

SEM-1-1493

October 2, 1996

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FROM: A. C. Sadilek
SUBJECT: Boresight Mapping of the EPAM Instrument
ENCLOSURE: Appendix 1, EPAM Boresight Computations

The five sensors on the EPAM instrument have had their boresights mapped into the instrument coordinate system on September 18, 1996. The instrument coordinate system was defined by indicating the Portage machine table until it was true within 0.0005" and by placing the EPAM instrument on its mounting spacers on the table. The +Z-axis side of the EPAM instrument was indicated true to within 0.0004" to set the rotation of the instrument on the table. This aligned the Y-axis of the Portage machine with the spin axis of the ACE spacecraft. To measure the boresights of the various EPAM sensors, the entrance plane of each of the sunshades was indicated at four points. This raw data is enclosed in appendix 1 of this memo. Vectors were computed which lay in the entrance plane of the sunshades, and their cross product vector was normalized to define the individual sensor boresights. Angles of the boresights from the coordinate system axes were computed, and the error angles of the boresights from the ACE spin axis were summarized in Figure 1. All angles were within one degree of their specified offset from the ACE spin axis.



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Analysis, Mechanisms, & Propulsions

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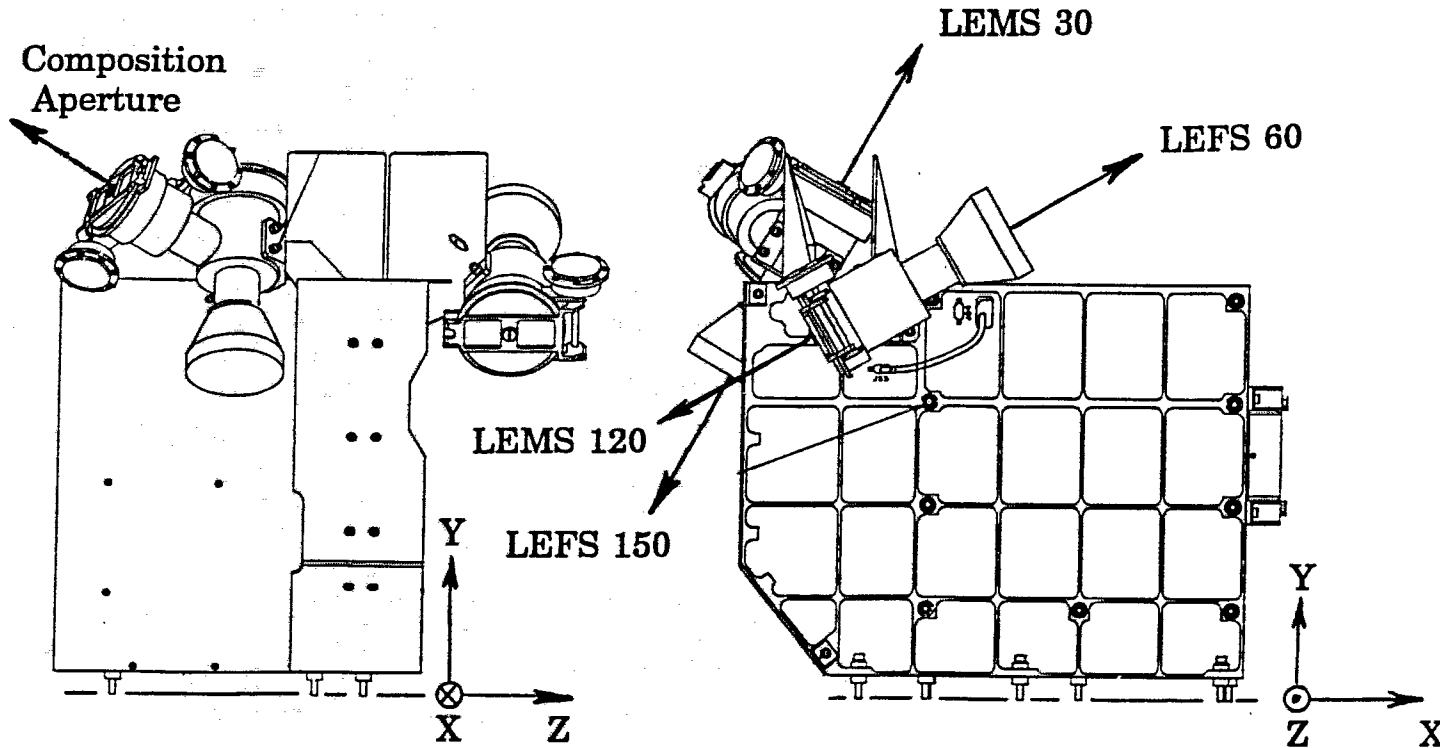
Figure 1: ACE EPAM Instrument

