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CSIRO DIVISION OF RADIOPHYSICS

Memoranda Series
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A COMPACT ARRAY CONFIGURATION FOR THE AUSTRALIA TELESCOPE

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INTRODUCTION

The compact part of the Australia Telescope will consist of 6 antennas (of diameter 22 m), 5 movable on a 3 km linear railtrack (running east-west) and the sixth one a further 3 km to the west, with limited (~ 100 m) movement. During an observation each antenna will be located at one of a number of stations on the railtrack. The positions of the antennas may be changed from day to day to give different configurations. In any one configuration we may obtain 10 baselines between 0 and 3 km from the 5 antennas on the 3 km track and a further 5 baselines between 3 and 6 km using the sixth antenna.

We consider grating arrays, so the baselines obtained are integral multiples of a fixed unit spacing. The location of a station is given as an integer - the number of unit spacings it is from the eastern end of the 3 km track. The location of an antenna is described by the integer corresponding to the station at which it is located and the baseline determined by two antennas in a configuration is given by the difference between the corresponding two integers.

In this report we present observing programs for arrays based on a 3 km length of 211 spacings, i.e., a unit spacing of 14.2 m.

Our basic arrays (§1) require 32 stations. Frequency scaled observations (§2) may be made with an additional 3 stations (total: 35 stations). With the addition of another 2 stations (total: 37 stations) we may also make redundant observations (§3).

1.0 THE BASIC ARRAYS (1.5 km, 3 km and 6 km)

We require a set of station locations and sequences of antenna configurations which give arrays of baseline lengths 1.5 km, 3 km and 6 km. They should satisfy the following conditions:

(i) the total number of stations is not too big;

(ii) we obtain a complete filling of the array - i.e., we obtain every baseline (being an integral multiple of the unit spacing) up to the maximum baseline length;

(iii) as few days of observation as possible are required;

(iv) we obtain an even fill - i.e., the progressive day to day coverage of baselines is an even coverage over the whole range of baselines.

We note that as the diameter of the antennas is larger than the unit spacing we can not obtain the baseline 1 (unit spacing). Also, as the sixth antenna has limited movement, (taking into account condition (i)) only a limited number of baselines between 3 and 6 km can be obtained. Thus the 6 km array can have only a partial fill between 3 and 6 km.

In the appendix we give a method for determining station locations on the 3 km track which will yield a complete filling of a 3 km array. We have modified this construction so that we obtain a reasonable coverage in the 6 km array. This has resulted in the loss of some of the long baselines in the 3 km array. Additional stations would be required to obtain these baselines once more.

We have added stations in order to incorporate a 1.5 km array on the 3 km track. These stations also improve the coverage of the 6 km array.

We use 32 stations, 30 on the 3 km track and 2 stations (with a separation of 85 m) at the 6 km point. Their locations are given in Table 1.0.

On the 3 km track					At the 6 km point
0	4	14	16	21	415 421
22	25	35	37	43	
63	67	77	79	84	
85	88	98	100	106	
147	151	161	163	169	
189	193	203	205	211	

Table 1.0 Station Locations

1.1 THE 1.5 km ARRAY

The method used in choosing configurations for the 1.5 km array is described in the appendix. We obtain 87 baselines between 2 and 106 in 11 days. Fig 1.1 shows the locations (x) of the antennas on each day, the progressive coverage of baselines (o) and the stations used (*) for the 1.5 km array. Table 1.1a gives the locations of the antennas and Table 1.1b the baselines obtained on each day for the 1.5 km array.

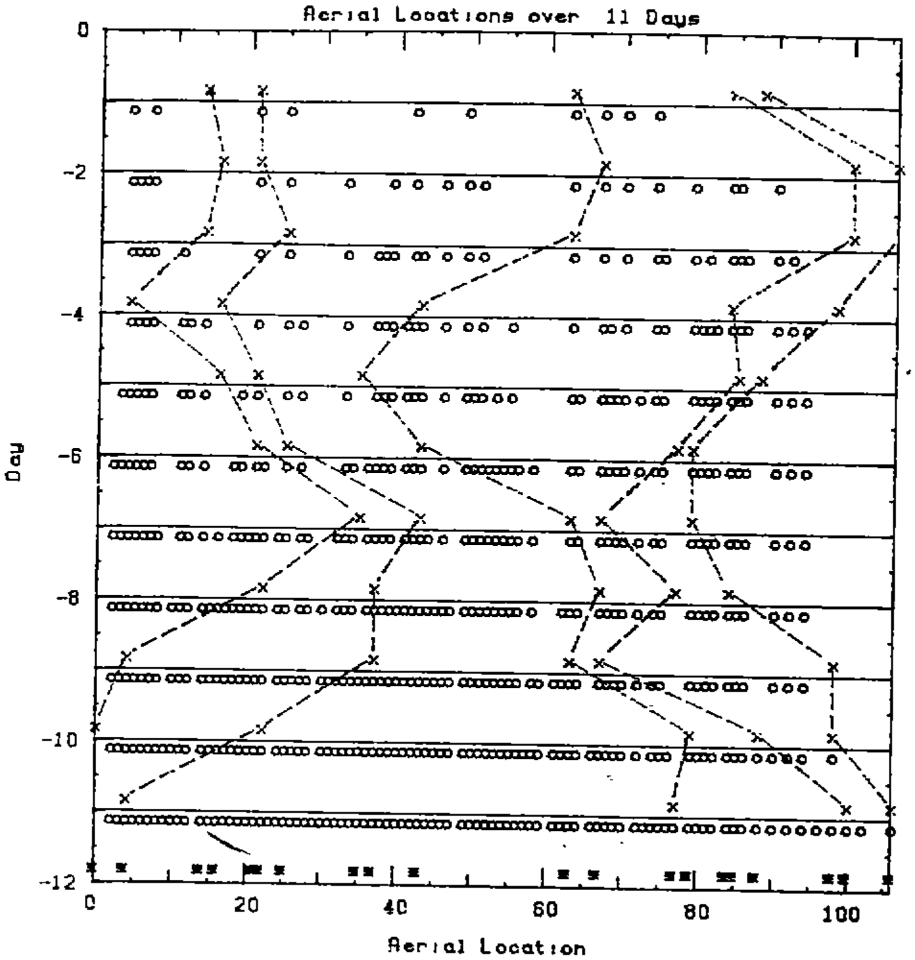

Fig. 1.1 1·5 km array

20 stations
11 days
87 baselines between 2 and 106.

day	Aerial no. 1	2	3	4	5
1	14	21	63	84	88
2	16	21	67	100	106
3	14	25	63	100	106
4	4	16	43	84	98
5	16	21	35	85	88
6	21	25	43	77	79
7	35	43	63	67	79
8	22	37	67	77	84
9	4	37	63	67	98
10	0	22	79	88	98
11	0	4	77	100	106

TABLE 11a Aerial locations for 15km array

day 1

```
      74
    70  67
  49  63  25
7   42  21   4
```

day 2

```
      90
    84  85
  51  79  39
5   46  33   6
```

day 3

```
       92
     86  81
   49  75  43
11   38  37   6
```

day 4

```
       94
     80  82
   39  68  55
12   27  41  14
```

day 5

```
      72
    69  67
  19  64  53
5   14  50   3
```

day 6

```
      58
    56  54
  22  52  36
4   18  34   2
```

day 7

```
      44
    32  36
  28  24  16
8   20   4  12
```

day 8

```
       62
     55  47
   45  40  17
15   30  10   7
```

day 9

```
       94
     63  61
   59  30  35
33   26   4  31
```

day 10

```
       98
     88  76
   79  66  19
22   57   9  10
```

day 11

```
       106
     100  102
    77  96  29
4   73   23   6
```

day

TABLE 11b Baselines obtained on each day of 15 km array

1.2 THE 3 KM ARRAY

In order to obtain a reasonable coverage between 3 and 6 km in the 6 km array we have chosen a 3 km array which does not obtain some of the long baselines. This array gives us 195 baselines between 2 and 211 in 22 days. Roughly speaking, every other baseline between 189 and 211 is missing. To obtain all the missing baselines would require extra days of observation and extra stations (for example : stations at 1, 5, 9 and 209).

