JET PROPULSION LABORATORY | **INTEROFFICE MEMORANDUM**
334RW–2000–004
March 7, 2001

To: W.T.K. Johnson, M. A. Janssen
From: R. West
Subject: Guidelines for C26 IEB

1 Introduction

This memo provides guidelines for preparing the RADAR IEB for the C26 sequence (scheduled for July 5-6, 2001). The C26 RADAR sequence is designed to characterize the Radiometer during the early warmup period. To this end, a box raster scan of Jupiter is scheduled as early after turn on as possible (about 11 minutes after the RFES powers on). A larger Sun scan similar to the Sun scan in C25 will be performed for more antenna pattern characterization. These scans will provide extensive calibration data for the radiometer calibration model. A Tau variation data set can also be collected at some convenient point. 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. Jupiter Box Scan
5. 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 C26. (ie., Auto-rad on, 4 sec. integration time.)

3 Tau Variation

For C26, the Tau variation set will probably have to occur after the large Sun scan, either before or after the simulated Titan flyby (staring at cold space). At the very end (while Earth pointed) looks like a good place for it. The Tau variation data set is useful for tracking down timing and bleed-through issues. If data volume permits, this data set should be included. This data can be obtained at any convenient point where the RADAR is staring at a fixed target. The test sequence itself will be the same as in C23 including the limitation imposed by the SAF-142 data mode (minimum burst period is 250 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. As for C25, this memo gives integration times as commanded times rather than actual times. The 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 C23 can be used again here. (C23 also used a slower burst time of 250 ms to accomodate the SAF-142 mode.) 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 box raster traces a rectangle with two scan lines crossing Jupiter over and over for 5 hours 10 minutes. The signal from Jupiter will be similar to the signal observed in C20 because the ranges are comparable. For C20 the range to Jupiter was 172.8 million km, while it is expected to be 174.1 million km for C26. The Jupiter box scan starts at UTC 19:39 and ends at 00:51 (July 5-6, 2001).

The Sun scan will have a slightly smaller signal because the range to the Sun will have increased (during 2001, the Sun signal drops about 0.2 dB/month). The Sun scan is larger (8 x 5 deg) so the duration is quite long (01:02 - 10:28, July 6, 2001).

The Jupiter box raster scan will occur early in the warmup period, so we need to pay special attention to warmup performance variation. Although C23 (Jupiter flyby) is the most recent data available, it does not cover the early warmup period. Therefore, system performance during C22 will be used to design the timing for C26.

5.1 Gain Performance

Experience with the EQM indicates that the warmup variation in performance is due to receiver gain change as the receiver temperature changes. Gain decreases as the temperature rises, so the warmup always shows a negative slope which takes about 8 hours to completely disappear. The post warmup gain was computed to be 0.1 counts/ms/K for C20 and C22 (ICO2-A,B). During C22, the warmup was conducted using Auto-Rad, and the normalized counts went from 207 counts/ms at the beginning to 162 counts/ms after 5 hours 10 minutes (matching the end of the Jupiter box scan in C26). This represents a change in gain of 28%. During the same time period, the resistive load and noise diode signals went through changes of 16%, and 32% respectively. The difference between the resistive load signal change and the cold sky signal change is likely due to the warming up of the resistive load itself. As the temperature increases the gain drops, but the signal coming from the resistive load increases thereby negating some of the gain drop. The noise diode is less sensitive to physical temperature, and its signal change matches the cold sky signal change much more closely.

The overall gain drop is 31% going from the maximum at turn on to the minimum after thermal equilibrium is acheived. Using the equilibrium gain value from C22, 0.104 counts/ms/K, the initial and final warmup gains are computed to be 0.137 counts/ms/K, and 0.107 counts/ms/K respectively.

5.2 Integration Time

For C26, table 1 shows the signal variation expected for all the scan targets at various commanded integration times. The system gains just computed from C22 are used along with the equilibrium system noise temperature from C22 (ie., 1511 K). The Jupiter and Sun signals are adjusted for the range during C26.

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 C26 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

Target Name	Integration Time (ms)	Source Temperature Range (K)	Equilibrium Signal Range	Initial Warmup Range	Final Warmup Range
Jupiter	45	2.8 - 5.7	3375 - 3388	5533 - 5551	3562 - 3576
Jupiter	40	2.8 - 5.7	2587 - 2599	4500 - 4516	2753 - 2765
Jupiter	35	2.8 - 5.7	1800 - 1810	3467 - 3481	1944 - 1955
Jupiter	30	2.8 - 5.7	1012 - 1021	2434 - 2445	1135 - 1144
Jupiter	25	2.8 - 5.7	224 - 232	1401 - 1410	326 - 334
Sun	45	2.8 - 644.3	3375 - 6310	5533 - 9384	3562 - 6577
Sun	40	2.8 - 644.3	2587 - 5189	4500 - 7912	2753 - 5425
Sun	35	2.8 - 644.3	1800 - 4067	3467 - 6441	1944 - 4273
Sun	30	2.8 - 644.3	1012 - 2946	2434 - 4970	1135 - 3121
Sun	25	2.8 - 644.3	224 - 1824	1401 - 3499	326 - 1969

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 (0.10, 0.14, 0.11 counts/ms/K), and system noise temperature (1511 K) computed for C22, 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].

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 C26.

5.4 Sun Scan Beam Sequence

The Sun scan in C26 is a large scan similar to the Sun scan performed in C25. The same choice of beam sequences apply. In C25, we chose to cover all 5 beams to provide pattern data for all the beams. In C26, we will focus on beam 3 and attempt to get the highest quality data possible. This means using the B3 only mask.

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 C22 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 after the Sun scan itself (July 6, 2001, 14:49 - 14:59). For this purpose, cycling between 30 ms, 25 ms, and 20 ms commanded integration times (RIP) would be appropriate. The burst period can be 4 sec here to get the most stable measurement. A minute for each should be adequate.

	Jupiter Scan	Sun Scan
RIP (ms)	30	30
HIP (ms)	4	5
CIP (ms)	20	25
RAD	33	33
BPD (ms)	990	990
Source Temperature Range (K)	2.8- 5.7	2.8- 644.3
Expected Signal Range	1135- 2445	1012- 3121
Expected ND Signal	799- 2005	1783- 1927
Expected RL Signal	1692- 3145	2842- 3015
BEM	B3	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 Jupiter assume the warmup gain values that are expected to apply, while the expected signal values for the Sun assume the equilibrium gain value that is expected to apply. Also assumed is the C22 system noise temperature of 1511 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 use beam 3 only.

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.) 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.