CONTRIBUTIONS TO THE UK MICROWAVE LANDING SYSTEM RESEARCH AND DEVELOPMENT PROGRAMME 1974 TO 1978.

Volume 3.

by

J.M. Jones

VOLUME 3

Procurement Executive, Ministry of Defence
Farnborough, Hants
Linear array of \( E \) elements and length \( L\lambda \)

Difference in received phase between ends of the array is

\[
2\pi \frac{L}{E-1} \sin \theta \text{ radians}
\]

Summing network

Array of \( E \) outputs

Difference in wavelengths between cables is

\[
\frac{1 \times F}{c \times V_c}
\]

Difference in phase between ends of simulated array is

\[
2\pi \frac{(E-1) \times F}{c \times V_c} \text{ radians}
\]

Fig 6.1 Comparison of Doppler antenna and cable transmission simulation
Fig 6.2 Simulator block diagram
Fig 6.3  Simulator array phase errors at 170 MHz
Fig 6.4  Simulator output spectrum - no multipath

IF bandwidth: 300 Hz
Spectrum width: 10 kHz/division
Amplitude: 10 dB/division

Fig 6.5  Simulator output spectrum - no multipath, expanded frequency scale

IF bandwidth: 300 Hz
Spectrum width: 10 kHz/division
Amplitude: 10 dB/division
Figs 6.6 & 6.7

IF bandwidth: 300 Hz
Spectrum width: 10 kHz/division
Amplitude: 10 dB/division

Fig 6.6  Simulator output spectrum with multipath signal

Reference
Array
Multipath

IF bandwidth: 300 Hz
Spectrum width: 2 kHz/division
Amplitude: 10 dB/division
Multipath -5° with respect to wanted signal

Fig 6.7  Simulator output spectrum with multipath signal. Expansion of Fig 6.6 around array signal
Fig 6.8 Expanded simulator output spectrum, multipath at -2 degrees separation

Fig 6.9 Expanded simulator array signal, no multipath
Fig 6.10 Receiver video output for a 200ms frame containing azimuth, elevation, missed approach azimuth flare and auxiliary data signals.

Fig 6.11 Part of Fig 6.10, expanded time scale.
Fig 6.12a  Azimuth angle noise as function of signal level (full system)
Fig 6.12b  Elevation angle noise as function of signal level (full system)
Rx 003, azimuth, 54λ, three frequency processor

<table>
<thead>
<tr>
<th>Angle period pulses</th>
<th>Rx signal level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-95 dBm</td>
</tr>
<tr>
<td></td>
<td>-100 dBm</td>
</tr>
<tr>
<td></td>
<td>-103 dBm</td>
</tr>
<tr>
<td></td>
<td>-104 dBm</td>
</tr>
<tr>
<td></td>
<td>-105 dBm</td>
</tr>
<tr>
<td></td>
<td>-106 dBm</td>
</tr>
<tr>
<td></td>
<td>-107 dBm</td>
</tr>
</tbody>
</table>

2s/division  time

Fig 6.13a Azimuth function identity decode success
Fig 6.14 Receiver performance at low signal level
Rx 002, 54λ, 6 6, direct = 1°, array signal -6dB relative to reference signal

<table>
<thead>
<tr>
<th>Angle output</th>
<th>Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1°</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ref. level
-85 dBm
agc=12
-90 dBm
-95 dBm
-100 dBm
-105 dBm
-110 dBm
agc < 0

Fig 6.15 Azimuth receiver noise as a function signal input level (FL preamble hard wired)
Rx 003, 54\lambda, BI-DIR, I/P signals $\approx -95\,\text{dBm}$

Fig 6.16 Azimuth angle output as a function of simulator angle
Fig 6.17a  Elevation error as a function of separation angle — single frequency processor
Elevation, 54\(\lambda\), image multipath signal -1dB relative to direct signal
Scallop rate = 0.2Hz

Fig 6.17b  Elevation error as a function of separation angle – Taylor taper processor
Fig 6.17c

Elevation error as a function of separation angle - three frequency processor

Rx 001, elevation, 5°, direct = +1°, multipath signal = -0.9 dB relative to direct
No multipath reference, scalloping rate = 0.2 Hz
Rx 003, elevation $54\lambda$, direct $= +3^\circ$, multipath signal $-3$ dB relative to direct
No multipath reference, scalloping rate $= 0.2$ Hz

