JET PROPULSION LABORATORY **INTEROFFICE MEMORANDUM**
334RW–2000–003
August 24, 2000

To: W.T.K. Johnson, M. A. Janssen
From: R. West
Subject: Guidelines for Radiometer integration times during the Jupiter Flyby

1 Introduction

This memo provides some guidelines for preparing the command table for the upcoming Jupiter Flyby RADAR activities scheduled for January 3, 2001. This data take serves scientific as well as engineering/calibration purposes. The expected sequencing for the Jupiter Flyby is:

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 Scans

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

2 Low Rate Data

The low rate data covers the warmup period and 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 ICO-2A/B can be used again for the Jupiter Flyby. (ie., Auto-rad on, 4 sec. integration time.) The warmup period occurs between the IEB trigger at 02:10 and the first GENMOS_R scan at 05:00. The first hour of the warmup is not scheduled to be stored or transmitted, but this should not be a problem since the early warmup behavior is covered by separate instrument checkout data sets.

3 Tau Variation

The Tau variation data set is useful for tracking down timing and bleed-through issues. If data volume permits, this data set should be repeated before and/or after the Jupiter Scans. This data can be obtained at any point during the warmup period but after the SSR recording begins at 03:00 (otherwise no data would be returned). I would put it 5 minutes after SSR recording begins so that we get the data earlier in the warmup period than we did in ICO-2A,B. (Just to see if there is any change due to the colder temperatures) The test sequence itself will be the same as in ICO-2B except that the baseline resistive load integration time is set to 20 ms instead of 25 ms to put the RL signal closer to midscale. Also, the minimum burst period is increased to 250 ms to keep the data production rate within the limits of the SAF-142 data mode which will be used throughout this sequence. 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. 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 ICO-2A/B can be used again here (except for the longer burst time). 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 Jupiter Scans

The Jupiter scans are the primary purpose of this data take. The actual scan design has been done using project tools, and is not covered here. Instead, this memo covers the issue of integration times and burst periods to be used.

5.1 Integration Time

We need to prepare the IEB for the Jupiter Flyby before we receive the data from ICO-2B (due in early October). Therefore, we have to rely on the same assumptions and data to plan the Jupiter timing that we used to plan ICO-2B. During ICO-2A, the raster scans were conducted using Auto-Rad to set the integration times at the beginning of the scan. For the Jupiter scan, this worked fine because the signal from Jupiter was very weak (2.8 K). During the ICO-2A Jupiter scan, the main lobe transit of Jupiter spiked up to 12.5 counts/window above the cold sky level. The integration time commanded was 39 ms/window, and the window count was 48, for a total integration time of 1872 ms per measurement. From this we can estimate the system gain to be, (12.5 counts/window)/(39 ms/window)/(2.8 K), or, 0.11 counts/ms/K.

For the Jupiter Flyby in January, the disk of Jupiter will fill the main lobe of beam 3, so the antenna temperature will be the same as the Ku-band brightness of Jupiter itself. We estimate this to be 170 K (from M. Janssens's Radiometry Book). Using these values, the Jupiter disk signal will be 0.11 counts/ms/K * 170 K = 18.7 counts/ms. With a 39 ms window (expected from Auto-Rad), the signal will be 729 counts/window. During ICO2-A, the cold sky background signal was 2900 counts/window, so the sum (3629 counts/window) would be just in range. Another important consideration is that the Auto-Rad algorithm keeps the signal between 2000 and 3500 counts/window. Therefore, the Auto-Rad algorithm could set the cold sky level as high as 3500, which would cause the Jupiter disk signal to saturate (maximum is 4095 counts/window).

If we decrease the integration time by one step to 34 ms/window, then the Jupiter disk signal will be reduced to 636 counts/window. Furthermore, during ICO-2A, the cold sky signal level was observed to be about 2100 counts/window with an integration time of 34 ms/window. This choice of integration time should bring the cold-sky and Jupiter-disk observations comfortably on scale (2100 - 2736), assuming that the system performance during the Jupiter Flyby is comparable to that observed during ICO-2A. This issue was discussed in IOM-334RW-2000-002 where the same problem arose when planning ICO-2B observations. Since we don't have ICO-2B data yet, the same analysis applies here, however, the ever increasing range from the sun may lead to higher deviations for the Jupiter Flyby. For ICO-2B planning, we computed a possible 12% deviation in system gain. For the Jupiter Flyby, let's assume that the system gain could vary by 20% from the value used above. Factoring in the voltage offset (which corresponds to about 3550 counts/window), a 20% change in the cold sky signal (3550 + 2100) is 1130 counts/window. This could drop the cold sky signal to 970 counts/window which is still ok. A 20% change in the Jupiter disk signal (3550 + 2736) is 1257 counts/window. This could increase the signal to 3993 counts/window which is just below saturation.

