SPECTRON ENGINEERING
1420-OMS-HDS-03
F-16 HUD SIMULATOR
Autocollimation Method
HUD SIMULATOR CALIBRATION PROCEDURE

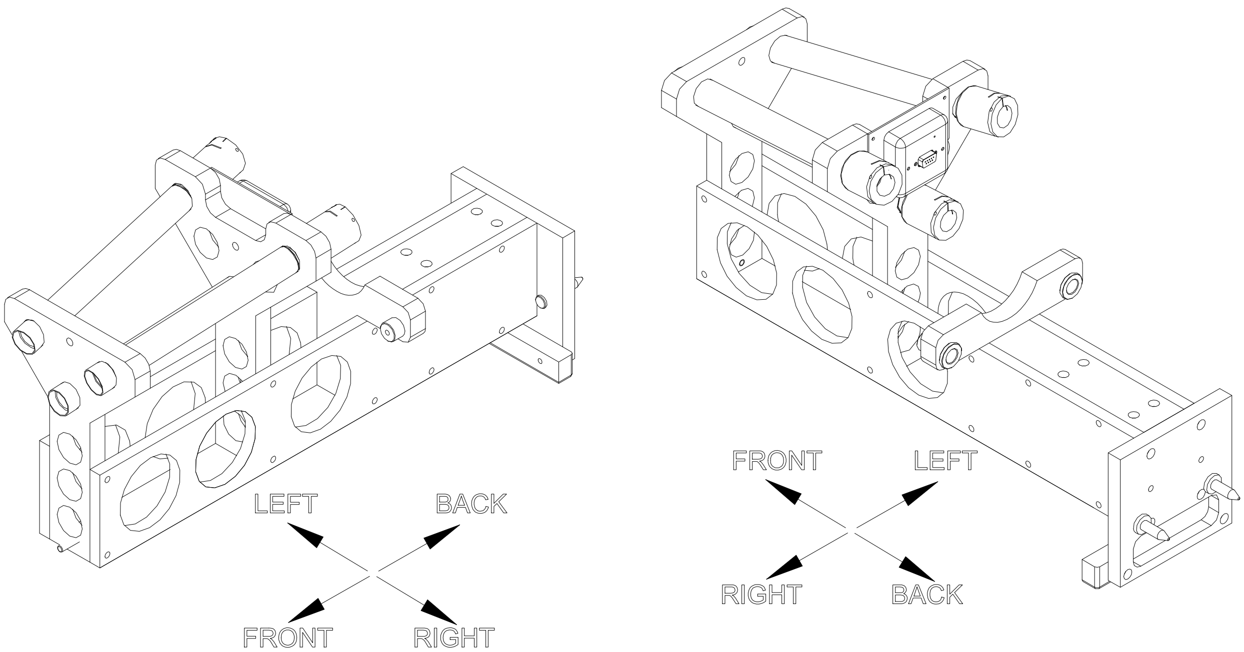

Figure 1. Two Isometric Views of the HUD Simulator Tool

<u>Overview</u>.

The calibration procedure which follows is used to verify the relationship of the alignment pins and bushings to the optical features of this unit. This is the only relationship needed to position the HUD (Head Up Display) Simulator. No other face or surface on the unit should be assumed to be qualified.

In Sections A, and B, the relationships of the mounting pins are verified. The source of the front and rear pin position specifications may be found in the configuration prints for the F-16 HUD.

In Sections C through M, the HUD Simulator is placed upside down on the angle iron and gage blocks. The flanges of the front bushings are placed against the angle iron. The Magnetic mirror is placed on the front face of the angle iron. The azimuth, elevation and roll of the reference collimators are measured in reference to the magnetic mirror. Only the left and right collimators are used in the alignment calibration.