Fig 6.18a Elevation error as a function of separation angle — three frequency processor $- 54\lambda$
Rx 003, elevation, 40λ, direct = +3°, multipath signal - 3dB relative to direct
no multipath reference, scalloping rate = 0.2 Hz

Fig 6.18b  Elevation angle as a function of separation angle — three frequency processor — 40λ
Rx 003, elevation, 30\lambda, direct = +3^\circ, multipath signal -3\,dB relative to direct no multipath reference, scalloping rate = 0.2\,Hz

Fig 6.18c  Elevation error as a function of separation angle — three frequency processor — 30\lambda
Fig 6.19 Elevation error as a function of separation angle — three frequency processor — 27λ
Fig 6.20a  Azimuth error as a function of separation angle — three frequency processor — 54λ
Rx003, azimuth, 27λ, direct = +1°, multipath signal -3dB relative to direct
Scallopino rate = 0.2Hz

Fig 6.20b  Azimuth error as a function of separation angle -- three frequency processor -- 27λ
Rx003, azimuth, 20\lambda, direct = +1^\circ, multipath signal -3dB relative to direct
No multipath reference, scalloping rate = 0.2Hz

Fig 6.20c  Azimuth error as a function of separation angle – three frequency processor – 20\lambda
Fig 6.20d

Rx 003, azimuth, 15λ, direct = +1°, multipath signal -3dB relative to direct
No multipath reference, scalloping rate = 0.2Hz

Azimuth error as a function of separation angle – three frequency processor – 15λ.
Direct signal code angle = $\alpha$

Multipath code angle = $\phi$

Differential fading rate = $\frac{v}{\lambda} (\cos \beta - \cos \Theta)$

a) Azimuth systems

Direct signal code angle = $\alpha = \tan^{-1} \frac{h}{R_1}$

Multipath code angle = $\phi = \tan^{-1} \frac{h}{R_2 + R_3}$

Differential fading rate = $\frac{v}{\lambda} (\cos \beta - \cos \Theta)$

b) Elevation system

Fig 6.21 Typical multipath geometries
Fig 6.22

Multipath curves, worst case phase

Azimuth $54 \lambda$ - 3 dB $\frac{M}{D}$

Separation angle degrees

Separation coding Hz

RF phase = $180^\circ$

RF phase = $0^\circ$

$0^\circ$, $180^\circ$
Rx003, azimuth, 54\lambda, UNI-DIR., multipath signal -3dB relative to direct
Direct = \pm 1^\circ, multipath = \pm 10^\circ, rate of change of scalloping = 0.65Hz/s

Fig. 6.23a  Azimuth error as a function of scalloping rate — 54\lambda, unidirectional scan
Rx 003, azimuth, 54λ, Bi-DIR., multipath signal -3dB relative to direct
Direct = +1°, multipath = +5°, rate of change of scalloping = 0.65Hz/s

Fig 6.23b  Azimuth error as a function of scalloping rate – 54λ, bidirectional scan
Rx 001, azimuth, 54λ, 6° 6', multipath signal -3dB relative to direct
Direct = +10°, multipath = +5°, rate of change of scalloping = 0.65Hz/s

Fig 6.23c  Azimuth error as a function of scalloping rate – 54λ, block scan (6°)
Rx 003, azimuth, $54\lambda$, multipath signal -3dB relative to direct
Direct = $+1^\circ$, multipath = $+5^\circ$, rate of change of scalloping = 0.65Hz/s

Fig 6.24  Azimuth error as a function of scalloping rate - $54\lambda$, block scan
Rx002, azimuth, 27λ, B1-DIR., direct = 0°, multipath = +8°
Multipath signal -3dB relative to direct
Rate of change of scalloping = 0.65Hz/s

Fig 6.25a  Azimuth error as a function of scalloping rate – 27λ, bidirectional scan
Rx 002, azimuth, 27λ, 12°12', direct = 0°, multipath = ±8°
Multipath signal -3dB relative to direct
Rate of change of scalloping = 0.65Hz/s