Coordinate System Definition:

X-Axis is defined by +Z side of EPAM

X-Z Plane is defined by mounting feet of EPAM

Y-Axis (Spin axis of ACE s/c) is normal to X-Z Plane



Boresight Orientation of EPAM Sensors:

(Y-Axis is ACE Spin Axis, ϵ is error angle of Boresight from Spin Axis)

Sensor	Boresight Normal Vector (x,y,z)=	Polar Coordinate System Angles (α,β,γ)=	ϵ =
LEFS 60	(0.86136, 0.50800, -0.00078)	(30.531°, 59.469°, 90.045°)	0.531°
LEMS 120	(-0.86395, -0.50357, 0.00228)	(149.763°, 120.236°, 89.869°)	0.236°
LEMS 30	(0.50534, 0.86292, 0.00108)	(59.646°, 30.354°, 89.938°)	0.354°
LEFS 150	(-0.50271, -0.86446, 0.00036)	(120.179°, 149.821°, 89.979°)	0.179°
Composition Aperture	(-0.34409, 0.50113, -0.79402)	(110.126°, 59.925°, 142.563°)	0.075°

ACE EPAM Instrument Boresight Computation:

LAN 2A (LEFS 60°)

$$X_1 = 0.0000$$

$$Y_1 = 0.0000$$

$$Z_1 = 0.0000$$

$$X_2 = -1.4671$$

$$Y_2 = 2.4876$$

$$Z_2 = 0.0000$$

$$X_3 = -0.7319$$

$$Y_3 = 1.2438$$

$$Z_3 = +1.4538$$

$$X_4 = -0.7345$$

$$Y_4 = 1.2438$$

$$Z_4 = -1.4277$$

$$u = \begin{pmatrix} X_2 - X_1 \\ Y_2 - Y_1 \\ Z_2 - Z_1 \end{pmatrix} = \begin{pmatrix} -1.4671 \\ 2.4876 \\ 0 \end{pmatrix}$$

$$u \times v = \begin{pmatrix} 7.16802 \\ 4.22745 \\ -0.00647 \end{pmatrix} \quad |u \times v| = 8.32177$$

$$N = \begin{pmatrix} X_3 - X_4 \\ Y_3 - Y_4 \\ Z_3 - Z_4 \end{pmatrix} = \begin{pmatrix} +0.0026 \\ 0 \\ +2.8815 \end{pmatrix}$$

∴ Boresight normal vector
of LEFS 60° = (0.86136, 0.5080, -0.00078)
α = 30.531° from X-axis
β = 59.469° from Y-axis (ACE spin axis)
[spec = 60°, off 0.53°]
γ = 90.045° from Z-axis

