Operational Impact of Delay/Rate Problems

21 feb 00; updated 6 apr 00

This document looks at the effect of the known problems encountered when the *a priori* delay on a specific baseline is close to zero or an appropriate number of tape-frame lengths, or when the *a priori* delay-rate is close to zero. The first part reviews formulations for the occurrence of these conditions, as confirmed empirically over the last few experiments. The second part show results from these experiments graphically, to provide a feel for the impact of these problems in a small number of specific (actual) cases. The third part simulates the percentage of data affected by the full EVN on a variety of source δ's, sub-band bandwidths, fan-outs, integration times, and frequencies. This paper can be found on the public ftp site under `.../rmc/dlyrt0.ps.gz` or through my web page `www.jive.nl/~campbell`.

1. Basic Rules, Pattern Recognition

The delay-based problem occurs when tape headers from the two data streams composing the baseline start to overlap with each other. This is a concern only for MkIV–MkIV baselines; baselines having one or more VLBA recorder will not be affected. This condition pertains when the *a priori* delay is within $\pm t_{\rm crit}$ of $nT_{\rm frm}$, where $n = 0, \pm1, \pm2, \ldots$. Equations that seem to work predictively are:

$$t_{\rm crit} = \frac{(160 + N_{\rm lag}/2) \cdot M_{\rm fanout}}{2BW} \quad (1)$$

$$T_{\rm frm} = \frac{2 \times 10^4 \cdot M_{\rm fanout}}{2BW}, \quad (2)$$

where 160 is the header size in bits and 2×10^4 is the tape-frame size in bits. The fan-out factor is required to obtain the total number of bits in the combined data stream, and the bandwidth factor converts delays from lag-units to physical time units. Something to keep in mind for §3 is that narrower sub-band bandwidths and higher fan-outs will increase $t_{\rm crit}$ linearly — especially important around the $n = 0$ "lobe", since the higher-order lobes will also be pushed outwards. Figure 1 shows typical amplitude and phase *vs.* time response for one of these delay instances (from EP027B). The affected baseline is On–Wb; On–Ef is provided as a control showing the Reference-Target nature of these phase-reference observations. The amplitude during the event (0807–0813 UT) shows a characteristic "double-trapezoid" response, and the phase a characteristic flat $\varphi \simeq +140°$ or $-40°$ trace (shifting by the 180° during the minimum of the "double-trapezoid". Note that this event started in the reference source & continued during the following program source scan. This pass was picked to show that the net behavior is unaffected by the source change, although you can see a little more structure during the bright-source portion.

The delay-rate-based problem occurs when the *a priori* fringe rotator makes only a small number of wraps within an integration period. From looking at the range over which the fringe amplitude was affected on a few instances, the following formulation appears safe:

$$|\mathrm{Rate}| \quad \leq \quad \frac{3}{t_{\mathrm{int}} \cdot \nu_0}. \tag{3}$$

For most cases, "2" in the numerator also suffices. The frequency dependence will result in slightly different ranges for different sub-bands, which could become somewhat significant for dual-frequency observations (or others with non-contiguous bands, say for single-band frequency-synthesis experiments or those trying to be especially clever about Faraday rotation or ionospheric delay). Figure 2 shows typical amplitude *vs.* time response for these delay-rate instances (this time from EP027A). The affected baseline is Nt–Ef; Wb–Ef is provided as a control. We can see separate events for both the reference and target sources (showing the effect of slightly different positions: reference $\alpha = 12^{\mathrm{h}}15^{\mathrm{m}}03^{\mathrm{s}}\!.9781; = 16^{\circ}54'37''\!.936$, target $\alpha = 12^{\mathrm{h}}18^{\mathrm{m}}50^{\mathrm{s}}\!.0; = 14^{\circ}24'53''$). The amplitude of both events shows a clear spike.

The relevant formulae for *a priori* delay and delay rate are:

$$\tau \quad = \quad \frac{-B}{c}\left[\cos\delta_b \cos\delta_s \cos\left(\alpha_b(t) - \alpha_s\right) + \sin\delta_b \sin\delta_s\right] \tag{4}$$

$$\frac{\partial\tau}{\partial t} \quad = \quad \frac{B\Omega_{\oplus}}{c} \cos\delta_b \cos\delta_s \sin\left(\alpha_b(t) - \alpha_s\right). \tag{5}$$

Subscripts b and s refer to the baseline and source, respectively. B is the baseline length. The key point from these equations is that the sinusoidal variation of delay and delay-rate will be smaller for shorter baselines; these will hence spend more time in the relevant Δt ranges in which the above problems will occur. The worst of all cases would be something like Wb–Ef in a UHF experiment with narrow sub-band bandwidths and high fan-out.

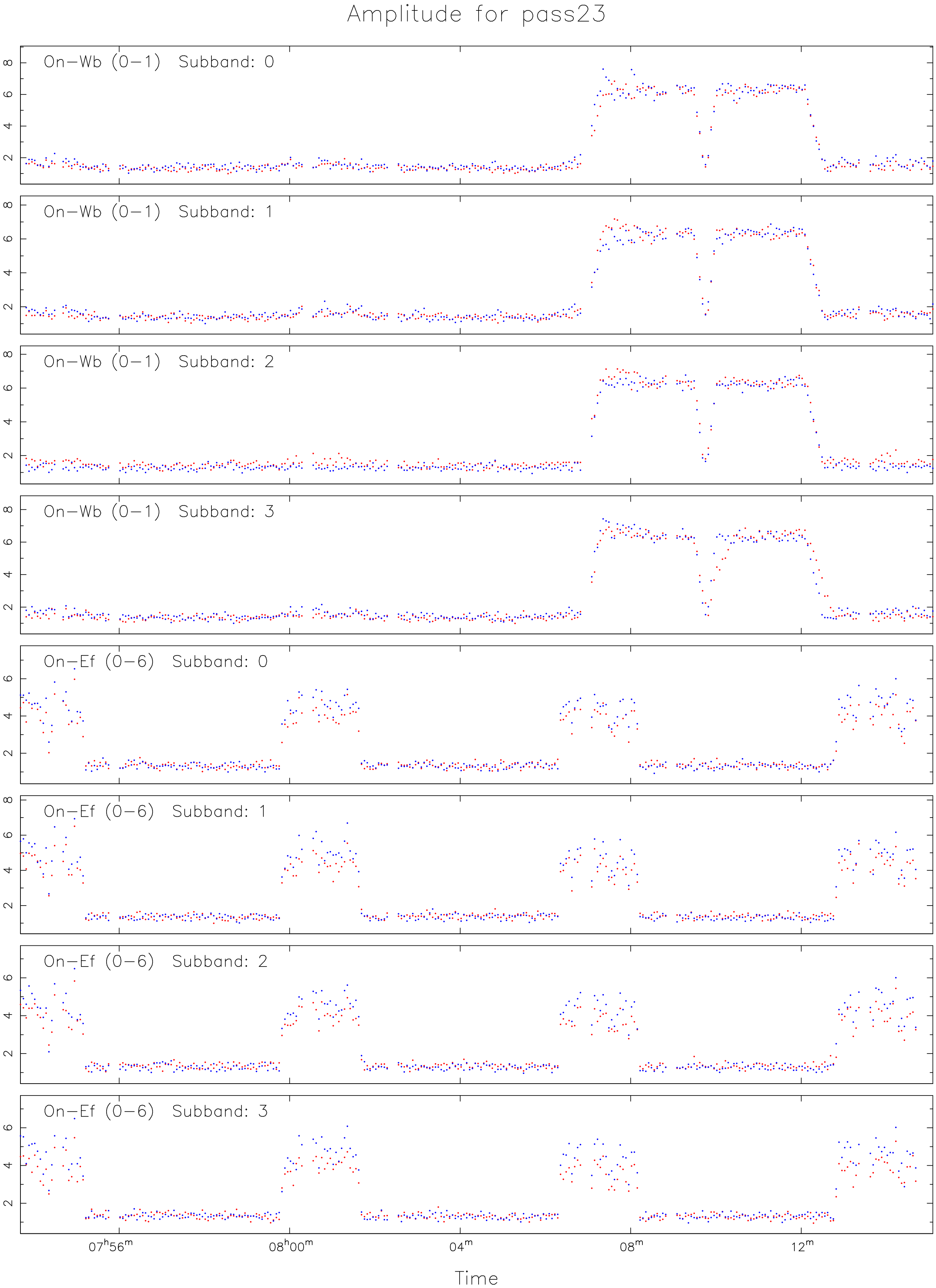

Fig. 1a: Amplitude *vs.* time during a delay=0 event.

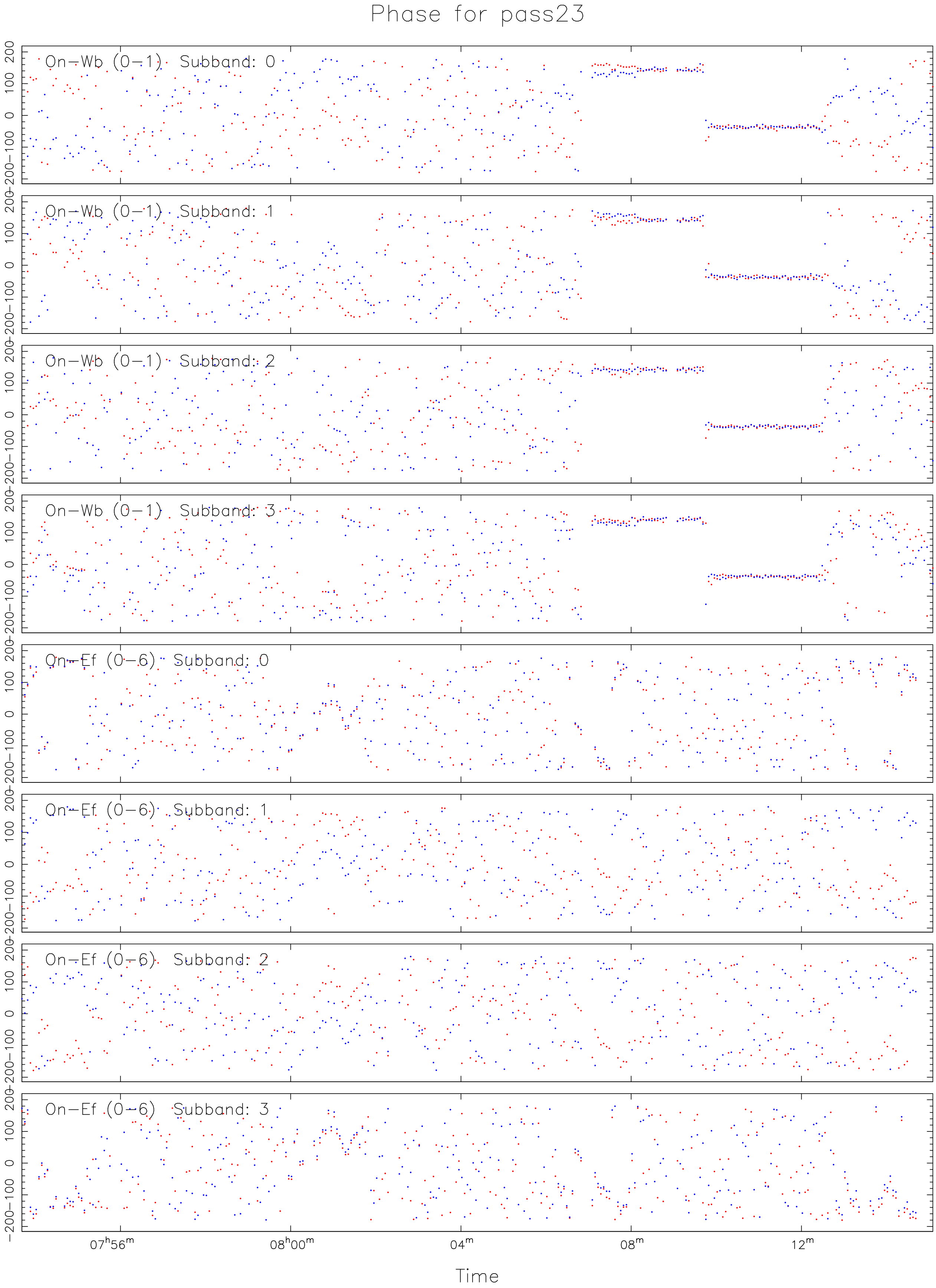

Fig. 1b: Phase *vs.* time during a delay=0 event.

