JET PROPULSION LABORATORY **NIMS 92-031-PW: Revised**

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From: Paul Weissman

Subject: NIMS Earth Avoidance Strategy -- Revised

This memorandum provides a revised thermal safeing plan for NIMS with minor changes in the timing of two of the TARGET PAs and some additional information on the TARGET slews. The target slews have been optimized to minimize the time spent at low cone angles during Earth closest approach, where some spacecraft heating is expected.

During the Galileo Earth-2 encounter closest approach, it is necessary to avoid pointing the NIMS radiator at the Earth for a period of +/- 3 hours, to prevent overheating of the NIMS focal plane. If the NIMS focal plane temperature exceeds 90 K, the data taken with the detectors is too noisy to be useful.

The NIMS radiator has a full width field of view of 144 degrees, centered on a point in the cone slewing plane, 62.5 degrees from the NIMS optical boresight. Note, that as a result of this large FOV, the NIMS radiator view includes whatever NIMS or any other scan platform instrument is viewing at any time. If the target to be imaged is either very warm, very bright or has a large angular extent (or any combination of the three), then the NIMS focal plane will heat. Thus, observations at both Venus and Earth (at E-1) heated the focal plane to temperatures in excess of 115 K, whereas the Gaspra encounter had no noticeable effect (Gaspra subtended a very small solid angle). Cooling times for the radiator and focal plane to return to their optimum temperature range are on the order of 12 - 24 hours.

Although the primary goal is to keep insolation from directly impinging on the radiator plate, it is also necessary to limit reflected energy off the inside of the NIMS radiator shield. The shield interior has an FOV of 180 degrees and at a minimum, we would like to protect 170 degrees of its FOV from any sources, or a half angle of 85 degrees.

Thus, for the Earth-2 encounter, a careful strategy of scan platform pointing has been formulated to keep the radiator from seeing the Earth. This strategy is complicated by the rapidly changing geometry during the Earth flyby and by the large angular diameter of the Earth at closest approach (nearly 150 deg.). It is also complicated by the fact that we are not free to point the radiator anywhere in cone-clock space due to the limited cone motion of the scan platform, and by the fact that the spacecraft itself is a heat source and some platform positions allow the radiator to view warm/bright spacecraft structures, such as the Photometric Calibration Target.

A minimum of five scan platform positions, requiring five TARGET PA's, have been identified for keeping the NIMS radiator viewing deep space as much as possible. The TARGET PAs are required because of the large angular distances between successive positions. Each TARGET PA is referenced to a right ascension and declination in inertial space. In the following, times are given in the format h:mm:ss relative to closest approach.

The first NIMS thermal safeing position is assumed following the last lunar observation, at approximately CA-2:50:00 (note, Galileo never gets close enough to the Moon for it to be a thermal problem). The position is chosen to be at a cone angle of 60 degrees, and at a clock angle exactly opposite that of the Earth. The 60 degree angle is chosen to be the minimum cone angle that NIMS can be placed at without viewing warm/bright spacecraft structures. The clock position, which is slowly varying during the hyperbolic approach, is chosen so that NIMS and its radiator view as far away from Earth as possible. The precise clock angle is chosen as that of the Earth+180 degrees, at the last time that this position is useable (see below). That time is approximately CA-0:07:20.

At CA-0:07:20, the spacecraft has begun to pass on the dayside of the Earth. Because of the Earth's large angular size at this time, the radiator and shield, which can see out to effective cone angles of 207.5 degrees, can just begin to see the dark limb of the Earth. The platform must be moved to lower cone angles to avoid Earth-viewing. Thus, the platform is moved to a cone angle of only 2 degrees, and a clock position 180 degrees from the Earth, again at the last time that this position is viable. This results in a slow heating of the radiator because of viewing of warm spacecraft structures, but it is less than would be obtained from viewing the Earth. The slew rate for this TARGET is chosen to move the platform at a rate fast enough so that the Earth does not enter the radiator's FOV, but slow enough to minimize the time spent at low cone angles.

As the trajectory continues to carry the spacecraft around the Earth, even this new position becomes untenable. At approximately CA-0:00:30 the spacecraft is in front of the Earth's lit disk, so that the Earth fills a large fraction of the anti-sun hemisphere. The angular diameter of the Earth is so large that no accessible position of the scan platform can prevent some Earth viewing. However, because the trajectory carries the spacecraft over the southern hemisphere, the minimum Earth exposure is obtained by pointing the scan platform southward, approximately 70 degrees in clock from the previous position, while still at a very low cone angle. The radiator will view a small portion of the Earth's southern limb which may be fairly cool, but unfortunately includes the high albedo Antarctic continent. Because of the continued low cone angle, some heating from spacecraft structures is also expected. The TARGET slew rate is chosen to roughly track the changing Earth geometry.

This position is maintained while the spacecraft sweeps across the lit hemisphere of the Earth. At approximately CA+0:07:20, the spacecraft is almost past the Earth and the radiator can once again obtain a clear view of space by being turned an additional 36 degrees in clock, but keeping it at 2 degrees cone angle. The radiator still views spacecraft structure but can no longer see the Earth. Movement to this position is at the maximum platform slew rate.

Finally, at CA+0:26:00, the trajectory has carried the spacecraft far enough past the Earth where the scan platform can be safely moved to a large cone angle where the radiator does not see either the Earth or any warm spacecraft structures. The slew to this position is again done slowly so that the radiator never views the Earth, but also so that it spends minimal time at low cone angles. This is the final safe position and is maintained until CA+3:00:00 when the NIMS Antarctic mosaic begins. The only exceptions to this are an SSI observation of the Andes which begins at CA+34 RIMs and lasts approximately 10 RIMs, and an optional SSI observation of Hawaii and aurora which may be included if the total NIMS heating from all three observations does not exceed an allowable limit of 13.4 K. However, at the end of each of these observations it is necessary that the scan platform immediately be returned to a thermal safe position; such positions for each of the SSI observations have been provided to the SSI team.

Note that any significant changes in the spacecraft attitude, trajectory, or the arrival time at closest approach will require a redetermination and tweaking of the pointing directions and timing given in Tables 1 and 2 for the five TARGET PAs.

The strategy described above has been worked out considering the thermal needs of NIMS and the observational requirements of SSI. The five TARGET PA calls are believed to be the minimum that can be used to achieve the desired protection for NIMS. Use of mosaic slews are precluded by the large angular distances through which the platform must be moved between successive positions.

Table 1. NIMS Thermal Safe Positions During Earth-2 Closest Approach

Position	Start time	Cone	Clock	R.A.	Dec.
1	CA-2:50:00	60.0	97.44	313.52	-18.71
2	CA-0:01:30	2.0	79.13	250.80	-24.56
3	CA+0:05:00	2.0	10.0	248.61	-25.64
4	CA+0:07:20	2.0	344.52	247.68	-25.36
5	CA+0:26:00	60.0	295.46	184.02	-19.19

Table 2. Target slews to positions

Position	Rate (mrad/s)	Slew duration (sec)	/ max angle (degrees)	/ axis
1	17.45	180	< 180	either
2	2.88	352	58	cone
3	3.66	330	69	clock
4	17.45	26	26	clock
5	1.70	596	58	cone

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