See Fig 1.2 and Tables 1.2a and 1.2b.

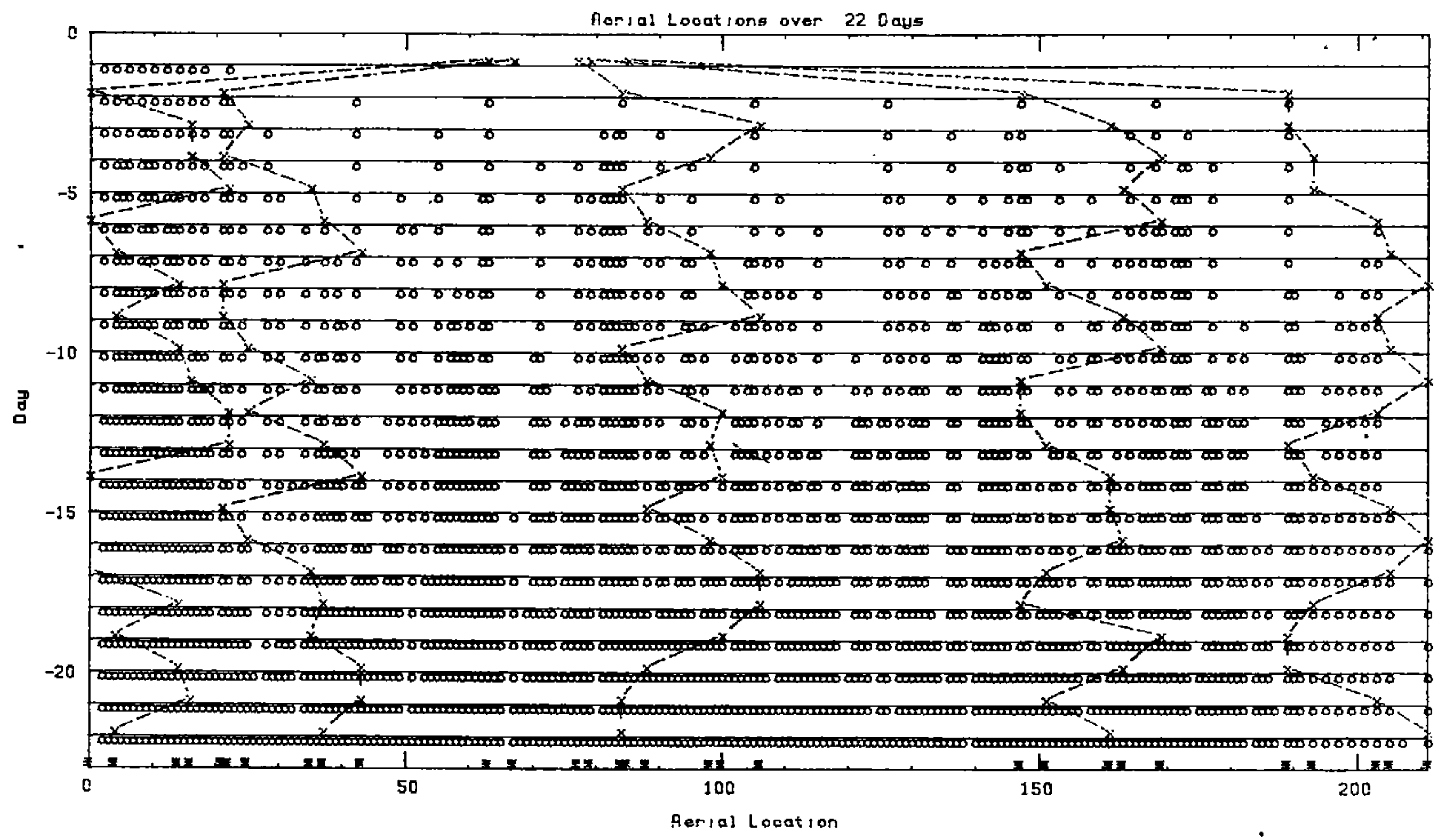

Fig.1.2. 3km array

30 stations
22 days
195 baselines between 2 and 211

day	1	2	3	4	5
1	[illegible]	67	77	79	85
2	0	21	84	147	189
3	16	25	106	161	189
4	16	21	98	169	193
5	22	35	84	163	193
6	0	37	88	169	203
7	4	43	98	147	205
8	14	21	100	151	211
9	4	21	106	163	203
10	14	25	84	169	205
11	16	35	88	147	211
12	22	25	100	147	203
13	22	37	98	151	189
14	0	43	100	161	193
15	0	21	88	161	205
16	0	25	98	163	211
17	0	35	106	151	205
18	14	37	106	147	193
19	4	35	100	169	189
20	14	43	88	163	189
21	16	43	84	151	203
22	4	37	84	161	211

TABLE 13 Aerial locations for 3 km array

day 1	day 2	day 3	day 4	day 5	day 6
22	189	173	177	171	203
16 18	147 168	145 164	153 172	141 158	169 166
14 12 8	84 126 105	90 136 83	82 148 95	62 128 109	88 132 115
4 10 2 6	21 63 63 42	9 81 55 28	5 77 71 24	13 49 79 30	37 51 81 34

day 7	day 8	day 9	day 10	day 11	day 12
201	197	199	191	195	161
143 162	137 190	159 182	155 180	131 176	125 178
94 104 107	86 130 111	102 142 97	70 144 121	72 112 123	78 122 103
39 55 49 58	7 79 51 60	17 85 57 40	11 59 85 36	19 53 59 64	3 75 47 56

day 13	day 14	day 15	day 16	day 17	day 18
167	193	205	211	205	179
129 152	161 150	161 184	163 186	151 170	133 156
76 114 91	100 118 93	88 140 117	98 138 113	106 116 99	92 110 87
15 61 53 38	43 57 61 32	21 67 73 44	25 73 65 48	35 71 45 54	23 69 41 46

day 19	day 20	day 21	day 22	day
185	175	187	207	
165 134	149 146	135 160	157 174	
96 134 89	74 120 101	68 108 119	80 124 127	
[illegible] 65 69 10	29 45 75 26	27 41 67 51	33 47 77 50	

TABLE 14 Baselines obtained on each day of 3 km array

1.3 THE 6 KM ARRAY

The 6 km array is simply the 3 km array with an additional antenna at the 6 km point (stations 415 and 421). See Fig 1.3 and Tables 1.3a and 1.3b. The gap between baselines 274 and 309 may be filled by the addition of one or two stations between 106 and 147. Taking note of the stations to be introduced in the next section, we may replace day 2 of Table 1.3a with

1 22 85 119 127 415

to obtain the coverage shown in Fig 1.3'