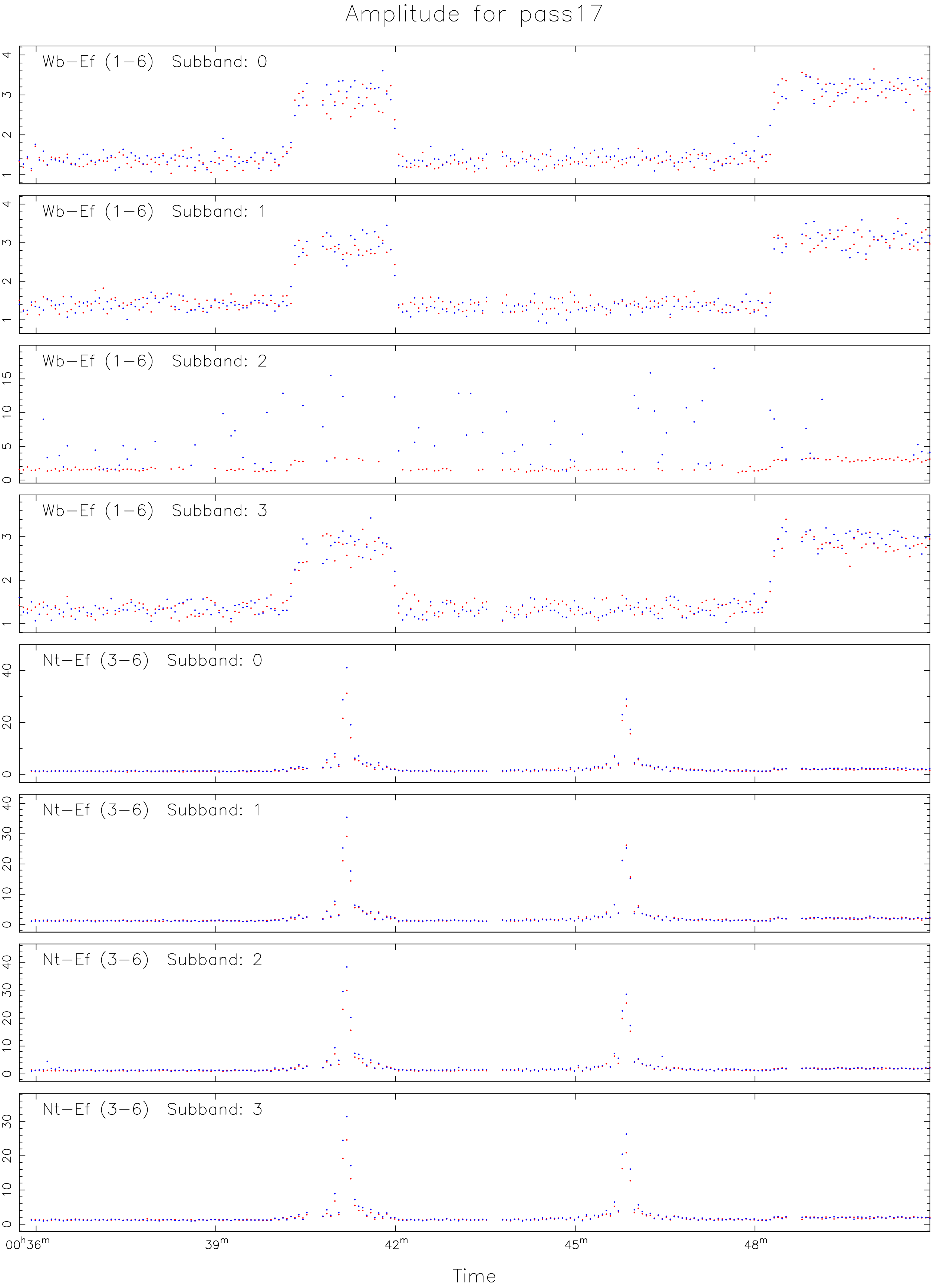

Fig. 2: Amplitude *vs.* time during a delay-rate=0 event.

2. Results from Actual Experiments

Figure 3 shows delay and rate calculations for some baselines (one-third) for both sources from ES030A, color coded as annotated. This was a phase-reference experiment of Cyg X-1 (target) and 1955 (reference). It used 8 MHz sub-bands and fan-out of 2:1. The vertical dotted lines denote the beginning of passes. The horizontal lines in delay plots (left column) show $\pm t_{\rm crit}$ of $n \cdot T_{\rm frm}$, as from equations (1)–(2). These lines are dashed if involving a VLBA station (*i.e.,* not actually relevant). The horizontal line in the rate plots (right column) marks zero. The source-curves were obtained by the (old) `CALC8.1/dcalc` method; `dcalc` output was read into, baselines formed in, and plotted from IDL. We see the delay problem whenever the curves enter the "danger zones'. I've been using such plots to see where to investigate the data for the delay and rate problems in actual experiments — finding problems in these plots or in `fplots/tplots` in `aips++` seems entirely reflexive: nothing seems missed either way you proceed (though sometimes the rate=0 problem doesn't leave an obvious trace in `fplot` lag-amplitude plots).

Note that in Wb–Ef we can see the effect of the delay problem first in Cyg X-1 and then later in the reference source 1955. This is confirmed by `tplots`. There's no delay problem for Wb–On during this experiment because during the observed UT range the delay is never close to a "lobe" (0 or –2500 μs). On longer baselines (say Wb–Nt), a source may see more than one "lobe", but generally spend less time sweeping through each.

As a general rule, the delay problems last a few minutes (5–8), but somewhat longer on the shortest baselines (Ef–Wb, Wb–Jb) when they can start to stretch on for up to ~20 min. The rate problems come and go within 90–120 seconds. However, as §3 will discuss, these numbers can get much worse for narrower sub-band bandwidths and higher fan-outs.

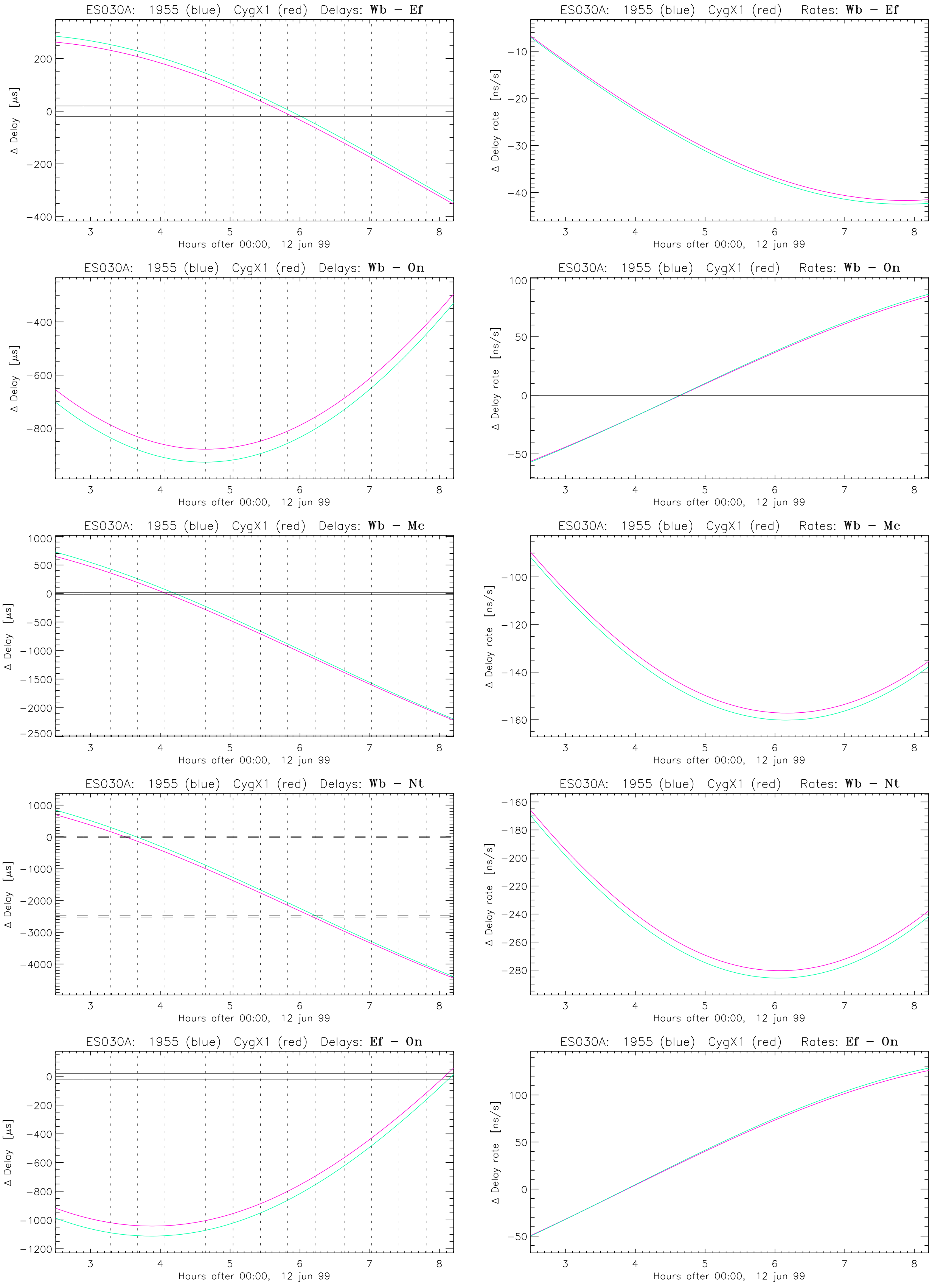

Fig. 3b: Delay and Rate *a priori* models for ES030A.

Figure 4 shows delay and rate calculations for some baselines for both sources from C99C3, color coded as annotated. This experiment used 2 MHz sub-bands and no fan-out. These two sources are unrelated, and not doing phase referencing. 13-minute scans were made every 40 minutes. The vertical dotted lines shows the boundaries of the scans. Each scan sat on only one of the sources for the full 13 minutes; the observed source is denoted by the darkening of the appropriate delay curve during specific scans.

Picking the “right” (or “wrong”) source, either by design or inadvertently, can effect the operational impact of these delay/rate problems. On Wb–Ef, pass 5, BL Lac (blue) is in the “danger zone”, but they were observing 0059 — no harm, no foul. However, on Jb–On during pass 9, BL Lac was in the “danger zone” and it was being observed. We can also see, due to the limited-duration of these problems (on all but the shortest baselines), that a non-continuous experiment could also get lucky by missing a delay/rate-crossing zero because it falls outside scan boundaries — such as Jb–Mc between passes 5 and 6 for 0059. On Jb–Sh, we can see the effect of long baselines allowing more “lobes” to come into play (of course, ignoring the fact that Sh has a VLBA recorder).

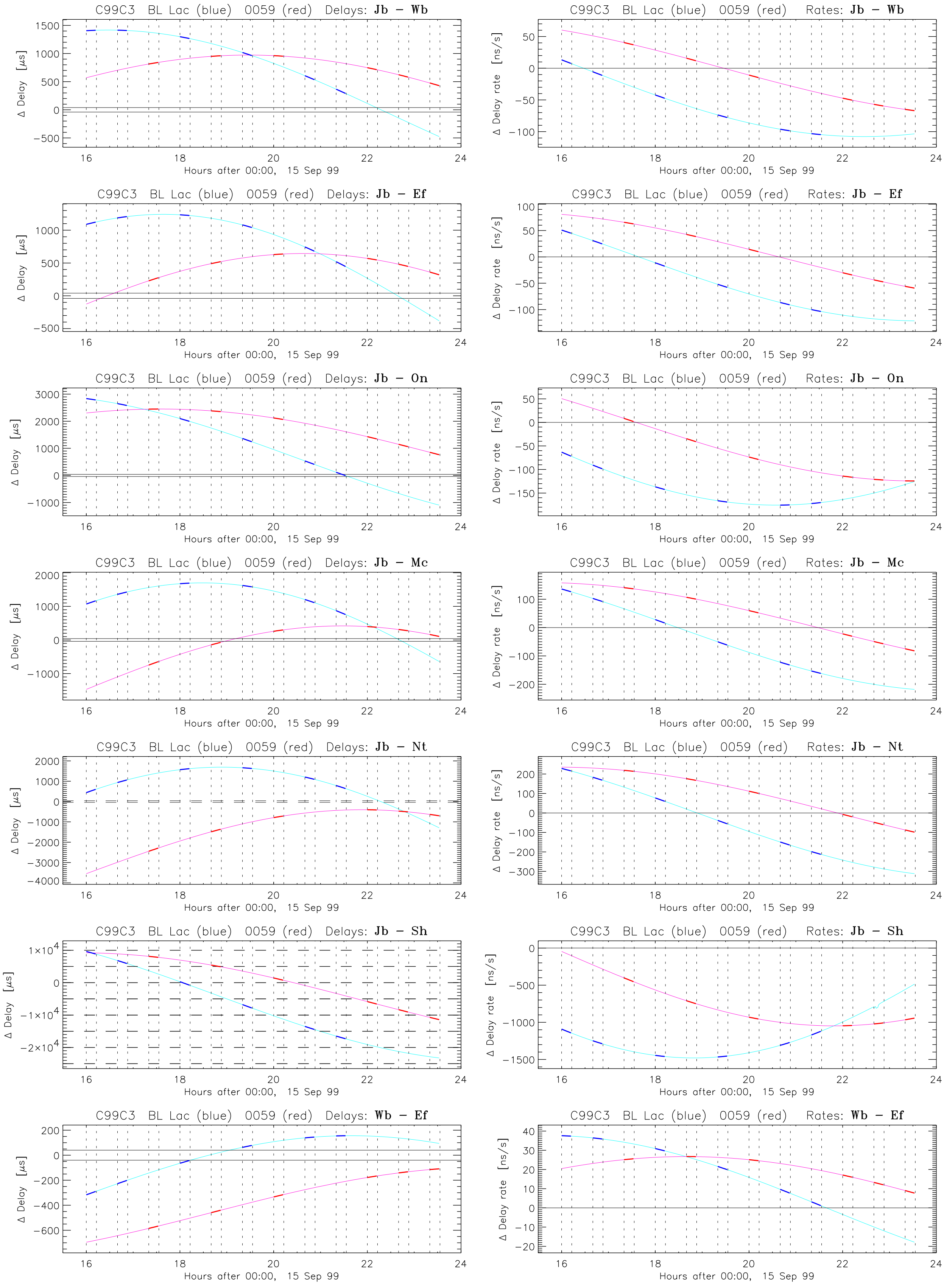

Fig. 4a: Delay and Rate *a priori* models for C99C3.