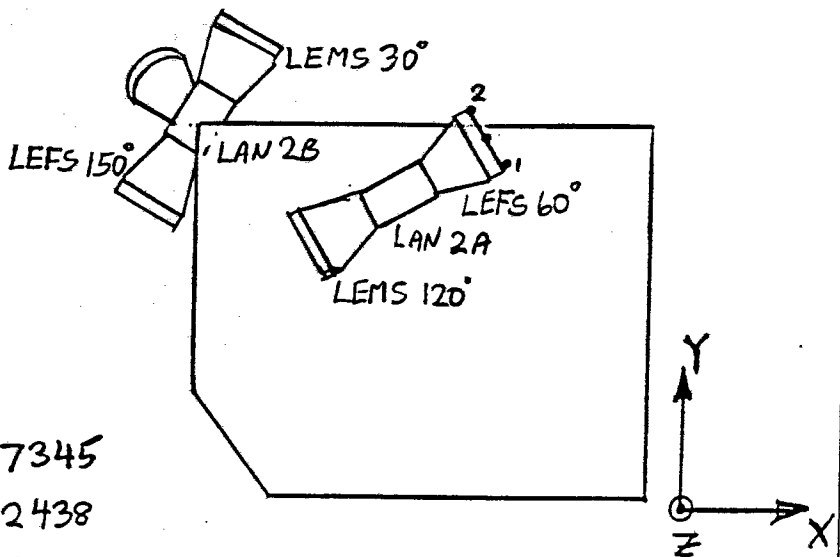
(LEMS 120°)

$$u = \begin{pmatrix} -1.4455 \\ 2.4800 \\ 0.0000 \end{pmatrix}$$

$$u \times v = \begin{pmatrix} -7.13298 \\ -4.15755 \\ +0.01885 \end{pmatrix} \quad |u \times v| = 8.25620$$

$$N = \begin{pmatrix} -0.7265 - 0.7189 \\ 1.2400 - 1.2400 \\ -1.4381 - 1.4381 \end{pmatrix} = \begin{pmatrix} -0.0076 \\ 0.0000 \\ -2.8762 \end{pmatrix}$$

∴ LEMS 120° Boresight Vector
= (-0.86395, -0.50357, 0.00228)
α = 149.763° from X-axis
β = 120.236° from Y-axis
[spec. = 120°]
γ = 89.869° from Z-axis
[.131° from X-Y plane]



LAN 2B (LEMS 30°)

$$u = \begin{pmatrix} -2.4820 \\ 1.4535 \\ -0.0001 \end{pmatrix}$$

$$u \times v = (4.16355, 7.10969, 0.00894)$$

$$|u \times v| = 8.23911$$

∴ Boresight normal vector for LEMS 30°

$$N = \begin{pmatrix} -1.2410 + 1.2410 \\ 0.7251 - 0.7287 \\ +1.4323 + 1.4322 \end{pmatrix} = \begin{pmatrix} 0 \\ -0.0036 \\ 2.8645 \end{pmatrix}$$

$$= (0.50534, 0.86292, 0.00108)$$

$\alpha = 59.646^\circ$ from X-axis

$\beta = 30.354^\circ$ from Y-axis

[Spec value is 30°]

$\gamma = 89.938^\circ$ from Z-axis

[0.062° from X-Y plane]

(LEFS 150°)

$$u = \begin{pmatrix} -2.4800 \\ 1.4422 \\ 0.0000 \end{pmatrix}$$

$$u \times v = \begin{pmatrix} -4.15354 \\ -7.14240 \\ 0.00298 \end{pmatrix}$$

$$|u \times v| = 8.26231$$

Boresight normal vector
for LEFS 150° =

$$N = \begin{pmatrix} -1.2400 + 1.2400 \\ 0.7207 - 0.7219 \\ -1.4440 - 1.4360 \end{pmatrix} = \begin{pmatrix} 0 \\ -0.0012 \\ -2.8800 \end{pmatrix}$$

$$(-0.50271, -0.86446, 0.00036)$$

$\alpha = 120.179^\circ$ from X-axis

$\beta = 149.821^\circ$ from Y-axis

[Spec. value = 150°, -0.179° off]