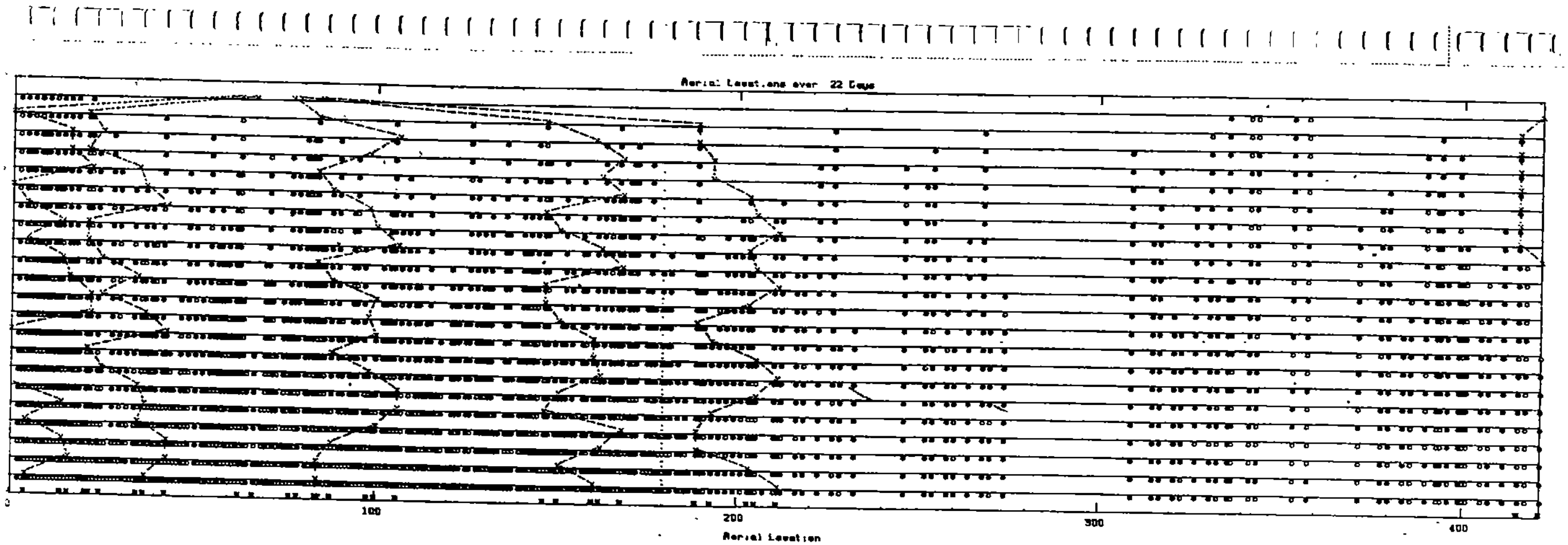

Fig 1.3 6 km array.

32 stations
22 days
245 baselines : 197 between 2 and 211
48 between 212 and 421

day	Aerial no. 1	2	3	4	5	6
1	63	67	77	79	85	421
2	0	21	84	147	189	415
3	16	25	106	161	189	415
4	16	21	98	169	193	415
5	22	35	84	163	193	415
6	0	37	88	169	203	415
7	4	43	98	147	205	415
8	14	21	100	151	211	415
9	4	21	106	163	203	421
10	14	25	84	169	205	421
11	16	35	88	147	211	421
12	22	25	100	147	203	421
13	22	37	98	151	189	421
14	0	43	100	161	193	421
15	0	21	88	161	205	421
16	0	25	98	163	211	421
17	0	35	106	151	205	421
18	14	37	106	147	193	421
19	4	35	100	169	189	421
20	14	43	88	163	189	421
21	16	43	84	151	203	421
22	4	37	84	161	211	421

TABLE 1.3a Aerial locations for 6 km array.

day 1
358
22 354
16 18 344
14 12 8 342
4 10 2 6 336

day 2
415
189 394
147 168 331
84 126 105 268
21 63 63 42 226

day 3
399
173 390
145 164 309
90 136 83 254
9 81 55 28 226

day 4
399
177 394
153 172 317
82 148 95 246
5 77 71 24 222

day 5
393
171 380
141 158 331
62 128 109 252
13 49 79 30 222

day 6
415
203 378
169 166 327
88 132 115 246
37 51 81 34 212

day 7
411
201 372
143 162 317
94 104 107 268
39 55 49 58 210

day 8
401
197 394
137 190 315
86 130 111 264
7 79 51 60 204

day 9
417
199 400
159 182 315
102 142 97 258
17 85 57 40 218

day 10
407
191 396
155 180 337
70 144 121 252
11 59 85 36 216

day 11
405
195 386
131 176 333
72 112 123 274
19 53 59 64 210

day 12
399
181 396
125 178 321
78 122 103 274
3 75 47 56 218

day 13
399
167 384
129 152 323
76 114 91 270
15 61 53 38 232

day 14
421
193 378
161 150 321
100 118 93 260
43 57 61 32 228

day 15
421
205 400
161 184 333
88 140 117 260
21 67 73 44 216

day 16
421
241 396
163 186 323
98 138 113 258
25 73 65 48 210

day 17
421
205 386
151 170 315
106 116 99 270
35 71 45 54 216

day 18
407
179 384
133 156 315
92 110 87 274
23 69 41 46 228

day 19
417
185 386
165 154 321
96 174 89 252
31 65 65 20 232

day 20
407
175 378
149 146 333
74 120 101 258
29 45 75 26 232

day 21
405
187 378
135 160 337
68 108 119 270
27 41 67 52 218

day 22
417
207 384
157 174 337
83 124 127 260
33 47 77 50 210

TABLE 1.3b Baselines obtained on each day of 6 km array.

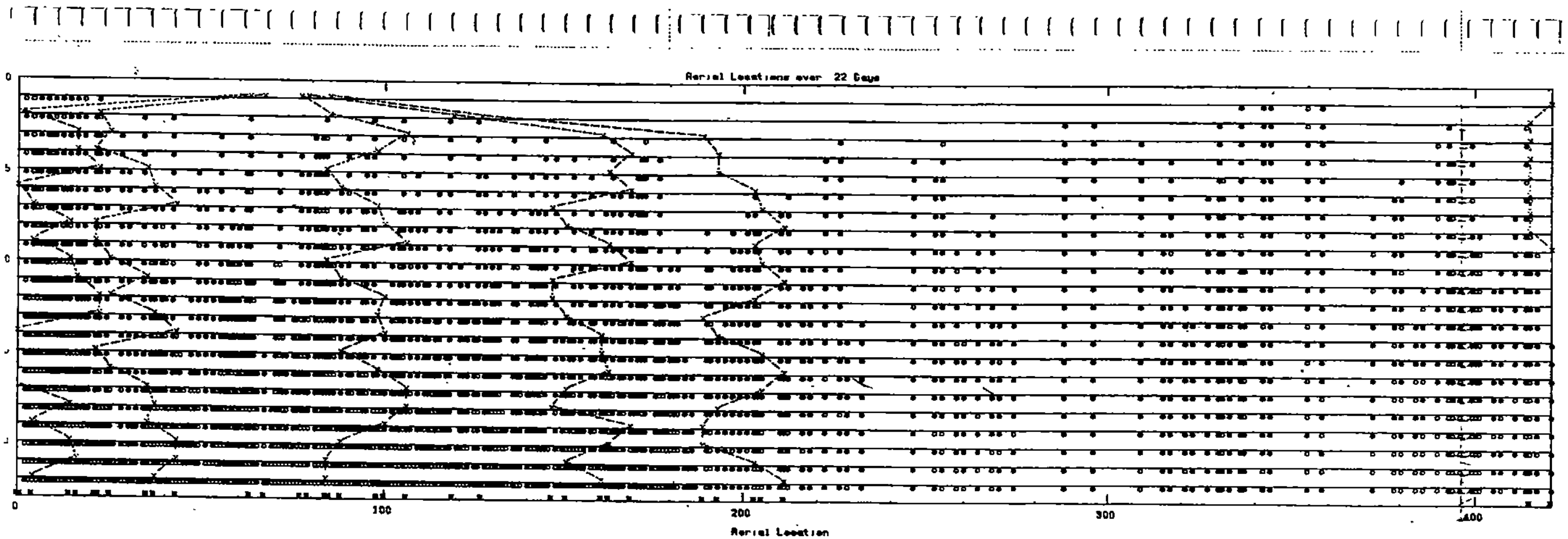

Fig. 1.3′ 6 km array using extra stations

35 stations
22 days
246 baselines : 194 between 2 and 211
52 between 212 and 421

2.0 FREQUENCY SCALING

We consider two pairs of frequency scaled arrays, both with a scaling factor of 2 :

1.5/3 km arrays and 3/6 km arrays

In frequency scaled arrays the larger array obtains baselines which are twice those obtained on the corresponding day of the smaller array. The frequency scaled arrays that we present here are not exact in that there are some exceptions to this rule.

