JET PROPULSION LABORATORY **INTEROFFICE MEMORANDUM**
334RW–2001–005
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To: W.T.K. Johnson
From: R. West
Subject: Guidelines for C27 IEB

1 Introduction

This memo provides guidelines for preparing the RADAR IEB for the C27 sequence (scheduled for August 27-28, 2001). The C27 RADAR sequence repeats some of the scans performed in C25 with some improvements. The large Sun scan is centered on the Sun this time so we should get data for all 5 beams. The microwave sources have updated epoch 2000 coordinates so they should be better centered. Jupiter is also scanned, but it will be fairly weak due to increasing range. These scans are performed to characterize the antenna patterns, and to add more data to the radiometer calibration model. A Titan simulation is scheduled at the end while executing a small raster scan on the Sun (2001-240T00:42:18 - 2001-240T01:45:07). A Tau variation data set can also be collected at some convenient point. The C27 sequence will be quite long, so it will need to be split into two IEB's (like C25). The split is currently planned to occur during the slew to Jupiter after performing the microwave source scans (2001-239T12:45:00). The radiometer data types are categorized below.

1. Low rate data (Radiometer warmup - 4 sec. burst period ok)
2. Tau variation data set (varying integration times for RL, ND, and B3)
3. High rate data (250 ms burst period) for 10 - 20 min
4. Microwave Source Scans
5. Jupiter Scan
6. Large Sun Scan

The Tau Variation and High Rate data segments are included on a space available basis. The raster scans have priority. The following sections describe each segment separately.

2 Low Rate Data

The low rate data covers any times between other tests (eg., during a slew to a target). This data will generally be collected looking at cold space. The same parameters used during earlier sequences can be used again for C27. (ie., Auto-rad on, 4 sec. integration time.)

3 Tau Variation

The C27 timeline is pretty full, so it may be difficult to fit in the Tau variation and high rate data sets. Nonetheless, if they can be included, it would be useful to continue monitoring the radiometer offset and noise performance. One possibility is to put the Tau variation set at the very end (while Earth pointed) after the large Sun scan, either before or after the Titan simulation. The second IEB is scheduled to halt at 2001-240T01:49:00. If the Tau variation set is put after the Titan simulation, then there is only 4 minutes so it may need to be truncated. If the time is very tight, the high rate data set should be sacrificed first. Another possibility is to put the Tau variation set at the end of the first IEB right after the last microwave source scan. There seems to be more time during the slew to Jupiter (about 10 minutes in the first IEB) so it may be easier to accomodate here. The test sequence itself will be the same as in earlier sequences. If it is conducted before the switch to SAF-248 mode, then the minimum burst period will be 250 ms (imposed by SAF-142 data mode) as shown in the tables. Otherwise, the minimum burst period can be dropped to 100 ms. The sequence is summarized in the tables at the end of this memo. More discussion of these tables can be found in IOM-334RW-2000-001,002. Just like C25 and C26 this memo gives integration times as commanded times rather than actual times. The nominal Tau variation test sequence lasts about 9 minutes.

4 High Rate Data

The high rate data is meant to characterize 1/f noise in the receiver. The same parameters used in earlier sequences can be used again here. If this test is performed after the mode change to SAF-248, then a faster 100 ms burst period can be used. This test has lower priority than the Tau variation test, so if data volume is limited, this test sequence should be deleted first. It can be performed immediately after the Tau variation test.

5 Raster Scans

The raster scans in C27 will be similar to the scans in C25. The Jupiter scans and the microwave source scans have been increased in size from 1 deg by 1 deg in C25 to a little over 2 deg by 2 deg in C27. The coordinates of the microwave sources have been corrected to epoch 2000. These changes should ensure that the sources are captured completely by the scans. The five microwave sources (M17, Cyg. A, Cas. A, Taurus A, Orion A) are scanned first after the warmup (2001-239T04:00:42 - 2001-239T12:35:56). (Note, times are UTC.)

Following the sources, Jupiter is scanned twice (2001-239T13:04:11 - 2001-239T15:56:29). During the slew to Jupiter the first IEB halts, and the second begins. The signal from Jupiter in C27 will be weaker than the Jupiter signal observed in C20 because of increasing range, however, it should still be detectable. For C20 the range to Jupiter was 172.8 million km, while it is expected to be 215.0 million km for C27.

Following the Jupiter scans, we slew to the Sun, and then offset to begin the large Sun raster scan. The Sun scan will have a slightly smaller signal than in C25 because the range to the Sun will have increased (during 2001, the Sun signal drops about 0.2 dB/month). The Sun scan is large (8.1 x 4.6 deg) so the duration is quite long (2001-239T16:22:25 - 2001-240T00:31:18). System performance during C25 will be used to design the timing for C27.