Fig 6.25b  Azimuth error as a function of scalloping rate – 27λ, block scan (12°12')
Rx 003, azimuth, $54\lambda$, $6^+ 6^-$, multipath signal $-3$dB relative to direct
Direct = $+1^\circ$, multipath = $+5^\circ$, rate of change of scalloping = $26Hz/s$

Fig 6.26 Azimuth error as a function of scalloping rate – $54\lambda$, $6^+ 6^-$ scan, high rate of change
Rx 001, elevation, 54λ, 20° multipath signal -3dB relative to direct
Direct = +3°, multipath = +2°, rate of change of scalloping = 0.65Hz/s

Fig 6.27a Elevation error as a function of scalloping rate = 54λ, block scan (20°)
Rx 001, elevation, $54\lambda$, $20^+ 20^-$, multipath signal level $-3\text{dB}$ relative to direct.
Direct $= +3^\circ$, multipath $= +2^\circ$, rate of change of scalloping $= 0.65\text{Hz/s}$

Fig 6.27b  Elevation error as a function of scalloping rate — $54\lambda$, block scan ($20^+ -$)
Rx 001, elevation, 54\,\lambda, 20^\circ20', multipath signal level -3\,dB relative to direct
Direct = +3^\circ, multipath = +2^\circ, rate of change of scalloping = 0.65\,Hz/s
No multipath reference

Fig 6.28a  Elevation error as a function of scalloping rate — 54\,\lambda, block scan (20^\circ20'),
no multipath reference
Rx 001, elevation, 54λ, 20° 20°, multipath signal -3dB relative to direct
Direct = +3°, multipath = +2°, rate of change of scalloping = 0.65 Hz/s
No multipath reference

Fig 6.28b  Elevation error as a function of scalloping rate – 54λ, block scan (20° 20°),
no multipath reference
Fig 6.29 Multipath acquisition as a function of relative signal level — low scallop rate

Rx 001, azimuth, 54λ, direct = +1°, multipath = +10°
Scallop rate = 0.2 Hz, AGC = 13.7
Rx 001, azimuth 54°, direct = +1°, multipath = +10°
Scalloping rate = 370 Hz, AGC = 13.7

Fig 6.30 Multipath acquisition as a function of relative signal level — high scallop rate
Rx001, azimuth, 54°, direct = +1°, multipath = +10°
Scalloping rate = 372.4 Hz, AGC = 13.7
--- Flag action

Fig 6.31 Multipath acquisition as a function of relative signal level — high scallop rate
Rx 001, azimuth, 54λ, direct = +1°, multipath = +10°, no multipath reference
Scalloping rate = 372.4 Hz, AGC = 13.7

Fig 6.32 Multipath acquisition as a function of relative signal level — high scallop rate, no multipath reference
Rx 001, azimuth, $54\lambda$, direct $= +1^\circ$, multipath $= +10^\circ$
Scalloping rate $= 0.2\text{Hz}$, AGC $= 13.7$

Fig 6.33  Signal reacquisition as a function of relative multipath level
Fig 6.35  Aircraft propeller effects — monopole antenna, $L = 28.3\lambda$, $H = 10\lambda$
Fig 6.36 Aircraft propeller effects — monopole antenna, $L = 28.3\lambda$, $H = 5\lambda$. 
Fig 6.37  Aircraft propeller effects — monopole antenna, $L = 16.6\lambda$, $H = 10\lambda$
Fig 6.38  Aircraft propeller effects – small horn antenna, $L = 16.6\lambda$, $H = 10\lambda$
Fig 6.39 Aircraft propeller effects – small horn antenna, $L = 16.6\lambda$, $H = 5\lambda$
Fig 6.40 Aircraft propeller effects — FAA data
Fig 6.41 Experimental arrangement for propeller modulation simulation
Fig 6.42  Propeller modulation waveforms — simulated two blade propeller

a  900 rev/min

b  2850 rev/min
Fig 6.43

N = No prop mod
Y = With prop mod

Loss of FI decodes

-92 dB m
-96 dB m
-100 dB m
-102 dB m

Time s

0 20 40 60 80 100 120

Fig 6.43  Typical effects of propeller modulation with max attenuation of -10 dB
Fig 6.44 Typical DMLS formats with $360^\circ$ azimuth and jitter
Fig 7.2 Azimuth part orbit at 4.4 n mile and 1900 ft (Site 3)
Fig 7.3 Azimuth part orbit at 5.8 n mile and 2000 ft (Site 3)
Effective image length \( L = 2a \tan \theta \)