Figure 5 shows delay and rate calculations some baselines (two-thirds) for EP027A. This used 8 MHz sub-bands and fan-out of 2:1. This experiment was a phase-referencing one, but one that changed target-reference pairs quite often (up to every 22-min pass). I calculated/plotted only the delay/rate curves reference source for the duration of each pass. As can be seen from the ES030A plots in Fig. 3, there will be some offset between the plotted curves and those for the target sources, depending on the relative positions of the two. Such differences are ignored in these plots, affecting to some degree their predictive power when applied blindly. Use of actual polynomials from the correlator will solve this sort of problem. Because of all the source-pair changes, the delay/rate curves are quite jumpy; the vertical offsets correspond to the source changes. The portions of the curves in red correspond to times when problems at On or Mc caused data loss.

In Fig. 5a, we can see an unlucky sequence of source changes in On–Jb between around 0100–0430 UT, where the source changes keep the delay fairly well centered on the $-1T_{\mathrm{frm}}$ "lobe" (irrelevant in practice, of course, since there's no data on On during this time). There are no major problems on other baselines (On–Wb has delay problems in the first two passes after On comes on-line). You can get an idea of the precision with which these kind of plots can predict delay problems by looking at Wb–Ef in Fig. 5b. There are two scans very close to the upper boundary of the "danger zone" around 0600UT. In the first instance, you can see the effect of the trailing edge of the delay problem during the first minute or so of the pass. (During the second instance, Ef didn't head peak [as it didn't for any of the first two reverse passes for the tapes in this experiment], so the possible problem was moot.)

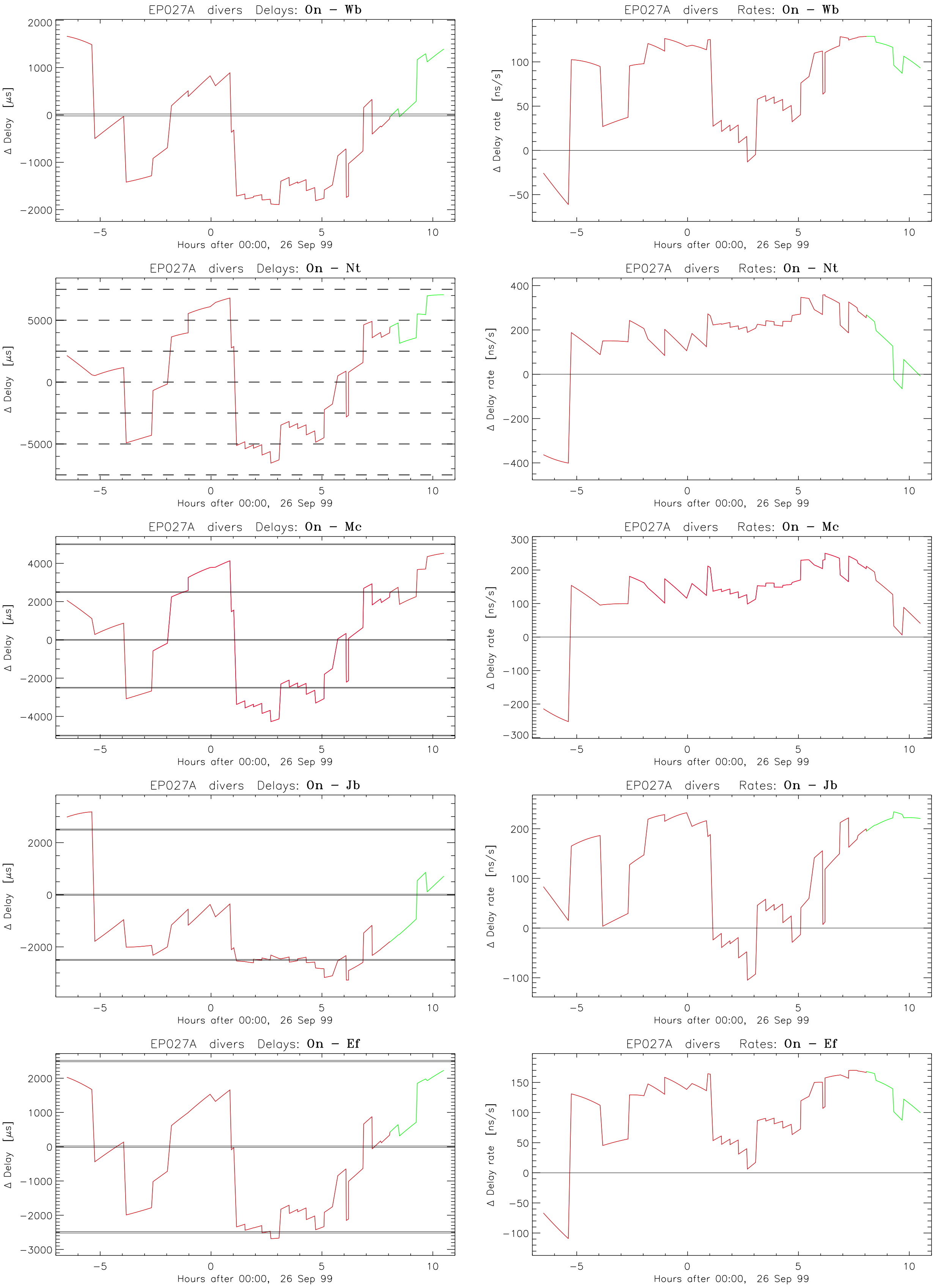

Fig. 5a: Delay and Rate *a priori* models for EP027A.

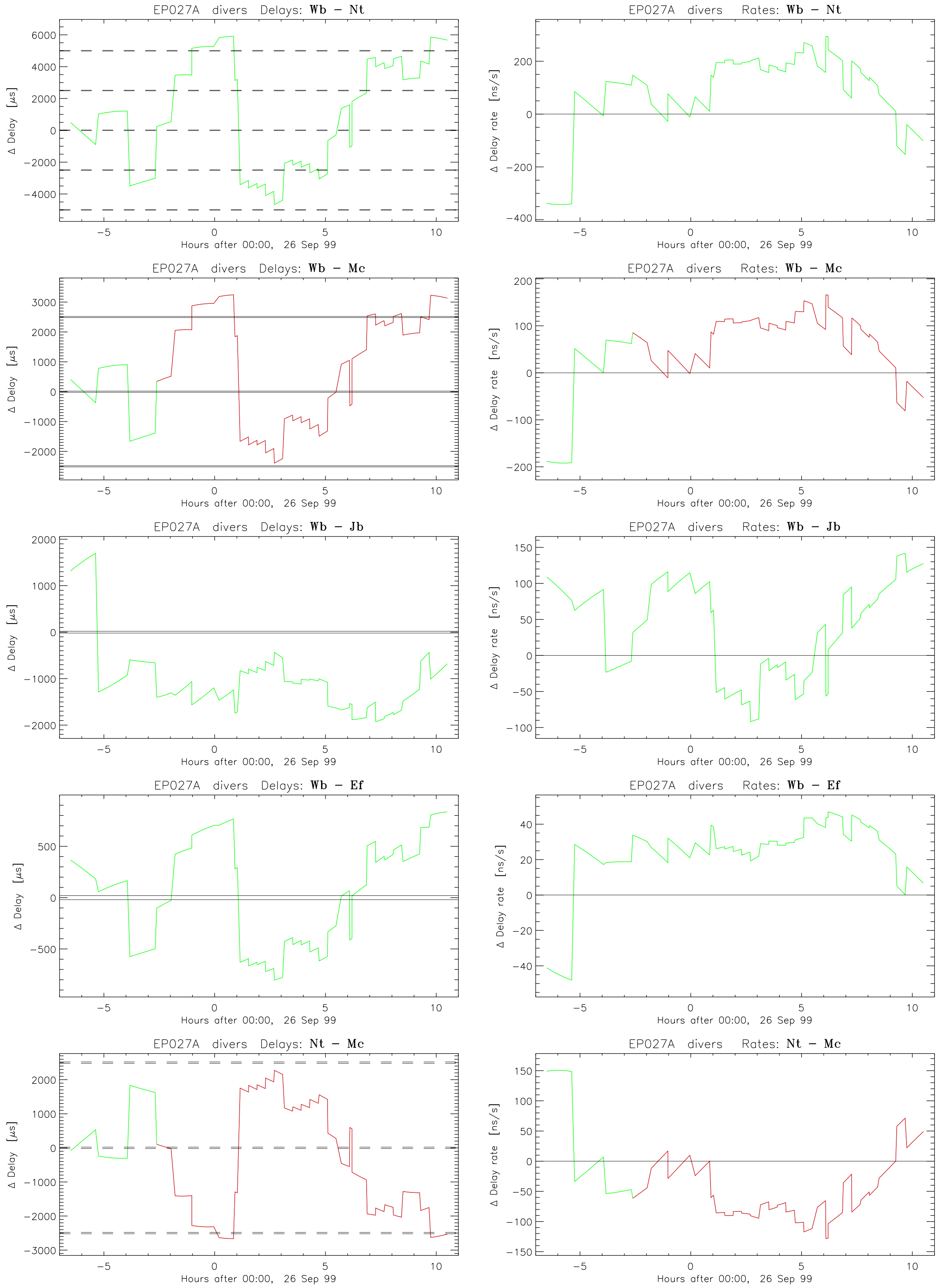

Fig. 5b: Delay and Rate *a priori* models for EP027A.

Figure 6 shows delay and rate calculations for EP027B. In many ways this plot is similar to that for EP027A, except here Jb was missing altogether, and there weren't any problems with On or Mc. In On–Ef, the observations were scheduled such that they just missed any effect from the $-1T_{\mathrm{frm}}$ "lobe" from 0200–0500UT, as opposed to in EP027A (Fig. 5a).

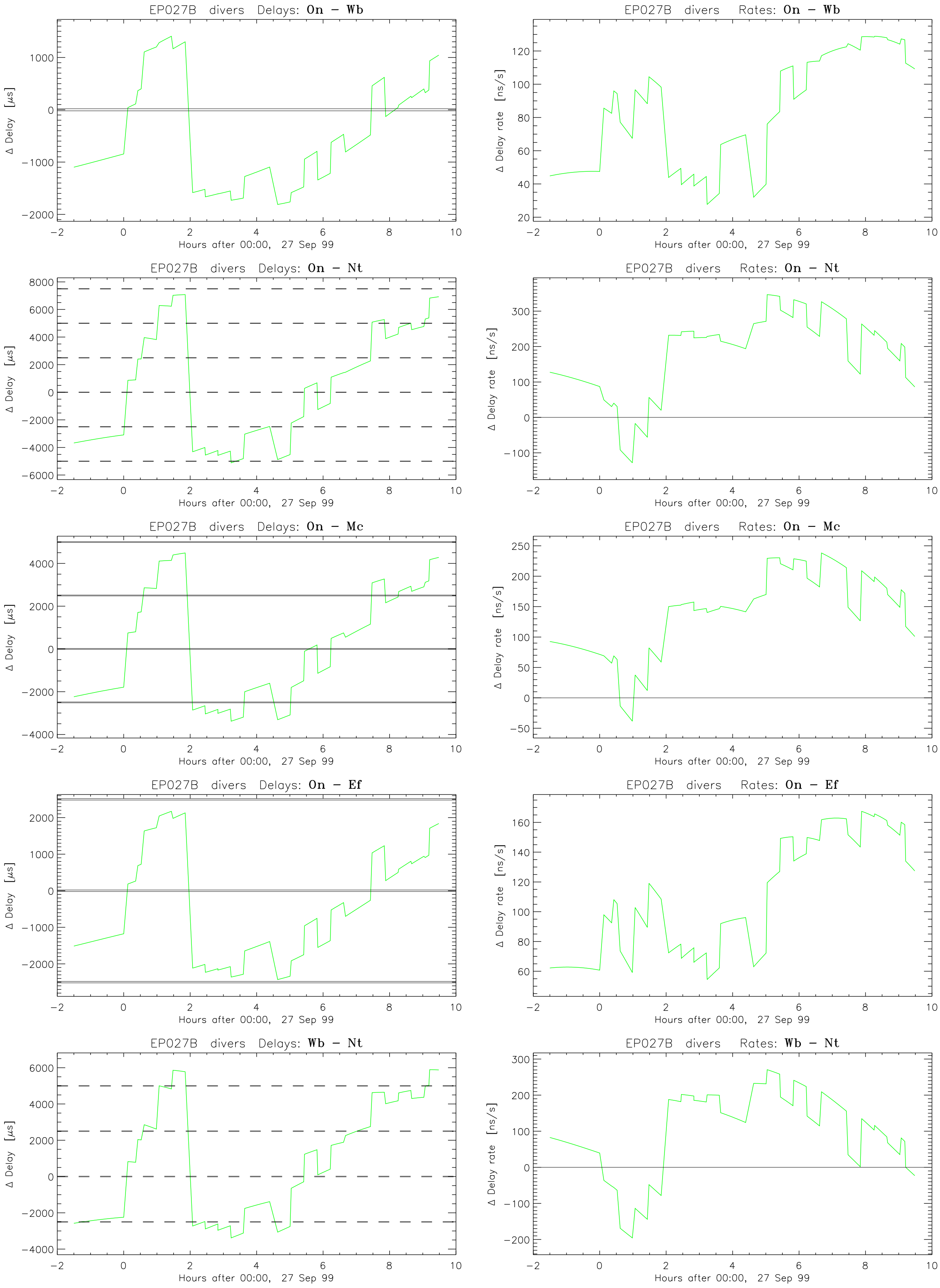

Fig. 6a: Delay and Rate *a priori* models for EP027B.