5.1 Gain Performance

The post warmup gain was computed to be 0.1 counts/ms/K for C20 and C22 (ICO2-A,B). In C25, the post warmup gain was 0.185 counts/ms/K. The system noise temperature fell from about 1500 K in C22 to 858 K in C25. These changes are most likely due to temperature changes. As range from the sun increases, temperatures are expected to fall. Looking at the equilibrium temperatures for C22 and C25, there is a slight drop (maybe a degree or two (C) - I'll have to dig into this quantitatively later). The drop in waveguide temperatures and HGA temperatures is more significant (a few degrees to almost 20 degrees C), so the drop in system noise temperature is not too surprising. I will use the C25 gain and noise performance to predict signal levels in C27.

5.2 Integration Time

For C27, table 1 shows the signal variation expected for all the scan targets at various commanded integration times. The system gain just computed from C25 is used along with the equilibrium system noise temperature (ie., 858 K).

Target Name	Integration Time (ms)	Source Temperature Range (K)	Equilibrium Signal Range	Initial Warmup Range	Final Warmup Range
Jupiter	45	2.8 - 4.7	3466 - 3481	5512 - 5532	3700 - 3716
Jupiter	40	2.8 - 4.7	2668 - 2682	4481 - 4499	2875 - 2889
Jupiter	35	2.8 - 4.7	1870 - 1882	3450 - 3466	2050 - 2063
Jupiter	30	2.8 - 4.7	1072 - 1082	2420 - 2433	1226 - 1237
Jupiter	25	2.8 - 4.7	274 - 282	1389 - 1400	401 - 410
Sun	45	2.8 - 603.0	3466 - 8358	5512 - 11830	3700 - 8755
Sun	40	2.8 - 603.0	2668 - 7003	4481 - 10081	2875 - 7355
Sun	35	2.8 - 603.0	1870 - 5649	3450 - 8331	2050 - 5956
Sun	30	2.8 - 603.0	1072 - 4295	2420 - 6582	1226 - 4556
Sun	25	2.8 - 603.0	274 - 2940	1389 - 4833	401 - 3157
uwave source	45	2.8 - 4.8	3466 - 3482	5512 - 5533	3700 - 3716
uwave source	40	2.8 - 4.8	2668 - 2682	4481 - 4500	2875 - 2890
uwave source	35	2.8 - 4.8	1870 - 1882	3450 - 3466	2050 - 2063
uwave source	30	2.8 - 4.8	1072 - 1082	2420 - 2433	1226 - 1237
uwave source	25	2.8 - 4.8	274 - 283	1389 - 1400	401 - 410

Table 1: Expected Radiometer signal levels for different commanded integration times. These integration times are per window. The window count is constrained by the burst period. The values above assume the same gain values (equilibrium - 0.19, turn on - 0.24, post warmup - 0.19 counts/ms/K), and system noise temperature (858 K) computed for C25, and a constant offset of 3550 counts. The warmup ranges show the signals expected right after system turn on, and after 5 hours 10 minutes of operation. Note that actual signals from the ADC will be confined to the range [0,4095].

The Jupiter and Sun signals are adjusted for the range during C27.

Auto-Rad is not a good idea for the Sun scan because it keeps the signal between 2000 and 3500 counts/window. Thus, the Auto-Rad algorithm could set the cold sky level as high as 3500, which would cause the Sun peak signal to saturate (maximum is 4095 counts/window).

5.3 Burst Periods

The criteria for determining the burst period is simply to avoid smearing the observations by excessive motion during one burst period. The numerical threshold used here is no more than 1/10 beamwidth of motion during one burst period. This is a fuzzy criteria, and if necessary, even 1/5 beamwidth motion in a burst period may be ok. The C27 scans were designed with the same angular rate of 0.29 mrad/s (0.0167 deg/s) that was used in prior sequences. With a beamwidth of 0.35 deg, 1/10 beamwidth of motion corresponds to 2.1 sec. Thus, any burst period of 2.1 sec or less will satisfy the motion requirement. To maintain high relative accuracy along with minimal motion blurring, a burst period of 1 sec. should work well for all of the scans in C27.

5.4 Sun Scan Beam Sequence

The Sun scan in C27 is a large scan similar to the Sun scans performed in C25 and C26. The same choice of beam sequences apply. In C25, we chose to cover all 5 beams to provide pattern data for all the beams, while in C26 we selected just beam 3 to get more detailed pattern information for use by the radiometer (which only uses B3). In C27, we will go back to cycling all 5 beams because the Sun scan in C27 is the first to be centered on the Sun. In the C25 Sun scan, pattern data was obtained for B1, B3, and B5, but B2 and B4 were missed because the scan was offset from the Sun to avoid triggering a constraint monitor. In C27 we are pushing this limit more closely because this may be the last opportunity (due to restrictions on momentum wheel use during cruise) to collect pattern data on B2 and B4.