For these frequency scaled arrays we require 3 more stations on the 3 km track : 1, 119, 127.

2.1 FREQUENCY SCALED ARRAYS 1.5/3 km

We use the 1.5 km array given in §1.1. Fig 2.1 and Tables 2.1a and 2.1b present the required frequency scaled 3 km array. Each day of this 3 km array obtains baselines double those obtained on the corresponding day of the 1.5 km array with the exception of days 10 and 11.

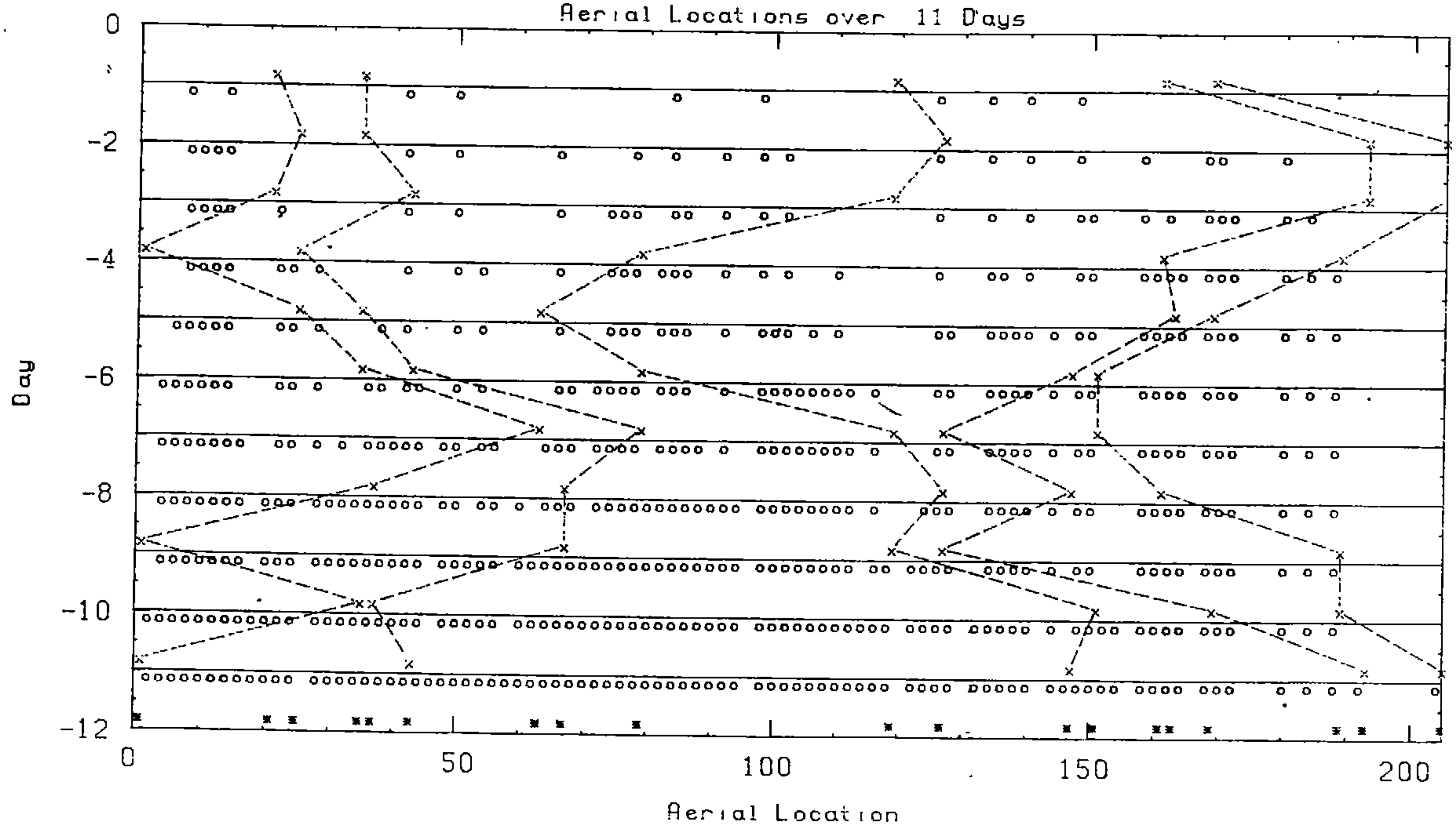

Fig 2.1 3 km array for 1.5/3 km frequency scaling

day	Aerial no. 1	2	3	4	5
1	21	35	119	161	169
2	25	35	127	193	205
3	21	43	119	193	205
4	1	25	79	161	189
5	25	35	63	163	169
6	35	43	79	147	151
7	63	79	119	127	151
8	37	67	127	147	161
9	1	67	119	127	189
10	35	37	151	169	189
11	1	43	147	193	205

TABLE 2.1a Aerial locations for 3 km array for 1.5/3 km frequency scaling

day 1

148			
140	134		
98	126	50	
14	84	42	8

day 2

180			
168	170		
102	158	78	
10	92	66	12

day 3

184			
172	162		
98	150	86	
22	76	74	12

day 4

188			
160	164		
78	136	110	
24	54	82	28

day 5

144			
138	134		
38	128	106	
10	28	100	6

day 6

116			
112	108		
44	104	72	
8	36	68	4

day 7

88			
64	72		
56	48	32	
16	40	8	24

day 8

124			
110	94		
90	80	34	
30	60	20	14

day 9

188			
126	122		
118	60	70	
66	52	8	62

day 10

154			
134	152		
116	132	38	
2	114	18	20

day 11

204			
192	162		
146	150	58	
42	104	46	12

TABLE 2.1b Baselines obtained on each day of 3 km array for 1.5/3 km frequency scaling.

2.2 FREQUENCY SCALED ARRAYS 3/6 km

As we cannot achieve a complete filling between 3 and 6 km in the 6 km array, for 3/6 km frequency scaling we use a 3 km array which does not have a complete filling between 1.5 and 3 km. This array is presented in Fig 2.2 and Tables 2.2a and 2.2b. Using 5 antennas on the 3 km track we obtain 109 baselines in 14 days. The frequency scaled 6 km array is presented in Fig 2.2' and Tables 2.2'a and 2.2'b. As this array uses 6 antennas we require only 11 days of observation. On each of the first 9 days we obtain baselines double those of the 3 km array which lie between 0 and 1.5 km.