3. Simulation of the Delay/Rate Problems

The above plots show illustrative examples of the occurrences of the delay and rate problems drawn from actual experiments. You can get a feel for the amount of data lost to the delay and rate problems by seeing for what fraction of the total observing time the delay/rate curves lie within the "danger zones." We can also run simulations of a full sidereal-day observation of a specific source from the full EVN to get a more quantitative value of the amount good data remaining after the delay and rate problems take their tolls. This will also allow us to summarize how various observing parameters (sub-band bandwidth, fan-out, frequency, integration time) affect the data loss. The following six pages show the result of such simulations: the first two a delay simulation for EVN stations ever having Mk IV formatters in the past few sessions, and the last four a rate simulation for the full EVN.

The delay simulation considers three different sub-band bandwidths (8, 2, 0.5 MHz), three different fan-outs (1:1, 1:2, 1:4), and three different N_{lag} configurations (32, 128, 512) — some combinations of all three parameters may not actually exist. The rate simulation considers three different observing frequencies (329MHz, 1.6GHz, 22GHz) and two different integration times (1, 4 s). Both consider source declinations ranging from $+80°$ to $-20°$ in steps of $20°$. At the top of the tables are listed the relevant parameters from equations (1)–(3) resulting from combinations of the appropriate "experimental" parameters. We follow each of the sources (at the different declinations) for a full sidereal day (sampled every 4 [UT]s), and keep track of those times for which it is up. (Since a full sidereal day is being followed, the RA of the source is irrelevant; it wound up being set at 0^{h} by omission.) The first column in the tables is the baseline, the second is the amount of time the source is up on the baseline.

- The remainder of the columns of the delay simulation table contain the percentage of time for which the source is up that it is unaffected by the delay problem, truncated down to the next lowest percent. Each of these columns belongs to one of the possible sub-band/fan-out/N_{lag} combinations as labeled in the column headings.
- In the rate simulation table, the next nine columns pertain to a delay simulation done without consideration of the N_{lag} factor, and should be ignored. The next two columns give the maximum and minimum delay for all times for which the source is up on the baseline (for which there wasn't room in the new delay-simulation table). The remainder of the columns relate to the rate problem. The next six columns contain the percentage of time for which the source is up that it is unaffected by the rate problem, and the last two columns give the maximum and minimum rates seen by the baseline while the source is up.

All delays in the tables are in [μs], and all rates in [ns/s].

A couple quick examples from the tables, and then you're on your own to read/interpret as you see fit for your favorite observing set-up/region of the sky (or let me know if you'd want something more specific). The keys to understanding the percentage numbers for delays involves the interplay among the minimum & maximum delays and the spacing & width of the "danger zones." The typical response is to have more data loss as the bandwidth decreases, the fan-out increases, and/or the $N_{\rm lag}$ increases.

- There's a sudden drop off in Ef–Wb in $BW = 0.5\,$MHz and fan-out=1:4 for $\delta = 80°$, even for the smallest $N_{\rm lag}$. This comes about because Ef–Wb's total spanned delay (–418 to –662 μs from columns 12–13 in the 2nd table) lies well outside any "danger zone" until this BW/fan-out combination which pushes the width of the $n = 0$ lobe up to $\pm 704\,\mu$s (for $N_{\rm lag} = 32$).
- By comparison, the delay for Wb–Jb $\delta = 80°$ crosses zero, so is more gradually affected by the increase in the width of the 0th lobe (until it mostly loses **all** data by 0.5 MHz).
- Check out Jb–Mc (still $\delta = 80°$) using 8 MHz sub-bands for a counter-example. Here, the its delay-range (1203 to 2651 μs) crosses two "danger zones" in the 8MHz/1:1 case (at 1250 & 2500 μs), but none in the 8MHz/1:4 case (first comes at 5000 μs).
- As the source declination changes, the range of delays also changes (eq. 4), with corresponding effect on these sorts of arguments.

Similar points apply to the rate tables. Here, the only egregious losses are in Ef–Wb at 1s integration period at L-band and below, and all baselines for the most northerly declinations at 329 MHz. Again, the problem is the reduced amplitude of the rate sinusoid (eq. 5) in relation to the size of the "danger zone" (the rate sinusoid is symmetric about 0, so the possibility of missing the zero-crossing doesn't arise as it does for delays). Especially for the rate data, remember how the percentages were truncated; a "99" could result from as little as 1 4-s sample out of 21554 falling into a "danger zone."