Delay of reflected signal \( \frac{2a \cos \theta}{2\pi} \) radians

Relative level of reflected signal is \( \rho \)

Received signals

Phasing

2a tan \( \theta \)

Direct

\[ 2 \pi L \sin \theta \]

Reflected

\[ \frac{2 \pi L \sin \theta}{\lambda} \cdot \frac{4 \pi a \cos \theta}{\lambda} \]

Resultant \( \rho << 1 \)

\[ 2 \pi L \sin \theta \cdot \tan^{-1} \left( \frac{\rho \sin \frac{4 \pi a \cos \theta}{\lambda}}{\rho \cos \frac{4 \pi D \cos \theta}{\lambda}} \right) \]

Error maxima occur at \( \frac{4 \pi a \cos \theta}{\lambda} = (2n+1) \frac{\pi}{2} \)

Fig 7.4 Effect of radome mismatch
Fig 7.5a Azimuth 3 degree approach to low overshoot
Fig 7.6a Azimuth 3 degree approach to low overshoot
Fig 7.6b  Azimuth 3 degree approach to low overshoot
To a first approximation, error peaks occur at

$$\frac{2\pi b}{\lambda} \pm \frac{2\pi b}{\sin \theta} (2n + 1) \frac{\pi}{2}$$
Fig 7.10a  Elevation radial at 2051 ft and zero azimuth
Fig 7.10b  Elevation radial at 2051 ft and zero azimuth
Fig 7.11b  Elevation 3 degree approach to low overshoot
Fig 7.12  Azimuth part orbit at 8.8 n mile and 1950 ft height
Fig 7.13  Azimuth part orbit at 7.5 n mile and 1950 ft height
Fig 7.14  Azimuth part orbit at 6.8 n mile and 1930 ft height

TR 79052
Fig 7.15  Azimuth part orbit at 6.6 n mile and 1950 ft height
Fig 7.16c  Azimuth in orbit at 7.5 n mile and 4020 ft height

5.1 DEGREE ELEVATION FROM AZIMUTH

LOSS OF KINE SYNC

TEST FLIGHT DIRECTION
Fig 7.17a  Azimuth 3 degree approach to low overshoot
Fig 7.18b  Azimuth 3 degree approach to low overshoot
Fig 7.19a  Azimuth radial at 5000 ft
Fig 7.19b  Azimuth radial at 5000 ft
Fig 7.20

Protection level dB

TDM waveguide element

FDM ground plane antenna

0 5 10 15 Degrees

Elevation angle

Fig 7.20  Azimuth antenna ground reflection attenuation factors
OFFSET 3 DEGREES

Fig 7.21a Elevation part orbit at 2.6 degrees elevation
Fig 7.21b  Elevation part orbit at 2.6 degrees elevation
Fig 7.22b  Elevation part orbit at 3.5 degrees elevation
OFFSET 3.0 DEGREES

Fig 7.23a  Elevation part orbit at 3.75 degrees elevation
Fig 7.24a  Elevation part orbit at 6.5 degrees elevation
Fig 7.24b  Elevation part orbit at 6.5 degrees elevation
Fig 7.25a  Elevation 3 degree approach
ICAQ NOISE LIMITS FOR SYSTEM B

Fig 7.25b  Elevation 3 degree approach
Fig 7.26a  Elevation radial at 5000 ft
CONTRIBUTIONS TO THE UK MICROWAVE LANDING SYSTEM RESEARCH AND D-ETC(U)
MAY 79 J M JONES
UNCLASSIFIED
RAE-TR-79052-VOL-3
DRIC-BR-73763
NL
Fig 7.26b  Elevation radial at 5000 ft
Fig 7.27a  Elevation 54λ, constant height radial at 2044 ft
Fig 7.27b Elevation 54°, constant height radial at 2044 ft
Fig 7.28  Azimuth 54\(^\circ\), part orbit at 6.8 n mile and height 1540 ft
Fig 7.29  Azimuth 54°, part orbit at 6.7 n mile and height 1554 ft
6.1 DEGREES ELEVATION FROM AZIMUTH