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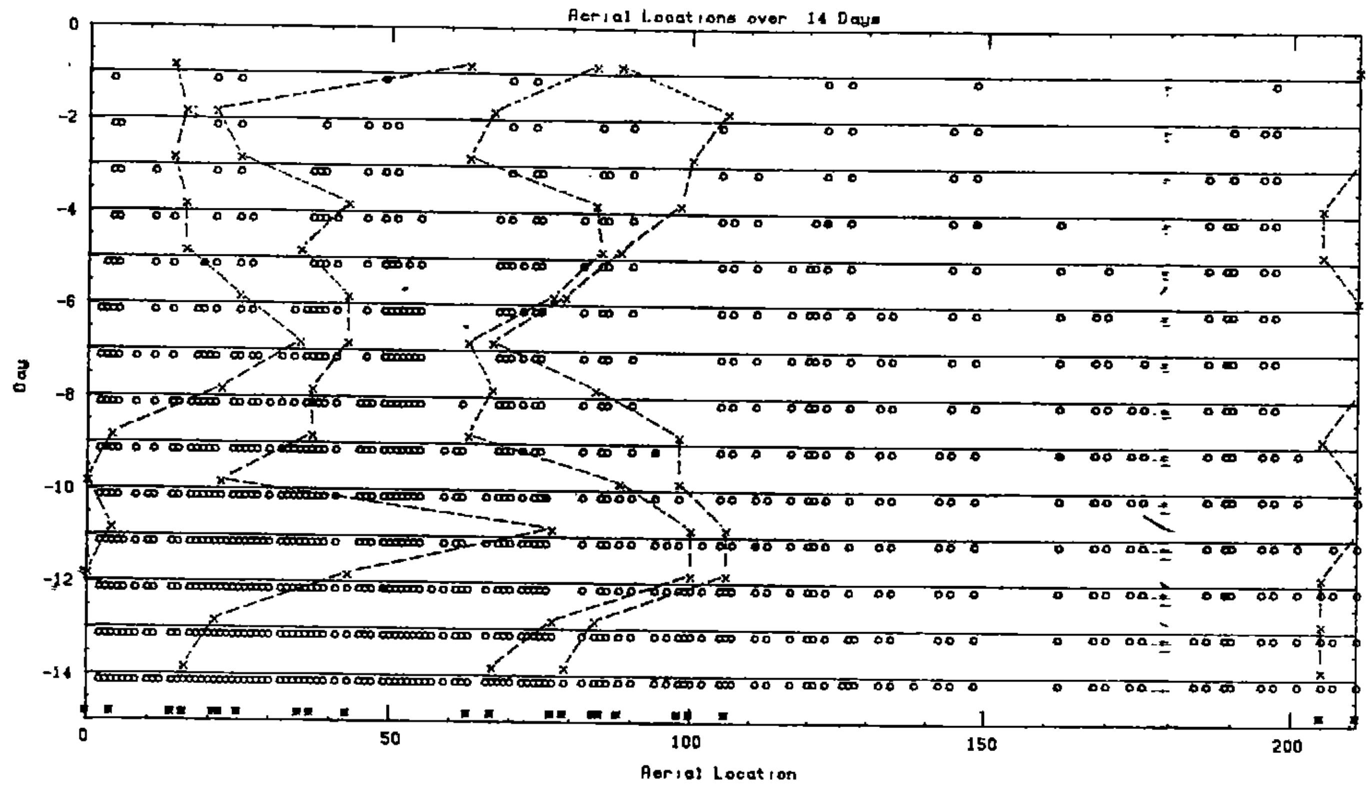

Fig. 2.2 3 km array for 3/6 frequency scaling

22 stations
14 days
109 baselines ; 75 between 2 and 100
34 between 101 and 211

day	Aerial 1	2	3	4	5
1	14	63	84	98	211
2	16	21	67	106	211
3	14	25	63	100	211
4	16	43	84	98	205
5	16	35	85	88	205
6	25	43	77	79	211
7	35	43	63	67	211
8	22	37	67	84	211
9	4	37	63	98	205
10	0	22	88	98	211
11	4	77	100	106	211
12	0	43	100	106	205
13	0	21	77	84	205
14	0	16	67	79	205

TABLE [illegible]. Aerial locations for 3 km array *for 3/6 frequency scaling*

day 1

197
74 148
70 25 127
49 21 4 123

day 2

195
90 190
51 85 144
5 46 39 105

day 3

197
86 186
49 75 148
11 38 37 111

day 4

189
82 162
68 55 121
27 41 14 107

day 5

189
72 170
69 53 120
19 50 3 117

day 6

186
54 168
52 36 134
18 34 2 132

day 7

176
32 168
28 24 148
8 20 4 144

day 8

189
62 174
45 47 144
15 30 17 127

day 9

201
94 168
59 61 142
33 26 35 107

day 10

211
98 189
88 76 123
22 66 10 113

day 11

207
102 134
96 29 111
73 23 6 105

day 12

205
106 162
100 63 105
43 57 6 99

day 13

205
84 184
77 63 128
21 56 7 121

day 14

205
79 189
67 63 138
16 51 12 126

day

TABLE [illegible]. Baselines obtained on each day of 3 km array *for 3/6 frequency scaling*

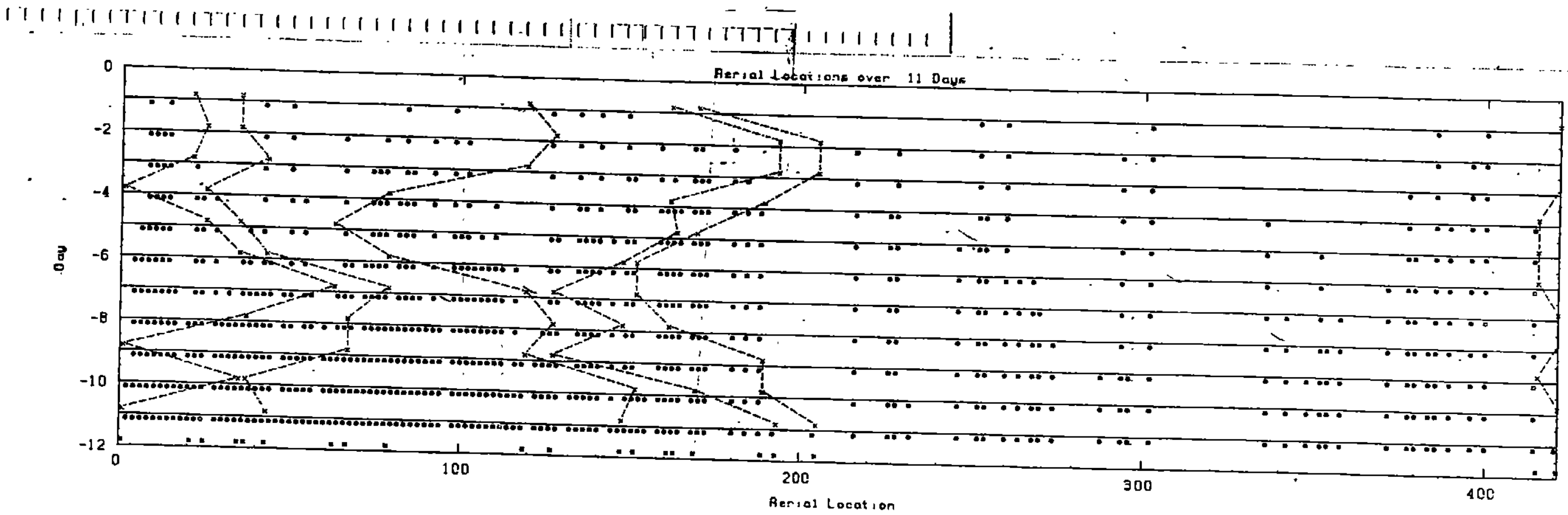

Fig 2.2' 6 km array for 3/6 km frequency scaling

19

day	Aerial no. 1	2	3	4	5	6
1	21	35	119	161	169	421
2	25	35	127	193	205	421
3	21	43	119	193	205	421
4	1	25	79	161	189	415
5	25	35	63	163	169	415
6	35	43	79	147	151	415
7	63	79	119	127	151	421
8	37	67	127	147	161	421
9	1	67	119	127	189	415
10	35	37	151	169	189	421
11	1	43	147	193	205	421

