MIT/IL
Apollo Guidance and Navigation
System Test Group Memo No. 472

To: Distribution

From: George L. Silver

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Subject: Earth Rate Corrections for IRIG Scale Factor Tests Performed in a Block I Spacecraft

ABSTRACT

This memo sets forth a method of correcting IRIG Scale Factor Tests for earth rate when the test is performed in Spacecraft orientation with the vehicle at any northern latitude and azimuth.

STIPULATIONS

1. A spherical earth is assumed.
2. The IMU is mounted in a spacecraft vertical to $\pm 1^{\circ}$.
3. Sunrise 69 program is in use.
4. X_{NB} axis is inclined 32.5° from vertical.

REQUIREMENTS

1. Corrections are required for OG axis and IG axis only.
2. Vehicle azimuth is known to $\pm 1^{\circ}$.

FORMULATIONS AND DEFINITIONS

W_e = Average earth rate = 15.041 arc sec/sec.

λ = Latitude in Northern hemisphere

A_z = Vehicle azimuth from North
with North being zero A_z, East being + 90° AZ, etc.

T = Test Time = approximately 17 minutes, 3 sec.

Vertical is assumed to be parallel to earth radius.

SFE Convention: If Θ_T is larger than Θ_C, the error is defined as positive where Θ is defined below.

Θ_C = Angle through which IRIG is commanded.

Θ_T = Angle through which IRIG is torqued.

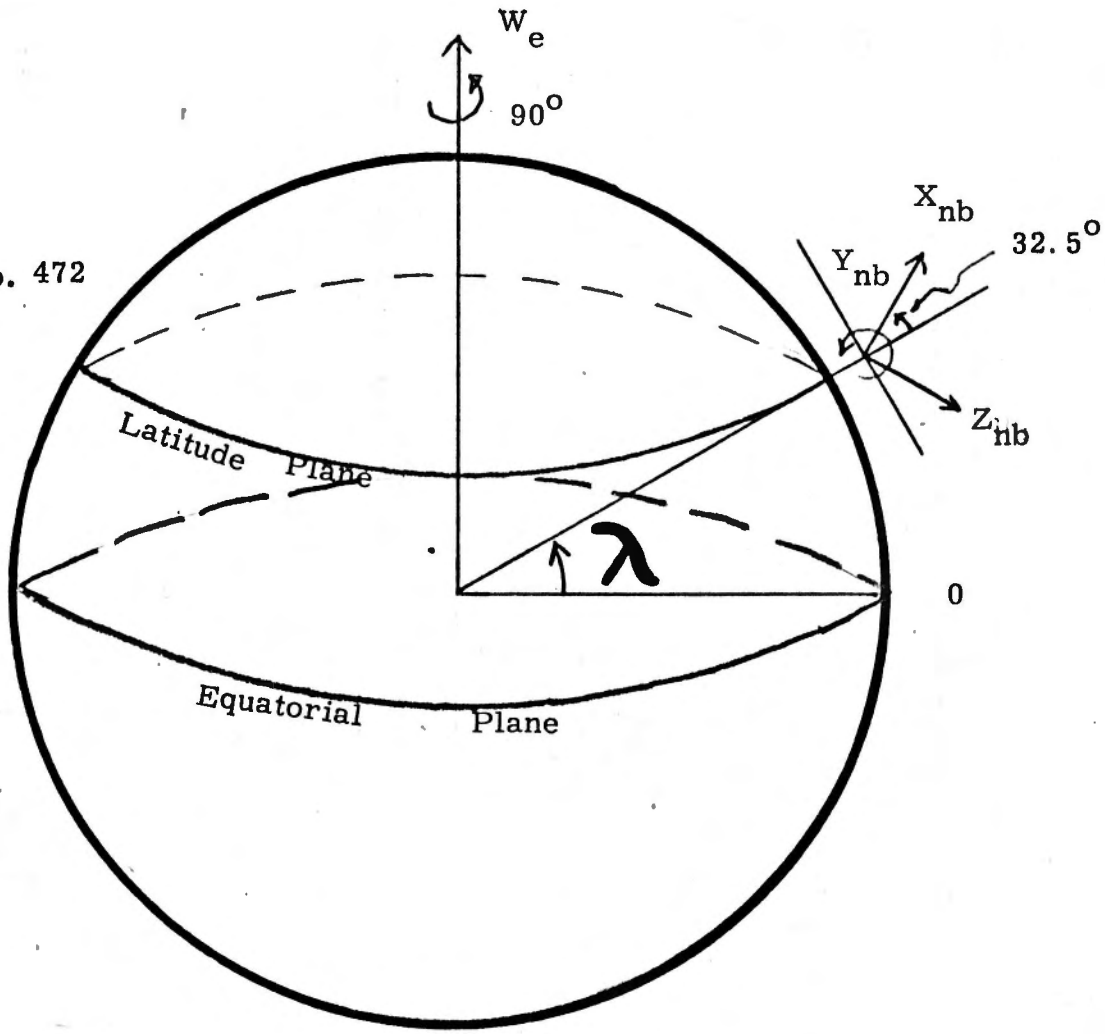

FIGURE 1

The earth rate sensed about the Y Gyro axis will be $W_y = - W_e \cos\lambda \sin A_Z$.

The earth rate sensed about the Outer Gimbal axis will be:

$$W_{x,\,z} = W_e \,(\cos 32.5 \sin\lambda - \sin 32.5 \cos\lambda \cos A_Z)$$

The earth rate induced error which must be compensated is then found by:

$$\Delta \text{Angle}_y = (T)(-W_e)(\cos\lambda \sin A_Z)$$

$$= (-4.274^\circ)(\cos\lambda \sin A_Z)$$

$$\Delta \text{Angle X, Z} = (T)(W_e)(\cos 32.5 \sin\lambda - \sin 32.5 \cos\lambda \cos A_Z)$$

$$= (4.274^\circ)(.84339 \sin\lambda - .53730 \cos\lambda \cos A_Z)$$

Correction to the Dsky readout is then:

$$\left(2777 \frac{\text{PPM}}{\text{deg}}\right)(\Delta \text{ angle})$$

Correct the Dsky readout as follows, for tests + 00001, + 00002 and + 00003 subtract

the PPM correction as indicated above, -00001, -00002 and - 00003 requires addition of the PPM correction.

Important Note: The earth rate induced corrections must be applied to the "sign corrected" Dsky output. Remember that the indicated Sunrise 69 IRIG Scale Factor error polarity has a sign reversal which must be corrected as the results are recorded.

EXCLUSIONS

This procedure does not correct for the earth rate terms which are caused by gyro misalignments and crosscoupling. An example of the error magnitude would be Sin (10 mr) (360°) (T) (W_e) (2777) or approximately 70 PPM considering X and Y axis.

EXAMPLE CALCULATION

Assume site is NAA:

Vehicle azimuth = 180°

X IRIG is under test (+ 00001)

$$\Delta \text{Angle}_X = (T)(W_e)(\cos 32.5 \sin\lambda - \sin 32.5 \cos\lambda \cos A_z)$$
$$\Delta \text{Angle}_X = (4.274^\circ)\left[(.84339)(.55807) - (.53730)(.82980)(-1)\right]$$
$$= +3.917^\circ$$

PPM SFE therefore = (-) (Dsky R 1) - (+ 3.917°) (2777)

= (-) (Dsky R 1) - 10887 PPM

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