Fig 7.30  Azimuth 54°, part orbit at 6.4 n mile height 4088 ft
Fig 7.31

Azimuth part orbit at 6.5 n mile height 6498 ft
Fig 7.32

Possible sensitivity error
\[ \theta_A = \sin^{-1} 1.0008 \sin \theta \]

Possible residual radome effect

Resultant mean error curve

Azimuth angle degrees

Probable source of orbital bias
Fig 7.33a  Azimuth 54\(\lambda\), constant height radial at 2000 ft and -35 degrees
Fig 7.33b Azimuth 54λ, constant height radial at 2000 ft and −35 degrees
Fig 7.4a  Azimuth 54λ, constant height radial at 2000 ft and -20 degrees
Fig 7.34b  Azimuth 54°, constant height radial at 2000 ft and -20 degrees
Fig 7.35a  Azimuth 54°, constant height radial at 2000 ft and -10 degrees
Fig 7.35b  Azimuth 54\(^\circ\), constant height radial at 2000 ft and -10 degrees
Fig 7.36a  Azimuth 54°, constant height radial at 2000 ft on centre line
Fig 7.36b  Azimuth 54°, constant height radial at 2000 ft on centre line
Fig 7.37a  Azimuth 54°, constant height radial at 2000 ft and +10 degrees
Fig 7.37b  Azimuth 54°, constant height radial at 2000 ft and +10 degrees
Fig 7.38b  Azimuth 54°, constant height radial at 2000 ft and +20 degrees
Fig 7.39a  Azimuth 54°, constant height radial at 2000 ft and +30 degrees
Fig 7.39b  Azimuth 54°, constant height radial at 2000 ft and +30 degrees
Fig 7.41c  Azimuth 54°, 3 degree approach to touch and go
Fig 7.42a Azimuth 54λ, 3 degree approach to 300 ft overshoot
Fig 7.42c  Azimuth 54°, 3 degree approach to 300 ft overshoot
Fig 7.43a  Azimuth 54°, 1.5 degree approach to 300 ft overshoot
Fig 7.44a  Azimuth 54°,3 degree approach to 300 ft overshoot
Fig 7.44c
Azimuth 5A): 3 degree approach to 300 ft overshoot

Normal Threshold

Offset = 0.000 DEC

N.M. 4

Test Flight Direction

Distance Along C. Felt

Normal Flight

Approach

El. Approach

Error Angle
Fig 7.45a  Azimuth 54λ, 3 degree approach to 300 ft overshoot
Fig 7.46a  Azimuth 54\(^\circ\), 3 degree approach to 50 ft overshoot
Fig 7.46c  Azimuth 54°, 3 degree approach to 50 ft overshoot
Fig 7.47a Azimuth 54λ, 3 degree approach to 50 ft overshoot
Fig 7.47c  Azimuth 54\(^\circ\), 3 degree approach to 50 ft overshoot
Fig 7.48a  Azimuth 54°, 3 degree approach to 50 ft overshoot
Fig 7.48c  Azimuth 54°,3 degree approach to 50 ft overshoot
Fig 7.49c  Azimuth 54°, 3 degree approach to 50 ft overshoot
Fig 7.51b

