME 7 nm from runway. Procedure misinterpretation	VOR DME 7-2 nm from runway LOC DME inop GS inop	Night	MK VII - No warning, but '500' smart callout and procedure, helped the flight crew become aware of the danger and began a go around.
cident	4 May 1995	Quito, Ecuador	G-II	VOR ILS 35	Approach flown based on the wrong VOR DME. Procedure misinterpretation	(2) VOR DME's, North 8-1/2 nm and South 5-1/2 nm	Night	No GPWS
cident	March 1992	Quito, Ecuador	DC-8	VOR ILS 35	Same error as 4 May 1995	Same	Night	GPWS warning and successful recovery
cident	11 Jan 1995	Cartagena, Columbia	DC-9/15	VOR DME 36	Aircraft prematurely descended; perhaps based on assumption DME on field. Hit 27 nm short of runway	VOR DME 'CTG' 13 nm from field	Night	GPWS Inoperative
cident	13 Sept 1994	Abuja, Nigeria	DHC-6	VOR ILS DME 22	Aircraft prematurely descended by 1-1/3 nm too soon. Hit hill some 7 nm short.	VOR DME 1-1/3 nm short of runway LOC DME 22	Day	No GPWS
ident	Jan 1994	Ft. St. John B.C.	DHC-8	VOR 11	Approach flown to VOR DME perhaps based on assumption DME on field.	VOR DME 5-1/3 nm from runway.	Night	MK II GPWS warning and successful recovery.
ident	Oct 1993	Gander, Nfld	DC-8/73	B/C LOC 22	Misinterpretation of instrument procedure. FAF determined by VOR DME not by LOC DME	VOR DME off runway axis some 3 nm beyond runway LOC DME	Night	MK II GPWS warning and successful recovery. Procedure later improved
cident	12 Nov 1992	Juneau, Alaska	C-12F (Be-300)	LDA-1 Rwy 8	Prematurely descended into Mt. Chilkat 20 nm short DME 'hold' feature found in 'Hold'	'Sisters' VOR DME 12 nm South of course and LDA DME	Day	No GPWS
ident	22 Oct 1985	Juneau, Alaska	LJ-24D	LDA-1 Rwy 8	Same error as 12 Nov 1992	Same	Night	No GPWS

Don Bateman

(E)