TABLE 2.2a Aerial locations for 6 km array for 3/6 frequency scaling.

day 1
400
148 386
140 134 302
98 126 50 260
14 84 42 8 252

day 2
396
180 386
168 170 294
102 158 78 228
10 92 66 12 216

day 3
400
184 378
172 162 302
98 150 86 228
22 76 74 12 216

day 4
414
188 390
160 164 336
78 136 110 254
24 54 82 28 226

day 5
390
144 380
138 134 352
38 128 106 252
10 28 100 6 246

day 6
380
116 372
112 108 336
44 104 72 268
8 36 68 4 264

day 7
358
88 342
64 72 302
56 48 32 294
16 40 8 24 270

day 8
384
124 354
110 94 294
90 80 34 274
30 60 20 14 260

day 9
414
188 348
126 122 296
118 60 70 288
66 52 8 62 226

day 10
386
154 384
134 152 270
116 132 38 252
2 114 18 20 232

day 11
420
204 378
192 162 274
146 150 58 228
42 104 46 12 216

TABLE 2.2b Baselines obtained on each day of 6 km array for 3/6 freuency scaling.

2.3 FOUR FREQUENCY SCALED SINGLE DAY OBSERVATIONS

Fig 2.3 and Tables 2.3a and 2.3b present four single day observations. In observation 1 we obtain baselines 2, 4, 6, 8, 10, 12, 14, 16, 18 and 22. Observation 2 obtains baselines double these, observation 3 four times these, and observation 4 eight times these.

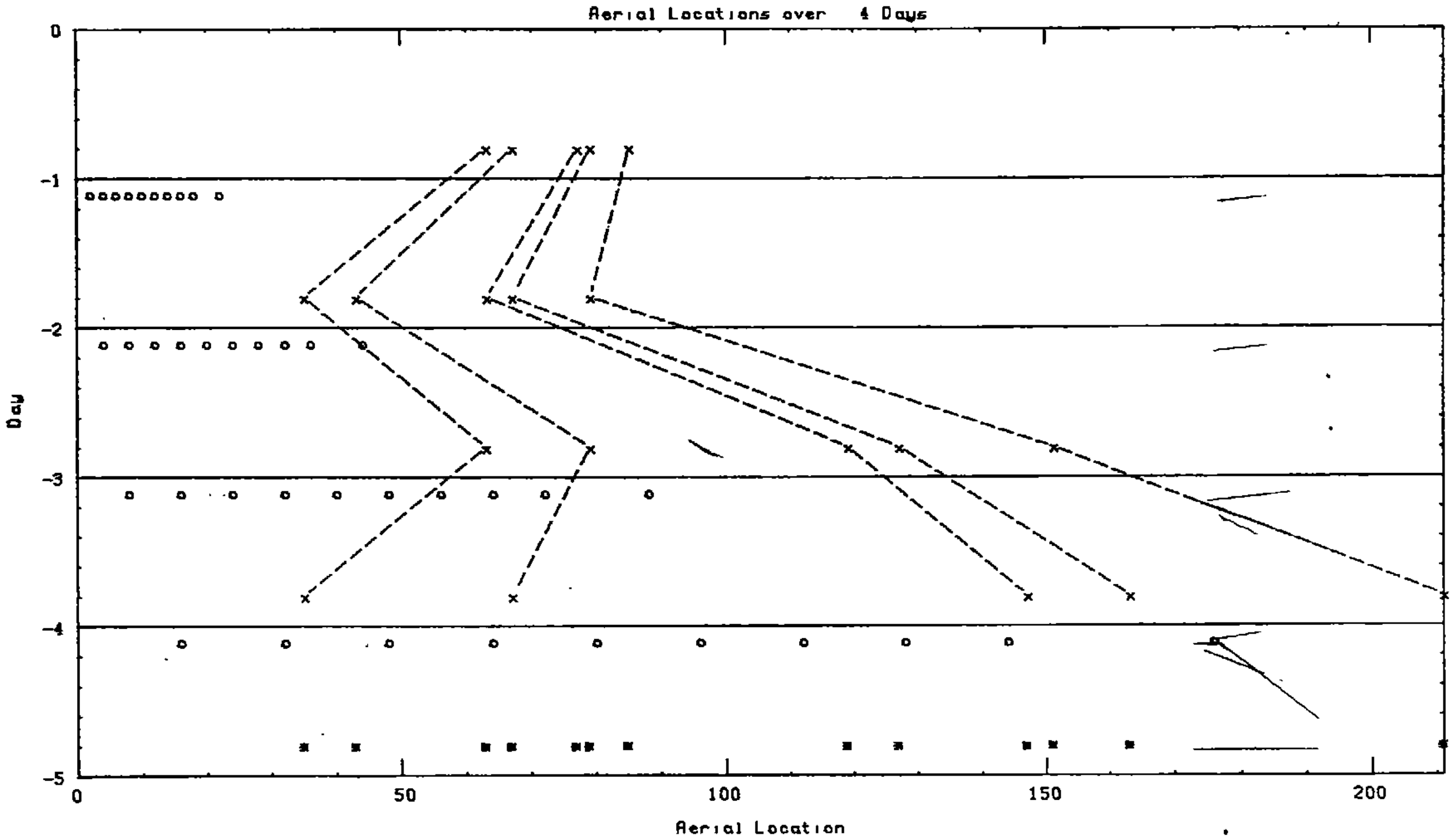

Fig 2.3 FOUR FREQUENCY SCALED SINGLE DAY OBSERVATIONS

Each observation obtains baselines double those of the previous one.

observation	Aerial no. 1	2	3	4	5
1	63	67	77	79	85
2	35	43	63	67	79
3	63	79	119	127	151
4	35	67	147	163	211

TABLE 2.3a Aerial locations for single day frequency scaled observations.

observation 1	observation 2	observation 3	observation 4
22	44	88	176
16 18	32 36	64 72	128 144
14 12 8	28 24 16	56 48 32	112 96 64
4 10 2 6	8 20 4 12	16 40 8 24	32 80 16 48

TABLE 2.3b Baselines obtained in frequency scaled observations.

3.0 REDUNDANT OBSERVATIONS

With the addition of two stations (91, 181) to the 35 stations used for the basic arrays and the frequency scaled arrays, we may make the following fully redundant observations (Tables 3.0a, 3.0b, 3.0'a, 3.0'b).

	Aerial No. 1	2	3	4	5	6
day 1	1	85	127	169	211	421
2	1	91	151	181	211	421

TABLE 3.0a Aerial locations for fully redundant observations with 6 antennas.

day 1

420				
210	336			
168	126	294		
126	84	84	252	
84	42	42	42	210

day 2

420				
210	330			
180	120	270		
150	90	60	240	
90	60	30	30	210

TABLE 3.0b Baselines obtained in each redundant observation.

	Aerial No. 1	2	3	4	5
day 1	67	79	85	88	91
2	43	67	79	85	91

TABLE 3.0'a Aerial locations for fully redundant observations with 5 antennas.

day 1

24			
21	12		
18	9	6	
12	6	3	3

day 2

48			
42	24		
36	18	12	
24	12	6	6

TABLE 3.0'b Baselines obtained in each redundant observation.