As presented, the delay and rate portions of the tables are independent; both give the percentage of good data out of the possible data (*i.e.,* when the source is up on a given baseline). The net data loss due to both errors would be at most the sum of the loss due to each. Individual UTs that are lost due to both would be double counted.

```
COMBINATIONS CONSIDERED

--- Delay:  frame size/header size [us] ---
  8MHz:  1:1   1250/ 10    1:2   2500/ 20    1:4   5000/ 40
  2MHz:  1:1   5000/ 40    1:2  10000/ 80    1:4  20000/160
0.5MHz:  1:1  20000/160    1:2  40000/320    1:4  80000/640

Lags:  32,  128,  512


**** Source declination = +80 ****

          %                       8MHz                                        2MHz                                     0.5MHz
         up         1:1           1:2           1:4             1:1           1:2           1:4             1:1           1:2           1:4
                 32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512

Ef-Wb   100.0   100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100  77  00    00  00  00
Ef-On   100.0    97  97  95   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  34
Ef-Jb   100.0   100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100  95  66     100  95  66    73  63  30    42  23  00
Ef-Mc   100.0    97  97  95   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  05
Ef-Nt   100.0    98  98  97   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Ef-Tr   100.0   100 100 100   100 100 100   100 100  94     100 100  94   100  91  77    81  76  61      81  76  61    65  58  32    41  27  00
Ef-Ro   100.0    98  98  97    97  97  95   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Wb-On   100.0    95  93  89   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100  60    77  54  00
Wb-Jb   100.0    97  97  95    95  94  90    91  89  80      91  89  80    83  78  57    65  53  02      65  53  02    19  00  00    00  00  00
Wb-Mc   100.0   100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  63
Wb-Nt   100.0    99  98  97   100 100  97   100  95  88     100  95  88   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Wb-Tr   100.0    98  98  96    96  96  92    93  92  85      93  92  85    87  84  70    75  67  25      75  67  25    44  15  00    00  00  00
Wb-Ro   100.0    96  95  92    96  95  92   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
On-Jb   100.0    98  97  95   100 100 100   100 100 100     100 100 100   100 100 100   100 100  79     100 100  79    86  76  51    59  48  00
On-Mc   100.0    98  98  97    97  96  94   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
On-Nt   100.0    99  99  98    98  98  96    97  96  93      97  96  93   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
On-Tr   100.0   100 100  94   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100  56    69  49  00
On-Ro   100.0    97  97  94    97  96  92    93  92  83      93  92  83   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Jb-Mc   100.0    95  94  89    96  95  92   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  61
Jb-Nt   100.0    98  97  95    98  97  95    96  94  90      96  94  90   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Jb-Tr   100.0    99  98  97    98  97  95    96  95  91      96  95  91    93  91  83    85  82  65      85  82  65    71  62  02    31  00  00
Jb-Ro   100.0    96  96  92   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Mc-Nt   100.0    97  96  94    95  93  88   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Mc-Tr   100.0   100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  65
Mc-Ro   100.0    99  98  97   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100  68    75  65  32
Nt-Tr   100.0    98  98  97   100 100 100   100 100  90     100 100  90   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Nt-Ro   100.0    99  99  98   100 100  94    96  93  88      96  93  88    89  87  80    82  80  71      82  80  71    73  69  55    60  53  26
Tr-Ro   100.0    98  98  96    98  98  96   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100

**** Source declination = +60 ****

          %                       8MHz                                        2MHz                                     0.5MHz
         up         1:1           1:2           1:4             1:1           1:2           1:4             1:1           1:2           1:4
                 32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512

Ef-Wb   100.0   100 100 100   100 100 100   100 100 100     100 100 100   100 100  77    82  75  55      82  75  55    61  52  00    27  00  00
Ef-On   100.0    99  99  98   100 100  94   100 100 100     100 100 100   100 100  88    91  87  77      91  87  77    80  75  63    66  61  39
Ef-Jb   100.0    98  98  96    98  98  96    97  96  93      97  96  93    94  92  86    88  85  71      88  85  71    76  68  41    45  39  00
Ef-Mc   100.0    99  99  98   100 100 100   100 100 100     100 100 100   100 100  88    91  87  76      91  87  76    79  74  60    64  58  33
Ef-Nt   100.0    97  96  94    97  97  94    96  96  92      96  96  92   100 100 100   100 100 100     100 100 100   100 100 100   100 100  76
Ef-Tr   100.0    98  98  97    98  98  97    97  97  94      97  97  94    95  94  89    91  88  78      91  88  78    82  77  51    61  41  18
Ef-Ro   100.0    98  98  96    99  99  98   100 100 100     100 100 100   100 100 100   100 100  89     100 100  89    93  87  76    79  74  59
Wb-On   100.0    96  96  92    95  94  88    90  86  80      90  86  80    81  79  74    76  73  65      76  73  65    67  63  49    54  47  09
Wb-Jb   100.0    99  99  98    98  98  96    97  96  93      97  96  93    94  92  86    88  85  72      88  85  72    77  70  36    49  27  00
Wb-Mc   100.0    98  98  97    98  98  96   100 100 100     100 100 100   100 100 100   100 100  87     100 100  87    92  85  70    74  68  49
Wb-Nt   100.0    98  98  97    98  98  96    98  98  96      98  98  96   100 100 100   100 100 100     100 100 100   100 100 100   100 100  81
Wb-Tr   100.0    96  95  90    98  98  97    97  97  95      97  97  95    95  94  90    91  89  79      91  89  79    82  78  57    64  53  00
Wb-Ro   100.0    98  98  97    99  99  98   100 100  96     100 100  96   100 100 100   100 100 100     100 100 100   100 100  84    88  82  66
On-Jb   100.0    99  98  97    99  98  97    98  97  95      98  97  95    96  95  90    92  90  81      92  90  81    84  79  55    65  47  31
On-Mc   100.0    98  98  96    99  99  98   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100  84    89  81  64
On-Nt   100.0    98  98  97    98  98  97    98  98  97      98  98  97   100 100 100   100 100 100     100 100 100   100 100 100   100 100  98
On-Tr   100.0    97  97  95    97  96  93    94  93  87      94  93  87    89  86  70    71  69  62      71  69  62    64  61  48    52  46  13
On-Ro   100.0    98  97  96    98  98  97    98  98  97      98  98  97   100 100 100   100 100 100     100 100 100   100 100  85    88  84  71
Jb-Mc   100.0    96  95  91    98  97  95    97  97  94      97  97  94    95  94  88    90  87  71      90  87  71    78  70  63    65  62  50
Jb-Nt   100.0    98  98  96    99  98  97    98  98  97      98  98  97   100 100 100   100 100 100     100 100 100   100 100  88    92  86  72
Jb-Tr   100.0    98  98  97    99  99  98    98  98  97      98  98  97    97  96  94    95  93  88      95  93  88    90  87  76    80  74  48
Jb-Ro   100.0    98  97  95    99  98  98   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  72
Mc-Nt   100.0    98  97  95    98  98  96   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  60
Mc-Tr   100.0    98  98  97    98  98  97   100 100 100     100 100 100   100 100  98   100  95  82     100  95  82    85  81  69    72  67  50
Mc-Ro   100.0    98  98  97    98  98  96    98  98  96      98  98  96    97  96  93    94  92  86      94  92  86    88  84  70    75  67  42
Nt-Tr   100.0    98  98  97    98  97  96    98  97  96      98  97  96   100 100 100   100 100 100     100 100 100   100 100 100   100 100  87
Nt-Ro   100.0    98  98  97    98  98  97    98  98  97      98  98  97    97  97  95    95  94  90      95  94  90    91  89  79    82  77  54
Tr-Ro   100.0    98  98  96    98  97  95    97  96  93      97  96  93    96  96  92    93  92  84      93  92  84    86  82  69    71  69  60

**** Source declination = +40 ****

          %                       8MHz                                        2MHz                                     0.5MHz
         up         1:1           1:2           1:4             1:1           1:2           1:4             1:1           1:2           1:4
                 32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512

Ef-Wb   100.0    98  97  95    96  95  91    93  91  82      93  91  82    85  81  58    65  57  46      65  57  46    50  44  14    27  00  00
Ef-On   100.0    98  97  96    97  96  94    98  97  95      98  97  95    96  95  91    92  90  81      92  90  81    84  80  52    66  51  37
Ef-Jb   100.0    97  97  94    99  98  98    98  97  96      98  97  96    96  95  92    93  91  84      93  91  84    86  82  66    72  63  23
Ef-Mc    81.1    99  98  97    98  98  96    97  96  93      97  96  93    94  93  87    89  86  73      89  86  73    77  71  39    42  38  28
Ef-Nt    71.5    98  98  96    98  97  95    96  96  92      96  96  92    96  95  91    92  90  81      92  90  81    84  80  52    65  51  42
Ef-Tr   100.0    94  93  91    93  93  90    98  98  96      98  98  96    97  96  93    94  93  87      94  93  87    89  86  73    78  71  38
Ef-Ro    75.1    97  96  94    98  98  97    98  98  96      98  98  96    96  96  92    93  92  85      93  92  85    87  84  70    75  67  35
Wb-On   100.0    98  98  97    98  98  97    97  97  94      97  97  94    95  94  88    90  88  77      90  88  77    80  75  44    55  43  21
Wb-Jb   100.0    97  97  95    99  98  97    98  97  95      98  97  95    96  95  91    92  90  82      92  90  82    85  81  63    69  60  00
Wb-Mc    81.1    98  98  97    98  97  96    97  97  94      97  97  94    95  94  89    91  89  79      91  89  79    82  77  45    61  44  31
Wb-Nt    71.5    98  97  95    98  98  96    97  97  94      97  97  94    96  95  92    93  91  84      93  91  84    86  82  63    71  56  43
Wb-Tr   100.0    98  98  97    99  99  98    98  98  96      98  98  96    97  96  93    94  93  86      94  93  86    88  85  73    77  71  39
Wb-Ro    75.1    96  95  92    98  97  96    97  96  93      97  96  93    97  96  93    94  92  86      94  92  86    88  85  71    76  69  38
On-Jb   100.0    98  98  96    98  98  96    98  98  97      98  98  97    97  97  94    95  94  89      95  94  89    90  88  77    81  75  50
On-Mc    81.1    98  98  97    98  98  96    98  97  96      98  97  96    96  95  92    93  91  84      93  91  84    87  83  66    72  62  40
On-Nt    71.5    98  98  97    98  98  96    98  97  95      98  97  95    97  96  93    94  92  86      94  92  86    88  84  69    75  65  47
On-Tr   100.0    98  98  97    98  98  97    97  97  95      97  97  95    95  94  90    91  89  79      91  89  79    83  78  53    63  43  23
On-Ro    75.1    98  98  96    98  98  97    98  98  96      98  98  96    98  97  95    96  95  90      96  95  90    92  90  81    84  79  59
Jb-Mc    81.1    98  98  97    99  98  97    98  98  97      98  98  97    97  97  94    95  93  88      95  93  88    90  88  79    82  78  57
Jb-Nt    71.5    98  98  97    99  98  94    98  98  96      98  98  96    97  97  95    95  94  90      95  94  90    91  89  82    84  81  62
Jb-Tr   100.0    98  98  97    98  98  96    99  98  98      99  98  98    98  97  96    96  95  92      96  95  92    93  91  84    87  83  68
Jb-Ro    75.1    98  98  96    98  97  95    97  97  94      97  97  94    95  94  89    91  88  77      91  88  77    81  75  54    56  52  40
Mc-Nt    71.5    97  96  94    95  94  89    92  90  77      92  90  77    83  76  71    73  71  63      73  71  63    65  61  48    53  47  34
Mc-Tr    81.1    98  98  96    98  97  95    98  97  95      98  97  95    96  95  91    92  90  82      92  90  82    84  80  60    68  56  30
Mc-Ro    73.7    97  97  94    96  96  92    99  99  98      99  99  98    98  98  97    97  97  94      97  97  94    95  94  89    90  88  71
Nt-Tr    71.5    98  97  96    97  97  95    97  96  93      97  96  93    95  94  90    91  89  79      91  89  79    82  77  57    59  56  44
Nt-Ro    68.0    99  98  97    99  98  93    96  94  90      96  94  90    99  98  97    98  97  95      98  97  95    96  95  90    92  90  81
Tr-Ro    75.1    98  98  96    98  97  96    98  98  97      98  98  97    98  97  96    96  95  92      96  95  92    93  91  84    87  83  71
```

```
**** Source declination = +20 ****

           %                      8MHz                                        2MHz                                       0.5MHz
          up        1:1           1:2           1:4             1:1           1:2           1:4             1:1           1:2           1:4
                 32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512

Ef-Wb    64.5    98  97  95    96  95  91    93  91  83      93  91  83    86  82  66    71  63  30      71  63  30    42  21  00    00  00  00
Ef-On    64.5    98  97  96    98  98  97    97  97  95      97  97  95    95  94  90    91  89  80      91  89  80    83  79  60    66  56  08
Ef-Jb    62.7    99  98  97    99  99  98    98  98  97      98  98  97    97  97  94    95  94  89      95  94  89    91  89  79    82  77  48
Ef-Mc    61.7    98  97  95    99  99  98    98  98  97      98  98  97    97  96  94    95  93  88      95  93  88    90  87  72    79  69  17
Ef-Nt    58.7    97  97  94    96  95  91    99  99  97      99  99  97    98  98  96    97  96  93      97  96  93    94  93  87    89  86  70
Ef-Tr    62.0    98  98  96    98  98  96    99  98  97      99  98  97    98  97  95    96  95  91      96  95  91    93  91  83    85  81  56
Ef-Ro    59.1    98  97  95    97  97  94    99  99  98      99  99  98    98  98  96    97  96  93      97  96  93    94  93  87    89  86  68
Wb-On    65.9    96  96  92    98  98  96    97  96  93      97  96  93    94  93  87    89  86  74      89  86  74    78  72  53    59  49  00
Wb-Jb    63.5    98  98  97    99  99  98    98  98  97      98  98  97    97  97  94    95  94  88      95  94  88    90  87  76    80  75  45
Wb-Mc    61.7    98  98  96    98  98  97    99  98  97      99  98  97    98  97  95    96  95  90      96  95  90    92  90  77    82  75  39
Wb-Nt    58.7    98  98  96    97  97  94    98  98  96      98  98  96    98  98  97    97  97  94      97  97  94    95  94  89    90  88  74