Elevation 54°, part orbit, 3 degrees nominal
Fig 7.52b  Elevation 54°, part orbit, 3 degrees nominal
Fig 7.54a  Elevation part orbit, 10 degrees nominal
Fig 7.55a  Elevation part orbit, 3 degrees nominal. Range 4.6 n mile. Height 1550 ft
Fig 7.55b  Elevation part orbit, 3 degrees nominal
Fig 7.56a  Elevation part orbit. Range 4.5 n mile. Height 3060 ft
Fig 7.56b: Elevation part orbit at 4.5 n mile and 3060 ft.
Fig 7.57a  Elevation 54λ, constant height radial 1934 ft, -20 degrees azimuth
Fig 7.57b  Elevation 54°, constant height radial 1934 ft, – 20 degrees azimuth
Fig 7.58b  Elevation 54°, constant height radial 2048 ft, 0 degree azimuth
Fig 7.59a  Elevation 54°, constant height radial 2038 ft, 0° degree azimuth
Fig 7.59b  Elevation 54°, constant height radial 2036 ft, 0 degree azimuth
Fig 7.60a  Elevation 54λ, constant height radial 2023 ft, +10 degrees azimuth
Fig 7.61b  Elevation 54°, constant height radial 2041 ft, +20 degrees azimuth
Fig 7.62b  Elevation 54λ, constant height radial 2034 ft, +30 degrees azimuth
Fig 7.63a  Elevation 54°, 3 degree approach to touch and go
Fig 7.63b Elevation 54\(^\circ\), 3 degree approach to touch and go
Fig 7.64a Elevation 54°, 3 degree approach to 300 ft overshoot
Fig 7.64b  Elevation 54°, 3 degree approach to 300 ft overshoot
Fig 7.65a  Elevation 54λ, 1.5 degree approach to 300 ft overshoot
Fig 7.65b  Elevation 54°, 1.5 degree approach to 300 ft overshoot
Fig 7.68b  Elevation 54°, 3 degree approach to 50 ft overshoot
Fig 7.67a Elevation 54°, 2 degree approach to low overshoot
Fig 7.67b  Elevation 54°, 2 degree approach to low overshoot
DMLSFD-DA15/ 2-EL-PC -19/07/77
OFFSET ~ 3.000 DEG

Fig 7.88a Elevation 54λ, 3 degree approach to low overshoot

R. A. E. BEDFORD
Fig 7.69a  Elevation 54°, 4 degree approach to low overshoot
Fig 7.69b  Elevation 54λ, 4 degree approach to low overshoot
Fig 7.70a  Elevation 54λ, 5 degree approach to low overshoot
Fig 7.70b  Elevation 54\(^\circ\), 5 degree approach to low overshoot
Fig 7.71a  Elevation 54\(^\circ\), 6 degree approach to low overshoot
Fig. 7.72a  Elevation 54°, 7 degree approach to low overshoot
Fig 7.73a  Elevation 54λ, 8 degree approach to low overshoot
Fig 7.74a  Elevation 54λ, 9 degree approach to low overshoot
Fig 7.74b Elevation 54\(^\circ\), 9 degree approach to low overshoot
Fig 7.75a  Elevation 54°, 9.9 degree approach to low overshoot
Fig 7.75b  Elevation 54°, 9.9 degree approach to low overshoot
Fig 7.76 Coverage profiles
Fig 7.77a Azimuth radial on $\zeta$ at 3000 ft height
Fig 7.77c  Received signal levels for UA05/3
CONTRIBUTIONS TO THE UK MICROWAVE LANDING SYSTEM RESEARCH AND D-ETC(U)

MAY 79  J M JONES

UNCLASSIFIED  RAE-TR-79052-VOL-3  DRIC-BR-73763  NL

END

DATE

7 80

OTIC
Fig 7.78a  Azimuth radial at -20 degrees and 3000 ft
Fig 7.78b

DMLSD-UR 5/4-EL-PC 24/05/77
FLIGHT LEVEL = 0 FT

R.A.E. BEDFORD

Fig 7.78b  Elevation radial at -20 degrees and 3000 ft

RANGE FROM Az Tx (n mile)
Fig 7.79b  Elevation radial at -30 degrees and 3000 ft
Fig 7.80b  Elevation radial at +20 degrees and 3000 ft

R.A.E. BEDFORD

TR 79052
Fig 7.81a  Azimuth radial at +30 degrees and 3000 ft

OFFSET = 30.000 DEG

R.A.E. BEDFORD

Fig 7.81a Azimuth radial at +30 degrees and 3000 ft RANGE FROM A2 Tx (n mile)
Fig 7.81b - Elevation radial at +30 degrees and 3000 ft

DMLSF D-U T 5/7-EL-PC 24/05/77
FLIGHT LEVEL = 0 FT

R.A.E. BEdford

Range from Az Tx (n mile)

TR 70082
Fig 7.82a  Azimuth, orbit at 20 n mile and 2500 ft
Fig 7.82b  Azimuth, orbit at 20 n mile and 2500 ft