... 24

3.1 DAY-TO-DAY REDUNDANCY

Fig 3.1 and Tables 3.1a and 3.1b present an observing program with day-to-day redundancy which allows us to solve for phase errors. Days 1, 2 and 3 come from the fully redundant observations given in §3.0 and have enough common baselines (using all 6 antennas) to be able to solve for phase errors from day-to-day. The remaining 7 days (taken in sequence) have 4 redundant baselines between the 5 antennas on the 3 km track so that phase errors between these may be determined. We also have enough redundancy to determine the phase of the sixth antenna.

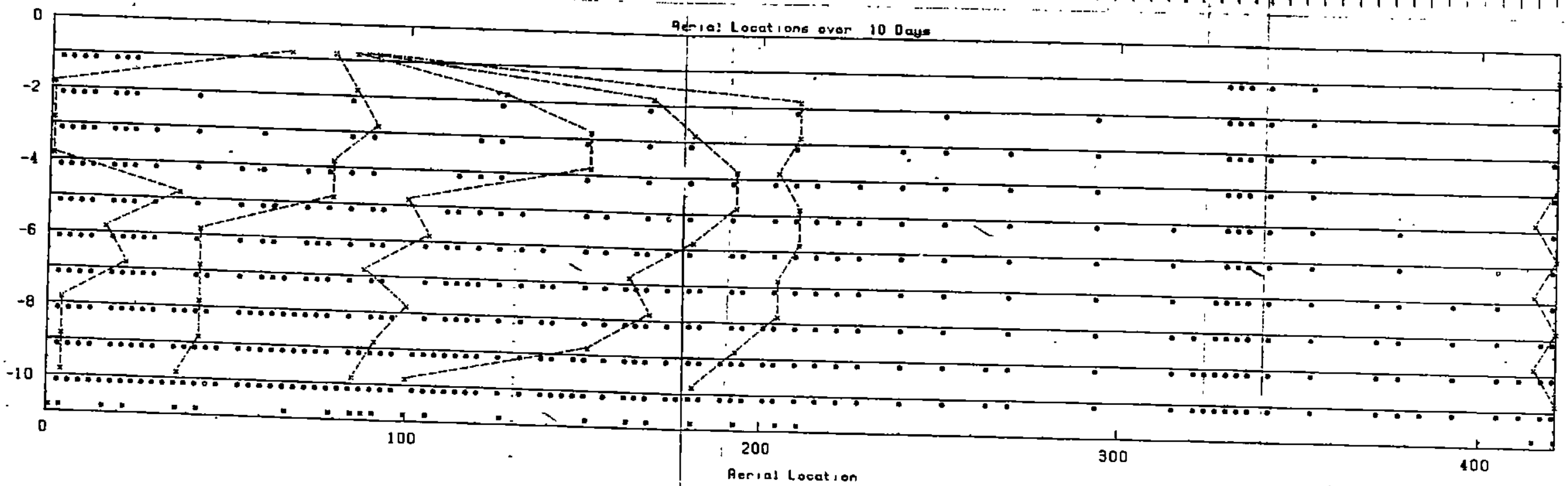

Fig. 3.1 Day-to-day redundancy

day	Aerial no. 1	2	3	4	5	6
1	67	79	85	88	91	421
2	1	85	127	169	211	421
3	1	91	151	181	211	421
4	1	79	151	193	205	421
5	37	79	100	193	211	415
6	16	43	106	181	211	421
7	22	43	88	163	205	415
8	4	43	100	169	205	421
9	4	43	91	151	193	415
10	4	37	85	100	181	421

TABLE 3.1a Aerial locations for day-to-day redundant observations.

```
day 1            day 2            day 3            day 4            day 5            day 6
    354              420              420              420              378              405
   24 342          210 336          210 330          204 342          174 336          195 378
  21 12 336      168 126 294      180 120 270      192 126 270      156 132 315      165 168 315
 18 9 6 333     126 84 84 252    150 90 60 240    150 114 54 228   63 114 111 222   90 138 105 240
12 6 3 3 330   84 42 42 42 210  90 60 30 30 210  78 72 42 12 216  42 21 93 18 204  27 63 75 30 210

day 7            day 8            day 9            day 10
    393              417              411              417
  183 372          201 378          189 372          177 384
 141 162 327      165 162 321      147 150 324      96 144 336
66 120 117 252   96 126 105 252   87 108 102 264   81 63 96 321
21 45 75 42 210  39 57 69 76 216  39 48 60 42 222  33 48 15 61 240
```

TABLE 3.1b Baselines obtained on each day of day-to-day redundant observations.

4.0 PSEUDO-ZOOM ARRAYS

Fig 4.0 and Tables 4.0a and 4.0b present an observing program which obtains a predominance of shorter baselines. This is an attempt to imitate the baseline distribution obtained by a zoom array.

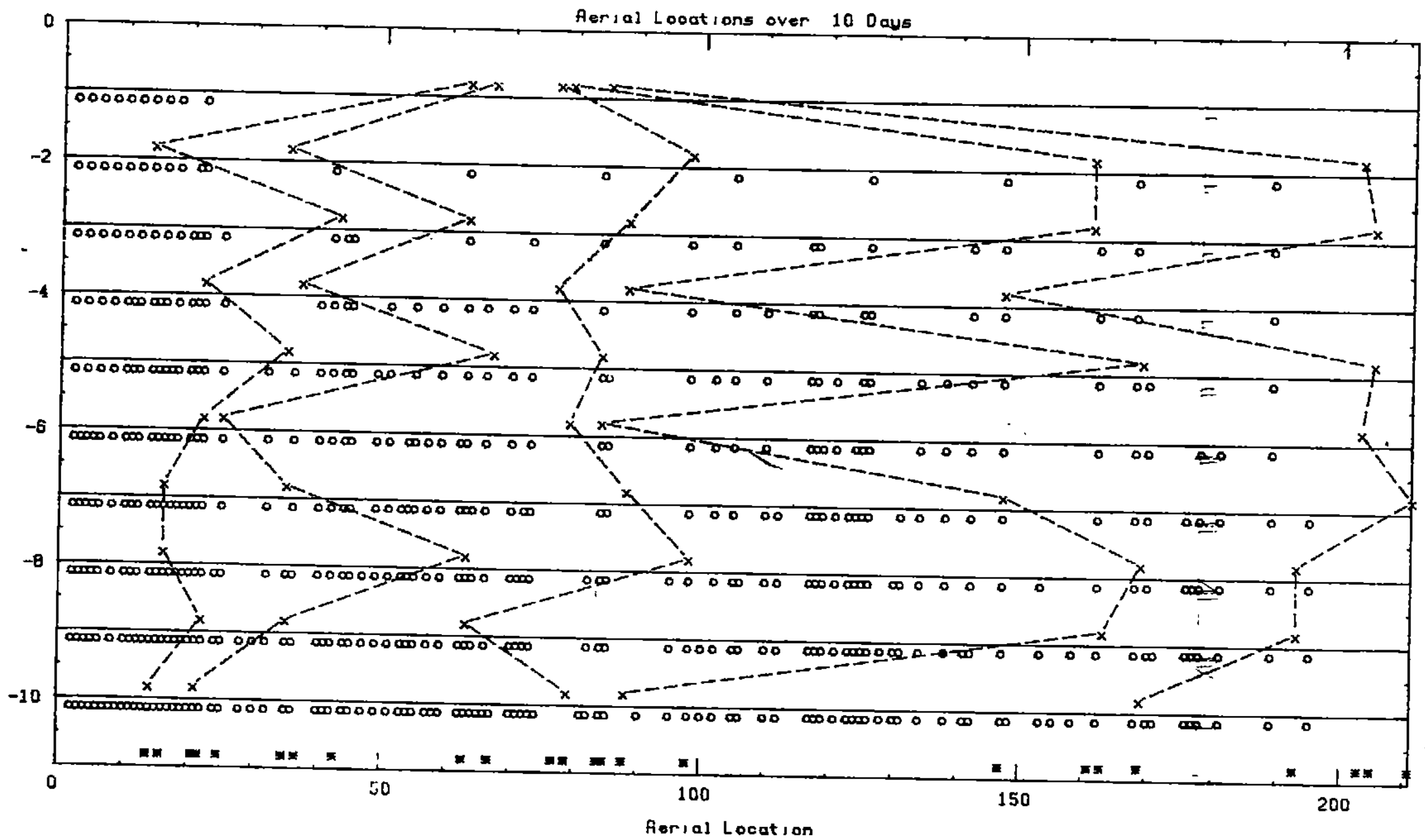

Fig 4.0 Pseudo-zoom array.