	Jupiter Scan	Sun Scan	Microwave Source Scans
RIP (ms)	40	30	40
HIP (ms)	5	5	5
CIP (ms)	25	25	25
RAD	25	33	25
BPD (ms)	1000	1000	1000
Source Temperature Range (K)	2.8- 4.7	2.8- 603.0	2.8- 4.8
Expected Signal Range	2668- 2682	1072- 4295	2875- 2890
Expected ND Signal	1984- 2168	1984- 2168	1984- 2168
Expected RL Signal	2989- 3207	2989- 3207	2989- 3207
BEM	B3	B1-B5	B3

Table 2: Recommended Radiometer command parameters. These commanded integration times are per window. The window count is constrained by the burst period. The expected signal values for the microwave sources assume the gain value at the end of warmup, 0.19 counts/ms/K, that is expected to apply, while the expected signal values for the Sun and Jupiter scans assume the equilibrium gain value, 0.19 counts/ms/K, that is expected to apply. Also assumed is the C25 system noise temperature of 858 K, and a constant offset of 3550 counts. The RL and ND ranges come from expected gain variation (not from temperature variation), so the RL variation is overestimated somewhat because its temperature variation tends to reduce its signal variation. BEM refers to the beam sequence to use. Note that the Sun scan should cycle all 5 beams.

5.5 Scan Command Recommendations

Table 2 summarizes the recommended command parameters for the raster scans. The integration times are chosen to center the expected signal range with the highest dynamic range that can be safely acheived.

Although the prediction is for the Sun Scan to remain on scale with an integration time of 30 ms, during the C25 Sun scan, the same integration time saturated at the beam peak (but not the half-power points). Thus, the Sun scan peak may still saturate. Because of this, it would be desireable to ensure an on-scale peak Sun measurement by varying the integration time during the Sun staring interval that occurs just before the Sun scan itself (2001-239T16:16:04 - 2001-239T16:18:34). In C25, the integration time was stepped over the values 20 ms, 25 ms, 30 ms, and 35 ms. The 35 ms measurement was saturated as expected. The 20 ms measurement was about midscale (around 2000 counts/window). The 25 and 30 ms measurements appear to be garbled by a dropped data packet. In C27, the same four steps can be used again. The burst period can be 4 sec here to get the most stable measurement. A few samples for each should be adequate (in C25 we obtained about 5 samples at each of the four levels).

N	time (s)	τ(ND) (ms)	τ(RL) (ms)	τ(ANT) (ms)	RAD (window count)	burst period (ms)
204	51.0	5	20	15	1	250
204	51.0	5	20	20	1	250
204	51.0	5	20	25	1	250
204	51.0	5	20	30	1	250
204	51.0	5	20	35	1	250
204	51.0	5	20	40	1	250
204	51.0	5	20	45	1	250
204	51.0	5	20	30	2	250
204	51.0	5	20	40	2	250
204	51.0	5	20	30	3	250
204	51.0	5	20	40	3	250
204	51.0	5	20	30	4	250
204	51.0	5	20	40	4	250
16	48.4	5	20	30	100	3025
12	48.3	5	20	40	100	4025

Table 3: Tau variation for antenna. Bleed through, ant to ND. N is the number of burst periods for each parameter set, time is the corresponding time for each parameter set. The burst period shown here is just the sum of the resistive load, noise diode, and antenna integration times. The actual value can be larger. (A minimum value of 250 ms is enforced to avoid missed data when in SAF-142 mode.) Total duration = 351.7 sec.

N	time (s)	τ(ND) (ms)	τ(RL) (ms)	τ(ANT) (ms)	RAD (window count)	burst period (ms)
120	30.0	5	15	35	1	250
120	30.0	5	20	35	1	250
120	30.0	5	25	35	1	250
120	30.0	5	15	35	2	250
120	30.0	5	25	35	2	250
120	30.0	5	15	35	3	250
120	30.0	5	25	35	3	250
120	30.0	5	15	35	4	250
120	30.0	5	25	35	4	250
8	28.2	5	15	35	100	3520
7	24.7	5	25	35	100	3530

Table 4: Tau variation for RL. Bleed through, RL to ant. N is the number of burst periods for each parameter set, time is the corresponding time for each parameter set. The burst period shown here is just the sum of the resistive load, noise diode, and antenna integration times. The actual value can be larger. Total duration = 82.9 sec.

N	time (s)	τ(ND) (ms)	τ(RL) (ms)	τ(ANT) (ms)	RAD (window count)	burst period (ms)
120	30.0	3	20	35	1	250
120	30.0	4	20	35	1	250
120	30.0	5	20	35	1	250
120	30.0	6	20	35	1	250

Table 5: Tau variation for ND. Bleed through, ND to RL. N is the number of burst periods for each parameter set, time is the corresponding time for each parameter set. The burst period shown here is just the sum of the resistive load, noise diode, and antenna integration times. The actual value can be larger. Total duration = 120.0 sec.