Wb-Tr    62.6    94  92  88    90  89  84    99  98  97      99  98  97    98  97  95    96  95  91      96  95  91    92  90  82    85  81  62
Wb-Ro    59.9    98  97  96    98  97  95    99  99  98      99  99  98    98  98  97    97  96  94      97  96  94    95  93  87    89  85  68
On-Jb    63.6    98  97  95    97  96  93    99  99  98      99  99  98    98  98  96    97  96  93      97  96  93    94  92  86    88  85  69
On-Mc    61.7    93  92  89    91  91  87    98  98  96      98  98  96    97  96  93    94  93  87      94  93  87    89  86  73    78  71  51
On-Nt    58.7    98  98  96    98  98  96    98  98  97      98  98  97    99  98  97    97  96  93      97  96  93    94  93  86    88  85  71
On-Tr    65.7    98  97  95    99  99  98    98  98  97      98  98  97    97  96  94    95  93  88      95  93  88    90  87  76    80  74  25
On-Ro    60.0    98  97  96    98  98  97    99  98  97      99  98  97    99  98  98    98  97  96      98  97  96    96  95  91    93  90  79
Jb-Mc    60.0    98  98  96    98  97  96    99  99  98      99  99  98    98  98  97    97  96  94      97  96  94    95  93  88    90  87  76
Jb-Nt    57.6    98  98  96    99  98  97    99  98  97      99  98  97    99  98  97    98  97  95      98  97  95    96  95  91    93  91  83
Jb-Tr    60.2    98  98  96    99  98  97    99  99  98      99  99  98    98  98  97    97  97  94      97  97  94    95  94  89    91  89  79
Jb-Ro    60.0    98  98  96    98  98  97    98  98  96      98  98  96    96  96  92    93  92  85      93  92  85    87  84  70    75  68  40
Mc-Nt    58.7    98  98  96    98  97  95    98  98  96      98  98  96    97  96  93    94  93  87      94  93  87    89  86  64    72  60  20
Mc-Tr    61.7    98  98  96    99  98  97    98  97  95      98  97  95    96  95  91    93  91  83      93  91  83    86  82  67    72  64  32
Mc-Ro    56.4    94  93  90    98  98  97    99  99  98      99  99  98    98  98  97    97  96  94      97  96  94    95  93  88    90  87  76
Nt-Tr    58.7    97  96  94    96  95  92    98  98  97      98  98  97    97  96  94    94  93  88      94  93  88    89  87  76    79  74  53
Nt-Ro    54.0    98  98  97    98  98  96    98  98  91      98  98  91    99  98  97    98  97  95      98  97  95    96  94  90    92  89  81
Tr-Ro    56.6    97  97  94    97  96  93    95  94  88      95  94  88    99  98  98    98  97  96      98  97  96    96  95  92    93  91  84

**** Source declination =  0  ****

           %                      8MHz                                        2MHz                                       0.5MHz
          up        1:1           1:2           1:4             1:1           1:2           1:4             1:1           1:2           1:4
                 32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512

Ef-Wb    49.9    98  98  97    97  97  95    95  94  90      95  94  90    91  89  80    83  79  59      83  79  59    66  55  00    00  00  00
Ef-On    48.6    98  98  97    99  99  98    98  98  97      98  98  97    97  96  94    95  93  90      95  93  90    91  89  79    82  77  50
Ef-Jb    47.4    98  98  97    99  99  98    98  98  96      98  98  96    97  96  93    94  93  87      94  93  87    89  86  74    78  72  44
Ef-Mc    48.7    98  98  97    99  99  98    98  98  96      98  98  96    97  96  93    94  92  86      94  92  86    88  85  72    76  70  38
Ef-Nt    47.7    98  97  95    98  98  97    99  99  98      99  99  98    98  98  96    97  96  93      97  96  93    94  92  86    88  85  72
Ef-Tr    46.8    97  97  95    97  96  92    98  98  97      98  98  97    97  97  94    95  94  89      95  94  89    91  88  79    82  77  56
Ef-Ro    46.9    97  97  94    99  98  97    99  99  98      99  99  98    98  98  96    96  96  92      96  96  92    93  92  85    87  84  70
Wb-On    48.5    98  98  96    99  98  98    98  97  96      98  97  96    96  95  92    93  91  84      93  91  84    86  83  70    76  68  22
Wb-Jb    47.5    98  98  96    99  99  98    98  98  96      98  98  96    97  96  93    94  92  85      94  92  85    88  84  71    75  68  34
Wb-Mc    48.6    97  96  93    96  94  90    98  98  97      98  98  97    97  97  94    95  94  89      95  94  89    91  88  78    82  77  55
Wb-Nt    47.7    98  98  97    98  98  97    99  99  98      99  99  98    98  98  97    97  96  94      97  96  94    94  93  88    89  87  75
Wb-Tr    46.7    97  97  94    97  96  92    98  98  97      98  98  97    97  97  94    95  94  89      95  94  89    90  88  78    81  76  54
Wb-Ro    47.0    98  98  96    99  99  98    99  99  98      99  99  98    98  98  96    97  96  93      97  96  93    94  92  86    88  85  73
On-Jb    46.0    98  98  96    98  97  96    99  98  97      99  98  97    98  97  95    96  95  91      96  95  91    92  90  82    84  80  62
On-Mc    49.9    98  98  97    98  98  96    99  99  98      99  99  98    98  98  96    96  96  92      96  96  92    93  92  85    87  84  70
On-Nt    49.2    98  97  96    98  97  95    97  96  93      97  96  93    98  98  97    97  97  95      97  97  95    95  94  90    91  89  80
On-Tr    48.2    98  98  96    99  99  98    98  98  96      98  98  96    96  96  92    93  92  85      93  92  85    87  84  70    75  67  30
On-Ro    45.5    98  98  97    98  98  96    97  97  94      97  97  94    98  98  97    97  97  95      97  97  95    95  94  90    91  89  80
Jb-Mc    46.1    98  98  96    98  98  96    99  99  98      99  99  98    98  98  96    97  96  93      97  96  93    94  92  86    88  85  71
Jb-Nt    45.2    98  98  97    98  98  97    98  98  96      98  98  96    98  98  97    97  97  95      97  97  95    95  94  90    91  89  80
Jb-Tr    44.2    98  98  96    98  98  97    99  99  98      99  99  98    98  98  96    97  96  93      97  96  93    94  93  86    89  85  73
Jb-Ro    49.5    98  98  97    98  98  96    99  98  98      99  98  98    98  97  96    96  95  92      96  95  92    93  91  84    86  83  69
Mc-Nt    49.1    98  98  97    99  99  98    98  98  96      98  98  96    97  96  93    94  92  86      94  92  86    88  85  73    77  70  40
Mc-Tr    48.1    98  97  95    97  96  94    98  98  97      98  98  97    98  97  96    97  96  94      97  96  94    95  93  84    87  83  63
Mc-Ro    45.6    98  97  96    98  98  97    99  99  98      99  99  98    98  98  96    97  96  93      97  96  93    94  92  86    88  85  73
Nt-Tr    49.0    98  98  96    98  98  97    99  99  98      99  99  98    98  98  96    97  96  93      97  96  93    94  93  87    89  86  76
Nt-Ro    44.7    98  97  95    97  97  94    96  96  92      96  96  92    98  98  97    97  97  94      97  97  94    95  94  89    91  88  78
Tr-Ro    43.7    98  97  96    98  98  97    98  98  97      98  98  97    99  98  97    98  97  95      98  97  95    96  95  90    92  90  81

**** Source declination = −20 ****

           %                      8MHz                                        2MHz                                       0.5MHz
          up        1:1           1:2           1:4             1:1           1:2           1:4             1:1           1:2           1:4
                 32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512      32 128 512    32 128 512    32 128 512

Ef-Wb    34.1   100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  91     100 100  91    96  89  18    62  00  00
Ef-On    30.9    97  96  94    95  93  88   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100  96
Ef-Jb    32.2    98  98  97    98  98  97    97  97  95      97  97  95    95  94  90    91  89  80      91  89  80    83  78  59    66  56  27
Ef-Mc    35.5    98  98  97    98  98  97    97  97  94      97  97  94    95  94  89    91  89  80      91  89  80    82  79  70    73  69  48
Ef-Nt    35.5    96  95  91    94  92  87    90  87  71      90  87  71    97  97  94    95  94  91      95  94  91    92  90  86    87  85  76
Ef-Tr    31.5    98  97  95    97  96  93    98  97  95      98  97  95    96  95  91    93  91  83      93  91  83    86  82  75    77  73  57
Ef-Ro    34.7    98  98  97    99  99  98   100 100  99     100 100  99    99  99  98    98  97  95      98  97  95    96  95  90    91  89  79
Wb-On    30.9    99  98  98   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100  98   100  96  65
Wb-Jb    31.5    97  97  94    98  98  97    97  96  94      97  96  94    95  93  88    90  87  77      90  87  77    80  75  53    61  49  00
Wb-Mc    34.1    98  98  97    98  98  96    99  99  98      99  99  98    98  97  96    96  95  92      96  95  92    93  91  84    86  83  68
Wb-Nt    34.1    98  98  97    98  98  97    98  98  96      98  98  96   100 100  99   100  99  97     100  99  97    98  97  93    94  92  84
Wb-Tr    30.8    98  97  95    96  96  92    98  97  95      98  97  95    96  95  91    92  90  82      92  90  82    85  81  64    70  62  36
Wb-Ro    34.1    97  96  93    95  94  89    92  90  81      92  90  81   100 100 100   100 100 100     100 100 100   100 100 100   100  99  90
On-Jb    28.4    98  98  96    98  97  95    98  97  96      98  97  96    96  95  92    93  91  84      93  91  84    87  83  74    76  73  58
On-Mc    30.9    99  98  97    99  99  98   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
On-Nt    30.9    98  98  97    99  98  97    98  98  97      98  98  97   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
On-Tr    30.6    98  98  96    98  98  96    97  96  93      97  96  93    94  93  87    89  86  75      89  86  75    79  73  49    57  46  19
On-Ro    30.9    98  98  97    99  98  97    98  98  97      98  98  97   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Jb-Mc    32.2    98  98  96    98  98  97    98  98  97      98  98  97    97  97  94    95  94  89      95  94  89    90  88  78    81  76  63
Jb-Nt    32.8    98  98  96    98  98  97    98  97  95      98  97  95    98  98  96    96  96  92      96  96  92    93  92  86    87  86  79
Jb-Tr    28.2    97  97  95    98  97  96    98  98  97      98  98  97    97  97  94    95  94  89      95  94  89    90  88  78    81  76  55
Jb-Ro    33.9    98  98  96    99  99  98   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Mc-Nt    38.3    98  97  95    96  96  92    97  97  95      97  97  95    95  94  90    91  89  85      91  89  85    87  84  76    79  75  58
Mc-Tr    34.0    98  98  97    97  97  95   100 100 100     100 100 100   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Mc-Ro    34.7    98  98  96    98  98  97    99  98  97      99  98  97    98  97  95    96  95  90      96  95  90    92  90  81    84  80  62
Nt-Tr    34.0    98  97  96    97  96  93    95  94  90      95  94  90   100 100 100   100 100 100     100 100 100   100 100 100   100 100 100
Nt-Ro    35.3    98  97  95    98  97  95    98  97  96      98  97  96    98  98  96    96  96  92      96  96  92    93  92  85    87  84  70
Tr-Ro    30.7    98  98  97    99  98  98    99  98  97      99  98  97   100 100 100   100 100 100     100 100 100   100 100  97    98  96  90
```

```
COMBINATIONS CONSIDERED

--- Delay:  frame size/header size [us] ---
  8MHz:  1:1   1250/ 10    1:2   2500/ 20    1:4   5000/ 40
  2MHz:  1:1   5000/ 40    1:2  10000/ 80    1:4  20000/160
0.5MHz:  1:1  20000/160    1:2  40000/320    1:4  80000/640

--- Rate:  proximity to 0 [ns/s] ---
 329MHz:  1s  9.119    4s  2.280
 1.6GHz:  1s  1.875    4s  0.469
 22GHz :  1s  0.136    4s  0.034


**** Source declination = +80 ****

          %        8MHz          2MHz         0.5MHz       delay  delay      329MHz    1.6GHz    22GHz    rate  rate
         up     1:1 1:2 1:4   1:1 1:2 1:4   1:1 1:2 1:4     max    min       1s  4s    1s  4s    1s  4s   max    min
Ef-Wb   100.0   100 100 100   100 100 100   100 100  19     -418   -662      00  83    86  96    99  99      9    -9
Ef-On   100.0    98 100 100   100 100 100   100 100 100    -1070  -1882      80  95    95  98    99  99     30   -30
Ef-Jb   100.0   100 100 100   100 100 100   100  76  47     -219  -1002      79  94    95  98    99  99     29   -29
Ef-Cm   100.0   100 100 100   100 100  76    76  55  12      -85   -663      71  93    94  98    99  99     22   -22
Ef-Mc   100.0    98 100 100   100 100 100   100 100 100     1670    964      76  94    95  98    99  99     26   -26
Ef-Nt   100.0    99 100 100   100 100 100   100 100 100     4305   2882      88  97    97  99    99  99     52   -52
Ef-Tr   100.0   100 100 100   100 100  83    83  68  46      -96  -1064      83  95    96  99    99  99     36   -36
Ef-Sh   100.0    97  96  95    95  94 100   100 100 100     9997    679      98  99    99  99    99  99    340  -340
Ef-Ro   100.0    99  98 100   100 100 100   100 100 100     3261   1898      88  97    97  99    99  99     50   -50
Wb-On   100.0    96 100 100   100 100 100   100 100  91     -628  -1242      73  93    94  98    99  99     23   -23
Wb-Jb   100.0    98  96  92    92  84  68    68  24  00      277   -418      76  94    95  98    99  99     26   -26
Wb-Cm   100.0    96  93  87    87  71  50    50  30  00      429    -96      68  92    93  98    99  99     20   -20
Wb-Mc   100.0   100 100 100   100 100 100   100 100 100     2316   1399      82  95    96  99    99  99     34   -34
Wb-Nt   100.0    99 100 100   100 100 100   100 100 100     4952   3316      90  97    97  99    99  99     60   -60
Wb-Tr   100.0    98  97  94    94  88  77    77  50  00      424   -503      82  95    96  99    99  99     34   -34
Wb-Sh   100.0    98  98  98    98  97 100   100 100 100    10449   1308      98  99    99  99    99  99    334  -334
Wb-Ro   100.0    96  97 100   100 100 100   100 100 100     3874   2367      89  97    97  99    99  99     55   -55
On-Jb   100.0    98 100 100   100 100 100   100  91  63     1431    299      85  96    97  99    99  99     42   -42
On-Cm   100.0    98 100 100   100 100 100   100 100  84     1622    582      84  96    96  99    99  99     38   -38
On-Mc   100.0    98  97 100   100 100 100   100 100 100     3436   2149      87  96    97  99    99  99     47   -47
On-Nt   100.0    99  98  97    97 100 100   100 100 100     6042   4097      91  97    98  99    99  99     71   -71
On-Tr   100.0   100 100 100   100 100 100   100 100  77     1230    561      75  94    95  98    99  99     25   -25
On-Sh   100.0    98  98  98    98  98 100   100 100 100    11078   2550      98  99    99  99    99  99    311  -311
On-Ro   100.0    98  97  94    94 100 100   100 100 100     5113   2997      92  98    98  99    99  99     78   -78
Jb-Cm   100.0   100 100 100   100 100  75    75  21  00      344    129      00  81    84  96    98  99      8    -8
Jb-Mc   100.0    96  97 100   100 100 100   100 100 100     2651   1203      88  97    97  99    99  99     53   -53
Jb-Nt   100.0    98  98  96    96 100 100   100 100 100     5274   3134      92  98    98  99    99  99     78   -78