$\gamma = 89.979^\circ$ from Z-axis

[0.021° from X-Y plane]

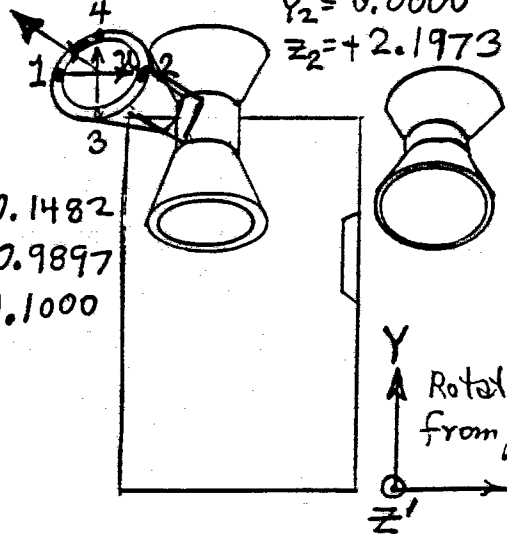
ACE Composition aperture Boresight Direction:

Portage Machine was rotated 90° from previous measurements

$$\begin{aligned} x_4 &= 1.1265 \\ y_4 &= 1.0300 \\ z_4 &= +1.0999 \end{aligned}$$

$$\begin{aligned} x_2 &= +0.9522 \\ y_2 &= 0.0000 \\ z_2 &= +2.1973 \end{aligned}$$

$$\begin{aligned} x_1 &= 0.0000 \\ y_1 &= 0.0000 \\ z_1 &= 0.0000 \end{aligned}$$



$$u = \begin{pmatrix} +0.9522 \\ 0.000 \\ 2.1973 \end{pmatrix}$$

$$\begin{aligned} x_3 &= -0.1482 \\ y_3 &= -0.9897 \\ z_3 &= +1.1000 \end{aligned}$$

$$v = \begin{pmatrix} 1.1265 + 0.1482 \\ 1.0300 + 0.9897 \\ 0.0000 \end{pmatrix} = \begin{pmatrix} 1.2747 \\ 2.0197 \\ 0 \end{pmatrix}$$

$$u \times v = \begin{pmatrix} |u_2 u_3| & |u_3 u_1| & |u_1 u_2| \\ |v_2 v_3| & |v_3 v_1| & |v_1 v_2| \end{pmatrix}$$

$$= (-4.43789, 2.80090, 1.92316)$$

$$|u \times v| = 5.58913$$

∴ Boresight normal vector = $(-0.79402, 0.50113, 0.34409)$

$\alpha = 142.563^\circ$ from X' -axis

$\beta = 59.925^\circ$ from Y -axis (ACE spin axis)

[Specification = $60^\circ \pm 1^\circ$, off 0.075°]

$\gamma = 69.8738^\circ$ from Z' -axis

BUT I NEED TO CHANGE COORDINATE SYSTEMS FIRST;

where $Z = X' \ \& \ X = -Z'$

$$u = \begin{pmatrix} -2.1973 \\ 0.0000 \\ 0.9522 \end{pmatrix}$$

$$u \times v = \begin{pmatrix} -1.92316 \\ 2.80090 \\ -4.43789 \end{pmatrix}$$

Boresight Vector = $\begin{pmatrix} -0.34409 \\ 0.50113 \\ -0.79402 \end{pmatrix}$

$$v = \begin{pmatrix} -1.0999 + 1.1000 \\ 1.0300 + 0.9897 \\ 1.1265 + 0.1482 \end{pmatrix} = \begin{pmatrix} 0 \\ 2.0197 \\ 1.2747 \end{pmatrix}$$

$$\begin{aligned} \alpha &= 110.126^\circ \\ \beta &= 59.925^\circ, \text{ off } 0.075^\circ \\ \gamma &= 142.563^\circ \end{aligned}$$

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