R.A.E. BEDFORD
Fig 7.82c  Elevation, orbit at 20 n mile and 2500 ft
TR 79052

DMLSFD-UR 6/ 4-FAZ-PC -24/05/77
OFFSET = 0.000 DEG

FLIGHT JU

DML S. ANGLE FROM OFFSET

-60° -40° -20° 0 20° 40° 60°

DEGREES

-60 -40 -20 0 20 40

TEST FLIGHT DIRECTION

R.A.E. BEDFORD

Fig 7.83a Azimuth, orbit at 20 n mile and 2000 ft

NOMINAL AZIMUTH ANGLE
Fig 7.83b  Azimuth, orbit at 20 n mile and 2000 ft

R.A.E. BEDFORD

TR 79052
Fig 7.83c  Elevation, orbit at 20 n mile and 2000 ft
Fig 7.84b Azimuth, orbit at 20 n mile and 10000 ft

R.A.E. BEDFORD

TR 79082
Fig 7.84c  Elevation, orbit at 20 n mile and 10000 ft

R.A.E. BEDFORD  

NOMINAL AZIMUTH ANGLE
DMLSFD-UA 8/ 4-FAZ-PC  -26/05/77
OFFSET = 0.000 DEG

R.A.E. BEDFORD
Fig 7.85a  Azimuth, orbit at 20 n mile and 10000 ft
FILTERED FOR
CONTROL MOTION NOISE

Fig 7.85b  Azimuth, orbit at 20 n mile and 10000 ft
Fig 7.85c Elevation, orbit at 20 n mile and 10000 ft
Fig 7.85d  Elevation, orbit at 20 n mile and 10000 ft
Fig 7.86a  Azimuth 27\(\lambda\), constant height radial at 2000 ft and -20 degrees
Fig 7.87a  Azimuth 27λ, 3 degree approach to low overshoot
Fig 7.87b  Azimuth 27°, 3 degree approach to low overshoot
Fig 7.88a Azimuth 27°, 2 degree approach to low overshoot
Fig 7.88b Azimuth 27°, 2 degree approach to low overshoot
Fig 7.90a  Elevation 27λ, constant height radial at 2000 ft and -20 degrees azimuth
Fig 7.90b  Elevation 270, constant height radial at 2000 ft and -20 degrees azimuth
Fig 7.91a  Elevation 27λ, 3 degree approach
Fig 7.91b  Elevation 27°, 3 degree approach
Fig 7.92 Effects of poles — test geometry
Fig 7.93a  Effect of metal poles - range 30 m (100 ft)
Fig 7.93b  Effect of metal poles – range 45 m (150 ft)
\( A = \text{DPSK} \quad F_c + \delta_1 F - F_{LO} + \delta_2 F + \delta_3 F \)

\( B = \text{odd scans} \quad F_c + \delta_1 F - F_{LO} + \delta_2 F + \delta_3 F + F_0 \)

\( C = \text{even scans} \quad F_c + \delta_1 F - F_{LO} + \delta_2 F + \delta_3 F - F_0 \)

Angle output \( B - C = 2F_0 \)

\( \delta_1 F + \delta_2 F + \delta_3 F = \pm 25 \text{KHz max} \)

\( F_0 = \text{doppler code} \)

\( F_c = \text{basic transmitter frequency} \)

\( \delta_1 F = \text{Tx drift} \)

\( \delta_2 F = \text{Rx motion doppler shift} \)

\( \delta_3 F = \text{Rx LO drift} \)

Fig 9.1 Reference-less DMLS
XTAL = crystal oscillator source
SYNTH = frequency synthesiser
$f_1$ to $f_7$ = frequency errors

Fig. 9.2 Simulation of reference-less system
Fig 9.3  Basic angle noise with reference-less transmission
Rx 002, azimuth, 54λ, reference injection at 20MHz IF
Bi-directional scanning AGC = 16.5, direct = +10°
Multipath signal -3dB relative to direct, scalloping rate = 0.2Hz

Fig 9.4 Receiver v separation angle – reference-less transmission
Rx002, azimuth, 54λ, reference injection at 20MHz IF
Bi-directional scanning, AGC = 16.5, direct = +1°
Multipath signal -1dB relative to direct, scalloping rate = 0.2Hz

Fig. 9.5 Receiver error v separation angle – reference-less transmission
Fig 9.6 Receiver error v scalloping rate — reference-less transmission
Fig 10.1 Angular error limits for long and short runways

2 sigma error limits

Degrees

Range from threshold n mile

Short runway

Long runway

Threshold