day	Aerial no. 1	2	3	4	5
1	63	67	77	79	85
2	14	35	98	161	203
3	43	63	88	161	205
4	22	37	77	88	147
5	35	67	84	169	205
6	22	25	79	84	203
7	16	35	88	147	211
8	16	63	98	169	193
9	22	35	63	163	193
10	14	21	79	88	169

TABLE 4.0a Aerial locations for pseudo-zoom array.

day 1	day 2	day 3	day 4	day 5	day 6
22	189	162	125	170	181
16 18	147 168	118 142	66 110	134 138	62 178
14 12 8	84 126 105	45 98 117	55 51 70	49 102 121	57 59 124
4 10 2 6	21 63 63 42	20 25 73 44	15 40 11 59	32 17 85 36	3 54 5 119

day 7	day 8	day 9	day 10	day
195	177	171	155	
131 176	153 130	141 158	74 148	
72 112 123	82 106 95	41 128 130	65 67 90	
19 53 59 64	47 35 71 24	13 28 100 30	7 58 9 81	

TABLE 4.0b Baselines obtained on each day of pseudo-zoom array.

APPENDIX

In this appendix we describe the method used to construct the observing programs that we have presented.

Definition: A system $A = A_1, \ldots, A_m$ of sets of non-negative integers, $A_i = \{a_{i_1}, \ldots, a_{in}\}$, with $|\bigcup_{i=1}^{m} A_i| = s$ is called an (s,m,n)-difference basis system for t if every integer x, with $1 \leq x \leq t$, may be represented as a difference $x = a_{ij} - a_{ik}$.

Theorem: Let A be an (s_1,m_1,n) - difference basis system for t_1 and let B be an (s_2,m_2,n) - difference basis system for t_2. Suppose n is a prime power and let G be a sharply 2-transitive permutation group acting on $\{1, \ldots, n\}$. Let C be the system consisting of the following sets:

$C_{ijg} = \{(2t_2H)\, a_{ik} + b_{jg(k)} | k = 1, \ldots, n\}$; $1 \leq i \leq m_1, 1 \leq j \leq m_2, g \in G$;

$A_i' = \{ 2(t_2+1)\, a_{ik} + b_{11} \mid k=1, \ldots, n\}$; $1 \leq i \leq m_1$;

$B_i' = \{ 2(t_2+1)\, a_{11} + b_{ik} \mid k=1, \ldots, n\}$; $1 \leq i \leq m_2$.

Then C is an $(s_1s_2, m_1m_2n(n-1)+m_1+m_2, n)$-difference basis system for $2t_1t_2+t_1+t_2$.

Remark: The system C is a difference basis system for $2t_1t_2+t_1+t_2-(d_2-t_2)$, where d is the largest of the differences $b_{ij}-b_{ik}$, under the weaker hypothesis that the differences $b_{ij}-b_{ik}$ form a complete set of representatives of the residue classes mod $2t_2+1$.

An (s,m,n)-difference basis for t determines an observing program for an array of n antennas, m days, s stations and maximum baseline t. Taking A = {0,1,4,7,9} (a (5,1,5)-difference basis system for 9) and B = {0,4,14,16,22} (whose differences give a complete set of representatives of the residue classes mod 21) we obtain a (25,22,5)-difference basis system for 187. We also obtain 189,190,191,193,195,197,199,201,203,205,207 and 211 as differences. This difference basis system is used as the 3 km array given in Table 1.2a. (We have changed one of these sets (day 15) to eliminate the difference 1).

... 31

Note: one could also choose B = {0,2,7,8,11} to obtain a difference basis system for 198. However the stations corresponding to this do not give as good a coverage in the 6 km array.

The observing program for the 1.5 km array (Table 1.1a) is obtained by using sets of the form

$$\{27a_k + b_{g(k)} \mid k=1, \ldots, 5\}$$

where $\{a_1, \ldots, a_5\} \subseteq \{0,1,3,4\}$

$$\{b_1, \ldots, b_5\} = \{0,4,14,16,22\}$$

and $g \in G$ (a sharply 2-transitive permutation group of order 20). As {0,1,3,4} is a difference basis system for 4 such sets form a difference basis system for 82. They also supply 84,85,86,88,90,92,94,96, 98,100,102 and 106 as differences.

Eight of these sets were chosen, using the criterion that their redundancy was small. Three more sets were then added, in an ad hoc manner, to obtain as many as possible of the missing differences, while not introducing any new stations.

The observing program for the 6 km array is simply the observing program for the 3 km array with the sixth antenna introduced at the 6 km point.

The 3 km array (Table 2.1a) for 1.5/3 km frequency scaling is obtained by using the set

$$\{27(2a_k+1) + (2b_{g(k)}-28) \mid k=1, \ldots, 5\}$$

corresponding to the set

$$\{21\, a_k + b_{g(k)} \mid k=1, \ldots, 5\}$$

of the 1.5 km array (with an adjustment to days 10 and 11). The factor 2 is introduced to give differences which are double those of the 1.5 km array and the translates 1 and -18 are introduced so that

$$2\,\{0,1,3,4\} + 1 \quad \text{and} \quad 2\,\{0,4,14,16,22\} - 28$$

have as many elements as possible in common with A = {0,1,4,7,9} and B = {0,4,14,16,22} thus keeping to a minimum the number of new stations required.

... 33

Eleven of the days of the observing program (Table 2.2a) for the 3 km array for 3/6 km frequency scaling are obtained by using 4 of the 5 antenna locations of the 1.5 km array (Table 1.1a) with the fifth antenna being placed at one of two stations at the 3 km point (205,211). The location left out is chosen to minimize the number of redundancies. The other 3 days of Table 2.2a are chosen to provide as many as possible of the missing baselines, while not using any new stations.

The observing program for the 6 km array used in 3/6 km frequency scaling is the program used for the 3 km array for 1.5/3 km frequency scaling with the addition of the sixth antenna at the 6 km point.

The observing program given in Table 3.1 for day-to-day redundant observation was found by computer search for configurations in which four (independant) baselines between the 5 antennas on the 3 km track had been observed on previous days (starting with the baselines obtained by fully redundant observations given in §3.0).

The observing program for the pseudo-zoom array (Table 4.0a) is obtained by computer search through sets of the form

$$\{27a_k+b_{g(k)} \mid k=1, \ldots, 5\}$$

with $\{a_1, \ldots, a_5\} \subseteq \{0,1,3,4,7,9\}$

and $\{b_1, \ldots, b_5\} = \{0,4,14,16,22\}$

and $g \in G$.

The sets $\{a_1, \ldots, a_5\}$ are suitably chosen so that, among the differences $a_i - a_j$, the smaller differences occur more often.