We can reduce the possibility of saturating the Jupiter disk data if we command the next lower integration time of 29 ms/window. At this integration time, the Jupiter disk signal delta is 542 counts/window. The cold sky signal level was 1270 counts/window during ICO-2A (29 ms/window integration time), so the expected signal range is (1270 - 1812). A 20% system gain change would expand these limits to (306 - 2884), which lies in range, although a bit on the low side. This may not be desirable because the scientifically important synchrotron radiation signals will be just a few K above the cold sky level which is uncomfortably close to zero-pegging.

The numbers in the preceeding discussion are summarized in the table below. Overall, an integration time of 34 ms/window seems to be the best choice.

Integration Time (ms)	Source Temperature Range (K)	Expected Signal Range	10% Expanded Range	20% Expanded Range
39	2.8 - 170	2900 - 3629	2255 - 4347	1610 - 5065
34	2.8 - 170	2100 - 2736	1535 - 3364	970 - 3993
29	2.8 - 170	1270 - 1812	788 - 2349	306 - 2885

Table 1: Expected Radiometer signal levels for different integration times. These integration times are per window. The window count is constrained by the burst period. The values above assume a gain of 0.11 counts/ms/K, a constant offset of 3550 counts, and the same cold sky levels that occurred in ICO2-A. The expanded ranges show the signals expected if the system gain changes by 10% or by 20%.

5.2 Burst Period

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 scans across the disk of Jupiter have been designed with a rate of 0.29 mrad/s (0.0167 deg/s). 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.

5.3 Jupiter Scan Command Recommendations

To summarize, the recommended integration time during the Jupiter scans is 34 ms with a burst period of 1 second. The recommended integration time for the resistive load is 20 ms. This value put the signal midscale in ICO-2A. The recommended integration time for the noise diode is 5 ms. This also put the signal midscale in ICO-2A.

N	time (s)	τ(ND) (ms)	τ(RL) (ms)	τ(ANT) (ms)	RAD (window count)	burst period (ms)
204	51.0	5	20	14	1	250
204	51.0	5	20	19	1	250
204	51.0	5	20	24	1	250
204	51.0	5	20	29	1	250
204	51.0	5	20	34	1	250
204	51.0	5	20	39	1	250
204	51.0	5	20	44	1	250
204	51.0	5	20	29	2	250
204	51.0	5	20	39	2	250
204	51.0	5	20	29	3	250
204	51.0	5	20	39	3	250
204	51.0	5	20	29	4	250
204	51.0	5	20	39	4	250
17	49.7	5	20	29	100	2925
12	47.1	5	20	39	100	3925

Table 2: 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 will be a little bit larger. (A minimum value of 100 ms is enforced to avoid missed data.) Total duration = 351.8 sec.

N	time (s)	τ(ND) (ms)	τ(RL) (ms)	τ(ANT) (ms)	RAD (window count)	burst period (ms)
120	30.0	5	15	34	1	250
120	30.0	5	20	34	1	250
120	30.0	5	25	34	1	250
120	30.0	5	15	34	2	250
120	30.0	5	25	34	2	250
120	30.0	5	15	34	3	250
120	30.0	5	25	34	3	250
120	30.0	5	15	34	4	250
120	30.0	5	25	34	4	250
8	27.3	5	15	34	100	3416
7	24.0	5	25	34	100	3426

Table 3: 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 will be a little bit larger. Total duration = 81.3 sec.

N	time (s)	τ(ND) (ms)	τ(RL) (ms)	τ(ANT) (ms)	RAD (window count)	burst period (ms)
120	30.0	3	20	34	1	250
120	30.0	4	20	34	1	250
120	30.0	5	20	34	1	250
120	30.0	6	20	34	1	250

Table 4: 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 will be a little bit larger. Total duration = 120.0 sec.