Jb-Tr   100.0    99  98  96    96  93  87    87  73  41      835   -774      90  97    97  99    99  99     59   -59
Jb-Sh   100.0    98  98  98    98  97 100   100 100 100    10712   1186      98  99    99  99    99 100    348  -348
Jb-Ro   100.0    97 100 100   100 100 100   100 100 100     3797   2583      86  96    97  99    99  99     45   -45
Cm-Mc   100.0    98 100 100   100 100 100   100 100 100     2308   1074      87  96    97  99    99  99     45   -45
Cm-Nt   100.0    99 100 100   100 100 100   100 100 100     4932   3003      91  97    98  99    99  99     71   -71
Cm-Tr   100.0    99  98  96    96  92  85    85  69  29      519   -932      88  97    97  99    99  99     53   -53
Cm-Sh   100.0    98  98  98    98  97 100   100 100 100    10469    956      98  99    99  99    99  99    347  -347
Cm-Ro   100.0    98  96 100   100 100 100   100 100 100     3532   2376      86  96    97  99    99  99     43   -43
Mc-Nt   100.0    97  95 100   100 100 100   100 100 100     2637   1917      77  94    95  98    99  99     27   -27
Mc-Tr   100.0   100 100 100   100 100 100   100 100 100    -1389  -2405      84  96    96  99    99  99     38   -38
Mc-Sh   100.0    97  98  98    98  97  95    95  91  81     8774   -731      98  99    99  99    99 100    347  -347
Mc-Ro   100.0    99 100 100   100 100 100   100 100  79     2038    488      89  97    97  99    99  99     57   -57
Nt-Tr   100.0    98 100 100   100 100 100   100 100 100    -3420  -4927      89  97    97  99    99  99     55   -55
Nt-Sh   100.0    98  98  98    98  98  97    97  95  91     6645  -3156      98  99    99  99    99  99    358  -358
Nt-Ro   100.0    99 100  98    98  90  83    83  75  62      -38  -1989      91  97    98  99    99  99     72   -72
Tr-Sh   100.0    98  97  97    97  95 100   100 100 100    10167   1670      98  99    99  99    99  99    310  -310
Tr-Ro   100.0    98  98 100   100 100 100   100 100 100     4314   2006      93  98    98  99    99  99     85   -85
Sh-Ro   100.0    97  97  98    98  98  97    97  95  90     2562  -8079      98  99    99  99    99  99    388  -388
```

```
**** Source declination = +60 ****

          %        8MHz          2MHz         0.5MHz       delay  delay      329MHz    1.6GHz    22GHz    rate  rate
         up     1:1 1:2 1:4   1:1 1:2 1:4   1:1 1:2 1:4     max    min       1s  4s    1s  4s    1s  4s   max    min
Ef-Wb   100.0   100 100 100   100 100  85    85  64  34     -125   -825      76  94    95  98    99  99     26   -26
Ef-On   100.0    99 100 100   100 100  92    92  81  69     -130  -2466      93  98    98  99    99  99     86   -86
Ef-Jb   100.0    98  98  97    97  94  89    89  78  47      589  -1663      92  98    98  99    99  99     83   -83
Ef-Cm   100.0    99  98  96    96  93  86    86  71  37      501  -1159      90  97    98  99    99  99     61   -61
Ef-Mc   100.0    99 100 100   100 100  94    94  80  67     2173    143      92  98    98  99    99  99     74   -74
Ef-Nt   100.0    97  97  97    97 100 100   100 100 100     5208   1112      96  99    99  99    99  99    150  -150
Ef-Tr   100.0    98  99  98    98  96  92    92  84  66      882  -1903      94  98    98  99    99  99    102  -102
Ef-Sh   100.0    98  98  98    98  99  99    99  98  96    18109  -8720      99  99    99  99    99 100    978  -978
Ef-Ro   100.0    98  99 100   100 100 100   100  96  81     4230    307      95  98    99  99    99  99    143  -143
Wb-On   100.0    97  95  91    91  81  77    77  69  56       61  -1706      90  97    98  99    99  99     65   -65
Wb-Jb   100.0    99  98  97    97  94  89    89  79  55      938  -1061      92  98    98  99    99  99     73   -73
Wb-Cm   100.0    99  98  96    96  93  86    86  71  27      901   -608      89  97    97  99    99  99     55   -55
Wb-Mc   100.0    98  98 100   100 100 100   100  96  77     2953    314      93  98    98  99    99  99     97   -97
Wb-Nt   100.0    99  98  98    98 100 100   100 100 100     5989   1282      96  99    99  99    99  99    172  -172
Wb-Tr   100.0    96  99  98    98  96  92    92  84  68     1299  -1369      94  98    98  99    99  99     98   -98
Wb-Sh   100.0    98  98  98    98  99  99    99  98  96    18330  -7990      99  99    99  99    99 100    960  -960
Wb-Ro   100.0    98  99 100   100 100 100   100 100  92     4913    575      96  99    99  99    99  99    159  -159
On-Jb   100.0    99  99  98    98  96  92    92  85  69     2389   -868      95  98    98  99    99  99    119  -119
On-Cm   100.0    99  98  97    97  95  90    90  81  57     2465   -528      94  98    98  99    99  99    110  -110
On-Mc   100.0    98  99 100   100 100 100   100 100  93     4308    604      95  98    99  99    99  99    135  -135
On-Nt   100.0    98  98  99    99 100 100   100 100 100     7257   1658      97  99    99  99    99  99    204  -204
On-Tr   100.0    98  97  95    95  90  78    78  66  54     1749   -174      91  97    98  99    99  99     71   -71
On-Sh   100.0    97  98  98    98  99  99    99  98  96    18270  -6286      99  99    99  99    99 100    895  -895
On-Ro   100.0    98  99  99    99 100 100   100 100  91     6612    521      97  99    99  99    99  99    222  -222
Jb-Cm   100.0    97  94  88    88  75  54    54  38  00      516   -100      73  93    94  98    99  99     23   -23
Jb-Mc   100.0    96  98  97    97  95  91    91  81  66     3778   -389      96  99    99  99    99  99    152  -152
Jb-Nt   100.0    98  99  99    99 100 100   100 100  96     6778    616      97  99    99  99    99  99    225  -225
Jb-Tr   100.0    99  99  98    98  97  95    95  91  82     2342  -2289      96  99    99  99    99  99    169  -169
Jb-Sh   100.0    98  98  98    98  99  99    99  98  96    18945  -8483      99  99    99  99    99 100   1000 -1000
Jb-Ro   100.0    98  99 100   100 100 100   100 100 100     4552   1059      95  98    99  99    99  99    128  -128
Cm-Mc   100.0    98  97  97    97  94  89    89  72  65     3263   -289      95  98    99  99    99  99    130  -130
Cm-Nt   100.0    96  98  98    98 100 100   100 100 100     6264    714      97  99    99  99    99  99    203  -203
Cm-Tr   100.0    98  99  98    98  97  95    95  90  80     1907  -2269      96  99    99  99    99  99    153  -153
Cm-Sh   100.0    98  98  98    98  99  99    99  98  96    18719  -8672      99  99    99  99    99 100    999  -999
Cm-Ro   100.0    98  99 100   100 100 100   100 100 100     4261    934      95  98    99  99    99  99    122  -122
Mc-Nt   100.0    98  98 100   100 100 100   100 100 100     3038    966      92  98    98  99    99  99     76   -76
Mc-Tr   100.0    99  98 100   100 100 100   100  87  74     -206  -3131      94  98    98  99    99  99    107  -107
Mc-Sh   100.0    98  98  97    97  96  99    99  98  96    17219 -10146      99  99    99  99   100 100    998  -998
Mc-Ro   100.0    99  98  98    98  97  94    94  89  78     3341  -1120      96  99    99  99    99  99    163  -163
Nt-Tr   100.0    98  98  98    98 100 100   100 100 100    -1502  -5839      96  99    99  99    99  99    158  -158
Nt-Sh   100.0    98  97  98    98  98  99    99  98  97    15644 -12575      99  99    99  99    99 100   1029 -1029
Nt-Ro   100.0    98  98  99    99  98  96    96  92  84     1917  -3700      97  99    99  99    99  99    205  -205
Tr-Sh   100.0    98  98  98    98  99  99    99  98  96    17438  -7028      99  99    99  99    99  99    892  -892
Tr-Ro   100.0    98  98  97    97  97  94    94  88  72     6102   -544      97  99    99  99    99  99    243  -243
Sh-Ro   100.0    98  98  98    98  98  99    99  98  97    12893 -17744      99  99    99  99    99 100   1117 -1117

**** Source declination = +40 ****

          %        8MHz          2MHz         0.5MHz       delay  delay      329MHz    1.6GHz    22GHz    rate  rate
         up     1:1 1:2 1:4   1:1 1:2 1:4   1:1 1:2 1:4     max    min       1s  4s    1s  4s    1s  4s   max    min
Ef-Wb   100.0    98  96  93    93  87  71    71  51  31      184   -889      84  96    96  99    99  99     40   -40
Ef-On   100.0    98  97  98    98  96  93    93  86  70      826  -2752      95  98    99  99    99  99    131  -131
Ef-Jb   100.0    97  99  98    98  96  93    93  87  74     1326  -2123      95  98    99  99    99  99    126  -126
Ef-Cm   100.0    98  98  97    97  95  91    91  83  65     1028  -1516      93  98    98  99    99  99     93   -93
Ef-Mc    81.1    99  98  97    97  95  90    90  80  54     2414   -695      93  98    98  99    99  99    114  -114
Ef-Nt    71.5    98  98  97    97  96  93    93  86  69     5483   -792      96  99    99  99    99  99    217  -229
Ef-Tr   100.0    95  93  98    98  97  95    95  90  80     1754  -2512      96  99    99  99    99  99    156  -156
Ef-Sh    66.8    98  98  98    98  99  98    98  99  98    24036 -17067      99  99    99  99    99 100   1498  -758
Ef-Ro    75.1    97  99  98    98  97  94    94  89  77     4688  -1321      96  99    99  99    99  99    219  -219
Wb-On   100.0    98  98  97    97  95  91    91  82  61      742  -1964      94  98    98  99    99  99     99   -99
Wb-Jb   100.0    98  99  98    98  96  93    93  86  72     1485  -1577      94  98    98  99    99  99    112  -112
Wb-Cm   100.0    95  98  97    97  95  91    91  82  62     1264  -1047      93  98    98  99    99  99     85   -85
Wb-Mc    81.1    98  98  98    98  96  92    92  84  65     3234   -809      95  98    98  99    99  99    148  -148
Wb-Nt    71.5    98  98  97    97  97  94    94  87  74     6304   -908      96  99    99  99    99  99    255  -263
Wb-Tr   100.0    98  99  98    98  97  95    95  89  79     2018  -2070      96  99    99  99    99  99    149  -149
Wb-Sh    66.8    98  98  98    98  99  98    98  99  98    23999 -16325      99  99    99  99    99 100   1470  -766
Wb-Ro    75.1    97  98  97    97  97  94    94  89  78     5357  -1286      98  99    99  99    99  99    243  -243
On-Jb   100.0    98  98  98    98  97  95    95  91  82     3060  -1930      96  99    99  99    99  99    182  -182
On-Cm   100.0    98  98  98    98  97  95    95  90  80     3011  -1573      96  99    99  99    99  99    168  -168
On-Mc    81.1    98  98  98    98  97  94    94  88  75     4602  -1014      98  99    99  99    99  99    207  -207
On-Nt    71.5    98  98  98    98  97  94    94  89  77     7451   -980      98  99    99  99    99 100    313  -313
On-Tr   100.0    99  99  98    98  96  92    92  84  67     2058   -889      94  98    98  99    99  99    108  -108
On-Sh    66.8    98  98  99    99  98  98    98  99  98    23258 -14363      99  99    99  99    99 100   1371  -718
On-Ro    75.1    98  98  98    98  98  96    96  92  85     7298  -2019      98  99    99  99    99  99    340  -340
Jb-Cm   100.0    98  97  94    94  88  76    76  38  00      626   -317      82  95    96  99    99  99     35   -35
Jb-Mc    81.1    98  99  98    98  97  95    95  91  83     4450  -1934      96  99    99  99    99  99    225  -233
Jb-Nt    71.5    98  99  98    98  98  96    96  92  86     7464  -1976      97  99    99  99    99  99    300  -344
Jb-Tr   100.0    98  98  99    99  98  97    97  94  88     3567  -3528      97  99    99  99    99  99    259  -259
Jb-Sh    66.8    98  98  99    99  99  99    99  99  98    24894 -17128      99  99    99  99   100 100   1532  -878
Jb-Ro    75.1    98  98  97    97  95  91    91  83  57     4419   -593      98  99    99  99    99  99    195  -195
Cm-Mc    81.1    97  99  98    98  97  94    94  89  81     3825  -1618      96  99    99  99    99  99    192  -199
Cm-Nt    71.5    98  99  98    98  97  95    95  91  83     6841  -1662      97  99    99  99    99 100    272  -310
Cm-Tr   100.0    98  98  99    99  98  96    96  93  87     3064  -3333      97  99    99  99    99  99    234  -234
Cm-Sh    66.8    98  98  98    98  99  99    99  99  98    24711 -17254      99  99    99  99    99 100   1530  -848
Cm-Ro    75.1    98  98  97    97  95  91    91  83  55     4335   -620      97  99    99  99    99  99    186  -186
Mc-Nt    71.5    97  96  93    93  85  74    74  66  55     3072   -100      93  98    98  99    99  99    111  -116
Mc-Tr    81.1    98  98  98    98  96  93    93  86  71     1002  -3260      97  99    99  99    99  99    164  -164
Mc-Sh    47.9    98  98  98    98  98  98    98  98  97    23587 -17262      99  99    99  99   100 100   1528  -858
Mc-Ro    73.7    97  97  99    99  98  97    97  95  91     4242  -2593      96  99    99  99    99  99    250  -211
Nt-Tr    71.5    98  98  97    97  96  92    92  84  60      598  -5543      98  99    99  99    99  99    243  -243
Nt-Sh    39.6    98  97  98    98  98  98    98  98  97 [illegible]2756  -9777      99  99    99  99   100 100   1576  -599
Nt-Ro    68.0    99  99  97    97  99  98    98  96  92     3641  -4964      97  99    99  99    99  99    314  -194
Tr-Sh    66.8    98  98  99    99  98  98    98  99  98    22605 -14879      99  99    99  99    99  99   1366  -750
Tr-Ro    75.1    98  98  98    98  98  97    97  94  88     7153  -3028      97  99    99  99    99  99    371  -364
Sh-Ro    41.9    98  98  97    97  98  97    97  98  97    21480 -25270      99  99    99  99    99 100    913 -1711
```

```
**** Source declination = +20 ****

           %       8MHz          2MHz         0.5MHz       delay  delay      329MHz    1.6GHz    22GHz    rate  rate
           up   1:1 1:2 1:4   1:1 1:2 1:4   1:1 1:2 1:4     max    min      1s  4s    1s  4s    1s  4s   max    min
Ef-Wb    64.5    98  96  93    93  87  74    74  48  00      470   -648      90  97    98  99    99  99     48   -48
Ef-On    64.5    98  99  98    98  96  92    92  85  69     1682  -1859      97  99    99  99    99  99    160  -160
Ef-Jb    62.7    99  99  99    99  98  96    96  92  84     1903  -2327      93  98    98  99    99  99    155   -94
Ef-Cm    63.0    97  99  98    98  97  94    94  89  78     1430  -1690      91  97    98  99    99  99    114   -61
Ef-Mc    61.7    98  99  98    98  97  95    95  91  81     2323  -1449      96  99    99  99    99  99    113  -139
Ef-Nt    58.7    97  96  99    99  98  97    97  95  90     4939  -2600      98  99    99  99    99  99    209  -281
Ef-Tr    62.0    98  98  99    99  98  96    96  93  87     2415  -2689      97  99    99  99    99  99    168  -191
Ef-Sh    29.0    98  98  98    98  99  98    98 100 100    27064   1183      99  99    99  99    99 100   1838  -407
Ef-Ro    59.1    98  97  99    99  98  97    97  95  90     4243  -2790      98  99    99  99    99  99    269  -227
Wb-On    65.9    97  98  97    97  95  90    90  80  63     1335  -1635      96  99    99  99    99  99    121  -121
Wb-Jb    63.5    99  99  98    98  97  95    95  91  82     1854  -1903      93  98    98  99    99  99    137   -61
Wb-Cm    63.8    97  99  98    98  97  94    94  88  76     1475  -1360      91  97    98  99    99  99    104   -66
Wb-Mc    61.7    98  98  99    99  98  96    96  93  84     2969  -1835      97  99    99  99    99  99    161  -181
Wb-Nt    58.7    98  97  98    98  98  97    97  95  91     5568  -2987      98  99    99  99    99  99    256  -323
Wb-Tr    62.6    95  91  99    99  98  96    96  93  86     2493  -2516      97  99    99  99    99  99    138  -183
Wb-Sh    29.6    98  98  98    98  99  98    98 100 100    26774    843      99  99    99  99   100 100   1803  -431
Wb-Ro    59.9    98  98  99    99  98  97    97  95  91     4621  -2992      98  99    99  99    99  99    297  -271
On-Jb    63.6    98  97  99    99  98  97    97  94  89     3349  -2760      97  99    99  99    99  99    223  -181
On-Cm    64.0    98  99  99    99  98  97    97  94  88     3095  -2429      97  99    99  99    99  99    205  -187
On-Mc    61.7    93  92  98    98  97  95    95  90  80     3366  -2510      98  99    99  99    99  99    254  -254
On-Nt    58.7    98  98  99    99  99  97    97  95  89     5908  -3500      98  99    99  99    99 100    359  -384
On-Tr    65.7    98  99  98    98  97  95    95  91  82     2118  -1496      93  98    98  99    99  99     81  -132
On-Sh    32.7    98  97  97    97  98  98    98  98  97    25441  -3114      99  99    99  99    99 100   1682  -407
On-Ro    60.0    98  98  99    99  99  98    98  96  93     6268  -4315      98  99    99  99    99  99    418  -386
Jb-Cm    65.1    99  98  96    96  93  86    86  64  04      658   -496      86  97    97  99    99  99     37   -43
Jb-Mc    60.0    98  98  99    99  98  97    97  95  91     4575  -3246      98  99    99  99    99  99    184  -286
Jb-Nt    57.6    98  99  99    99  99  98    98  96  93     7155  -4330      98  99    99  99    99  99    259  -422
Jb-Tr    60.2    98  99  99    99  99  98    98  96  92     4362  -4341      96  99    99  99    99  99    179  -318
Jb-Sh    27.2    98  97  98    98  99  98    98 100 100    27839   6248      99  99    99  99   100 100   1854  -561
Jb-Ro    60.0    98  98  98    98  97  94    94  88  77     2921  -2174      97  99    99  99    99  99    240  -240
Cm-Mc    60.3    97  97  99    99  98  97    97  94  89     3921  -2751      98  99    99  99    99  99    157  -244
Cm-Nt    57.9    97  98  98    98  99  98    98  96  92     6517  -3837      98  99    99  99    99 100    236  -381
Cm-Tr    60.6    97  99  99    99  98  97    97  95  91     3852  -3990      98  99    99  99    99 100    187  -286
Cm-Sh    27.5    98  97  98    98  99  98    98 100 100    27723   5085      99  99    99  99    99 100   1863  -520
Cm-Ro    60.0    98  98  98    98  97  94    94  88  76     3178  -2100      97  99    99  99    99  99    228  -226
Mc-Nt    58.7    98  98  98    98  97  95    95  90  76     2631  -1155      96  99    99  99    99  99    110  -142
Mc-Tr    61.7    98  99  98    98  96  93    93  87  74     2089  -2016      97  99    99  99    99  99    201  -201
Mc-Sh    28.9    98  98  98    98  98  98    98  98  97    27111  -1051      99  99    99  99   100 100   1874  -282
Mc-Ro    56.4    94  99  99    99  98  97    97  95  91     4595  -3753      98  99    99  99    99  99    306  -156
Nt-Tr    58.7    97  96  98    98  97  95    95  90  81     2625  -3793      98  99    99  99    99  99    297  -297
Nt-Sh    28.4    98  98  98    98  98  98    98  98  97    27123  -2793      99  99    99  99   100 100   1933  -161
Nt-Ro    54.0    98  98  98    98  99  98    98  96  92     4925  -5630      97  99    99  99    99  99    385   -72
Tr-Sh    33.0    97  96  92    92  98  98    98  98  97    25045  -5524      99  99    99  99    99  99   1676  -277
Tr-Ro    56.6    98  97  95    95  99  98    98  97  94     6651  -5147      98  99    99  99    99  99    456  -355
Sh-Ro    23.6    98  98  99    99  99  98    98 100 100   -10597 -29747      99  99    99  99    99 100    531 -1977

**** Source declination =  0  ****

           %       8MHz          2MHz         0.5MHz       delay  delay      329MHz    1.6GHz    22GHz    rate  rate
           up   1:1 1:2 1:4   1:1 1:2 1:4   1:1 1:2 1:4     max    min      1s  4s    1s  4s    1s  4s   max    min
Ef-Wb    49.9    99  98  96    96  92  85    85  69  26      700   -218      88  97    97  99    99  99     51   -49
Ef-On    48.6    99  99  98    98  97  95    95  91  84     2335   -276      96  99    99  99    99  99    167  -171
Ef-Jb    47.4    98  99  98    98  97  95    95  90  80     2251  -2108      96  99    99  99    99  99    165   -33
Ef-Cm    48.1    98  99  98    98  96  93    93  87  73     1660  -1617      95  98    98  99    99  99    121   -14
Ef-Mc    48.7    98  99  98    98  97  94    94  89  79     1604  -2029      95  98    99  99    99  99     81  -148
Ef-Nt    47.7    98  98  99    99  98  97    97  94  89     3123  -4095      97  99    99  99    99  99    160  -299
Ef-Tr    46.8    98  97  99    99  98  96    96  92  84     2784  -1905      96  99    99  99    99  99    117  -203
Ef-Sh    18.2    98  98  98    98  99  98    98 100 100    26828  11131      99  99    99  99    99 100   1779    -7
Ef-Ro    46.9    98  99  99    99  98  97    97  94  88     2480  -3922      97  99    99  99    99  99    286  -183
Wb-On    48.5    98  99  98    98  97  94    94  88  77     1766   -554      95  98    99  99    99  99    118  -129
Wb-Jb    47.5    98  99  98    98  97  94    94  89  78     1987  -1996      99 100   100 100   100 100    146     7
Wb-Cm    48.2    97  99  98    98  96  92    92  85  71     1432  -1509      94  98    98  99    99  99    110   -23
Wb-Mc    48.6    97  96  99    99  98  96    96  92  83     1816  -2639      96  99    99  99    99  99    128  -193
Wb-Nt    47.7    98  99  99    99  98  97    97  95  90     3328  -4707      98  99    99  99    99  99    205  -343
Wb-Tr    46.7    98  97  98    98  97  95    95  91  83     2668  -2255      96  99    99  99    99  99     68  -195
Wb-Sh    18.2    97  98  98    98  99  98    98 100 100    26319  11455      99  99    99  99   100 100   1727   -41
Wb-Ro    47.0    98  99  99    99  98  97    97  94  89     2275  -4337      98  99    99  99    99  99    317  -233
On-Jb    46.0    98  98  99    99  98  96    96  93  86     2513  -3257      97  99    99  99    99 100    238  -102
On-Cm    46.7    98  97  99    99  98  96    96  92  85     1935  -2992      97  99    99  99    99  99    219  -134
On-Mc    49.9    98  98  99    99  98  97    97  94  88     1414  -3703      97  99    99  99    99  99    249  -270
On-Nt    49.2    98  98  97    97  99  98    98  96  92     3068  -5599      98  99    99  99    99 100    329  -408
On-Tr    48.2    98  99  98    98  97  94    94  88  77     1851  -1923      95  98    99  99    99  99     23  -141
On-Sh    19.6    98  98  98    98  98  98    98 100 100    24555   8666      99  99    99  99    99 100   1675   -44
On-Ro    45.5    98  98  97    97  99  98    98  96  92     2478  -6090      98  99    99  99    99  99    444  -340
Jb-Cm    49.4    98  97  95    95  91  83    83  64  00      508   -615      86  96    97  99    99  99     24   -45
Jb-Mc    46.1    98  98  99    99  98  97    97  94  89     3492  -4167      97  99    99  99    99  99    100  -304
Jb-Nt    45.2    98  98  98    98  99  98    98  96  92     4767  -6162      98  99    99  99    99  99    169  -450
Jb-Tr    44.2    98  98  99    99  98  97    97  95  90     4631  -4155      98  99    99  99    99  99     32  -338
Jb-Sh    15.7    98  98  98    98  99  98    98 100 100    27427  16992      99  99    99  99   100 100   1569  -167
Jb-Ro    49.5    98  98  99    99  98  97    97  94  88      826  -3492      97  99    99  99    99  99    255  -246
Cm-Mc    46.8    98  98  99    99  98  96    96  93  87     3060  -3552      97  99    99  99    99  99     84  -259
Cm-Nt    45.8    98  98  98    98  98  98    98  95  91     4401  -5550      98  99    99  99    99 100    156  -405
Cm-Tr    44.9    98  98  99    99  98  97    97  94  89     4175  -3557      97  99    99  99    99 100     69  -305
Cm-Sh    16.3    98  99  98    98  99  98    98 100 100    27391  15578      99  99    99  99    99 100   1642  -122
Cm-Ro    48.8    99  98  99    99  98  96    96  93  87     1208  -3326      97  99    99  99    99  99    243  -219
Mc-Nt    49.1    98  99  98    98  97  94    94  89  79     1631  -2071      96  99    99  99    99  99     86  -151
Mc-Tr    48.1    98  97  99    99  98  97    97  95  89     2925    -83      97  99    99  99    99  99    211  -214
Mc-Sh    19.6    98  98  98    98  98  98    98 100 100    27299   7366     100 100   100 100   100 100   1921   137
Mc-Ro    45.6    98  98  99    99  98  97    97  94  89     3920  -4461      98  99    99  99    99 100    326   -71
Nt-Tr    49.0    98  98  99    99  98  97    97  95  90     4336  -1437      98  99    99  99    99  99    316  -291
Nt-Sh    20.5    98  98  98    98  98  98    98 100 100    27956   4116     100 100   100 100   100 100   2035   280
Nt-Ro    44.7    98  98  97    97  98  97    97  95  91     5492  -5572     100 100   100 100   100 100    410    51
Tr-Sh    21.5    98  98  98    98  98  98    98 100 100    24429   4056     100 100   100 100   100 100   1759    96
Tr-Ro    43.7    98  98  98    98  99  98    98  96  92     3718  -6646      98  99    99  99    99  99    485  -265
Sh-Ro    15.2    98  98  97    97  96  98    98 100 100   -18650 -30637      99  99    99  99    99 100     80 -1772
```

```
**** Source declination = -20 ****

          %        8MHz          2MHz         0.5MHz       delay  delay      329MHz    1.6GHz    22GHz    rate  rate
         up     1:1 1:2 1:4   1:1 1:2 1:4   1:1 1:2 1:4     max    min       1s  4s    1s  4s    1s  4s   max    min
Ef-Wb    34.1   100 100 100   100 100 100   100  99  73      845    307      82  95    96  99    99  99     48   -33
Ef-On    30.9    97  95 100   100 100 100   100 100 100     2707   1530      94  98    98  99    99  99    121  -142
Ef-Jb    32.2    98  99  98    98  96  92    92  84  69     2258  -1162     100 100   100 100   100 100    155    39
Ef-Cm    33.2    98  98  97    97  95  90    90  80  59     1598  -1049     100 100   100 100   100 100    114    38
Ef-Mc    35.5    98  99  98    98  96  92    92  84  75      384  -2364      94  98    98  99    99  99     29  -139
Ef-Nt    35.5    96  94  91    91  98  96    96  92  88      296  -5096      97  99    99  99    99  99     70  -281
Ef-Tr    31.5    98  97  98    98  96  93    93  87  78     2818   -448      95  98    98  99    99  99     31  -191
Ef-Sh     7.5    98  98  98    98  97  94    94 100 100    22765  17612     100 100   100 100   100 100   1168   395
Ef-Ro    34.7    99  99 100   100  99  98    98  96  92      -56  -4581      96  99    99  99    99  99    269  -100
Wb-On    30.9    99 100 100   100 100 100   100 100 100     1984    786      92  98    98  99    99  99     74  -117
Wb-Jb    31.5    98  98  97    97  95  91    91  82  64     1569  -1572     100 100   100 100   100 100    137    72
Wb-Cm    32.5    98  98  97    97  94  88    88  77  54      910  -1421     100 100   100 100   100 100    104    28
Wb-Mc    34.1    98  98  99    99  98  97    97  94  87       -7  -3125      95  98    99  99    99  99     56  -181
Wb-Nt    34.1    98  98  98    98 100 100   100  98  95     -185  -5859      97  99    99  99    99  99     92  -323
Wb-Tr    30.8    98  97  98    98  96  93    93  86  73     2495  -1198     100 100   100 100   100 100    -26  -183
Wb-Sh     6.7    98  99  98    98  96  93    93 100 100    22204  18062     100 100   100 100   100 100   1050   355
Wb-Ro    34.1    97  96  93    93 100 100   100 100 100     -866  -5159      97  99    99  99    99  99    297  -147
On-Jb    28.4    98  98  98    98  97  94    94  88  78      548  -3354     100 100   100 100   100 100    223    14
On-Cm    29.4    99  98 100   100 100  98    98  95  89      -94  -3194      95  98    99  99    99  99    205   -36
On-Mc    30.9    99  99 100   100 100 100   100 100 100    -1675  -4450      96  99    99  99    99  99    138  -249
On-Nt    30.9    98  99  98    98 100 100   100 100 100    -1870  -7022      97  99    99  99    99 100    146  -384
On-Tr    30.6    98  98  97    97  95  90    90  81  61      847  -2012     100 100   100 100   100 100    -44  -132
On-Sh     6.6    98  97  96    96  93  86    86 100 100    20266  16555     100 100   100 100   100 100    963   327
On-Ro    30.9    99  99  99    99 100 100   100 100 100    -2441  -7132      97  99    99  99    99  99    411  -219
Jb-Cm    33.6    98  96  93    93  86  73    73  57  15      179   -660      86  94    95  98    99  99      4   -43
Jb-Mc    32.2    98  98  98    98  97  95    95  91  83     1169  -4582     100 100   100 100   100 100     -9  -286
Jb-Nt    32.8    98  98  98    98  98  97    97  94  88      684  -7250      97  99    99  99    99  99     47  -422
Jb-Tr    28.2    98  98  98    98  97  95    95  91  83     3976  -2507     100 100   100 100   100 100   -127  -318
Jb-Sh     4.2    99  97 100   100 100 100   100 100 100    23466  21697     100 100   100 100   100 100    727   256
Jb-Ro    33.9    98  99 100   100 100 100   100 100 100    -1972  -4390      96  99    99  99    99  99    231  -176
Cm-Mc    33.2    98  98  98    98  97  95    95  90  81     1169  -3923     100 100   100 100   100 100     -9  -244
Cm-Nt    33.8    98  98  98    98  98  96    96  93  87      803  -6593      97  99    99  99    99 100     46  -381
Cm-Tr    29.2    97  98  98    98  97  95    95  91  82     3867  -1868     100 100   100 100   100 100    -72  -286
Cm-Sh     5.1    98  98 100   100 100 100   100 100 100    23430  20826     100 100   100 100   100 100    869   297
Cm-Ro    34.6    98  99 100   100 100 100   100 100 100    -1376  -4152      96  99    99  99    99  99    227  -150
Mc-Nt    38.3    98  97  98    98  96  92    92  87  80      209  -2737      94  98    98  99    99  99     42  -142
Mc-Tr    34.0    99  98 100   100 100 100   100 100 100     3407   1914      95  98    99  99    99  99    173  -179
Mc-Sh    10.2    98  98  98    98  98  96    96 100 100    23251  13962     100 100   100 100   100 100   1503   534
Mc-Ro    34.7    98  99  99    99  98  96    96  92  85     2279  -4612     100 100   100 100   100 100    306    28
Nt-Tr    34.0    98  97  96    96 100 100   100 100 100     5524   1864      97  99    99  99    99  99    296  -184
Nt-Sh    12.6    98  98  98    98  98  97    97 100 100    24241  10230     100 100   100 100   100 100   1764   675
Nt-Ro    35.3    98  98  98    98  98  97    97  94  88     5019  -4427     100 100   100 100   100 100    385   163
Tr-Sh    10.0    98  97  97    97  96  94    94 100 100    20075  12200     100 100   100 100   100 100   1315   453
Tr-Ro    30.7    98  99  99    99 100 100   100 100  99     -529  -7342      97  99    99  99    99  99    456  -120
Sh-Ro     6.7    98  99  98    98 100 100   100 100 100   -22750 -27344     100 100   100 100   100 100   -384 -1191
```