Tools required:

1. Granite Surface Plate 18” x 24” or larger
2. Micrometer 0-1 inch, 0.0001” resolution.
3. Angle Iron, Precision, 8” x 10” x 12”.
4. Magnetic Mirror
5. Precision Master Level, 0.0005”/10” resolution.
6. Gage block set, 81 piece, grade 3 or better.
7. Theodolite[1] calibrated to NIST standards, with adjustable height Tripod. Autocollimation capability is required. It is recommended that an aperture of approximately 3/8 inch diameter be fitted to the Theodolite telescope to reduce focus problems.
8. One Pair Calibration pins, ∅0.5625 x 1.5 inch long. These are included with the HUD Simulator.
9. Measuring Tape.
10. Auxiliary Power supply. Included with HUD Simulator.

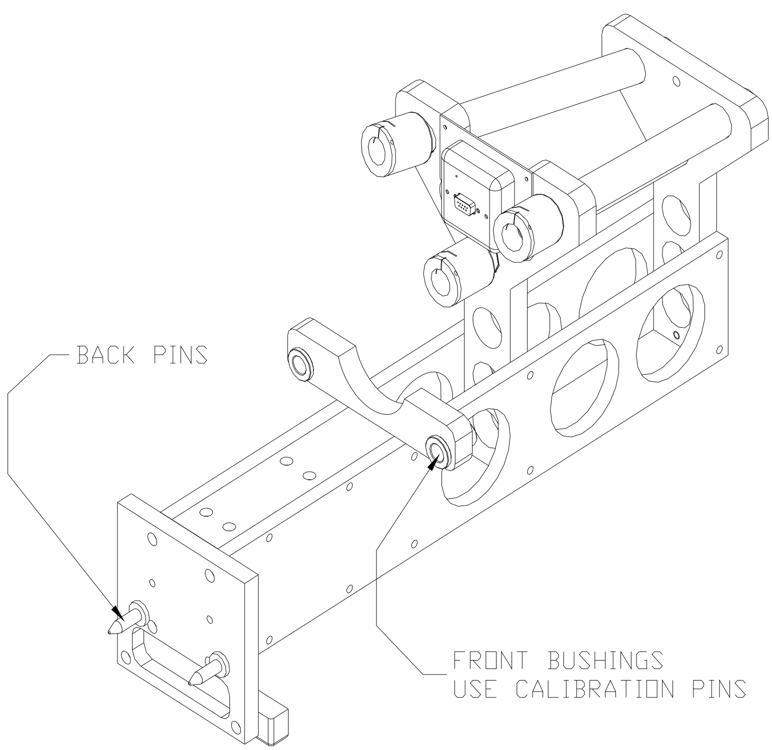

Figure 2. Left Hand Side Shown

A. Insert the Calibration Pins into the front Bushings in the mounting flange of the HUD Simulator. Measure with a micrometer, the diameter of the 2 calibration pins. Record the measurements below.

A.1 _______________ Diameter of Left Pin.
A.2 _______________ Diameter of Right Pin.

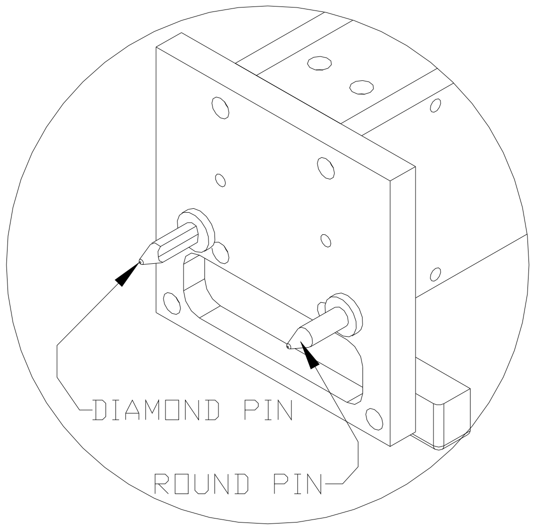

Figure 3. Close-up view of HUD Simulator in upright position, showing back pins

B. Measure with a micrometer, the diameter of the Round back pin. Record the measurement below.
B.1 ______________ Diameter of Round Pin.

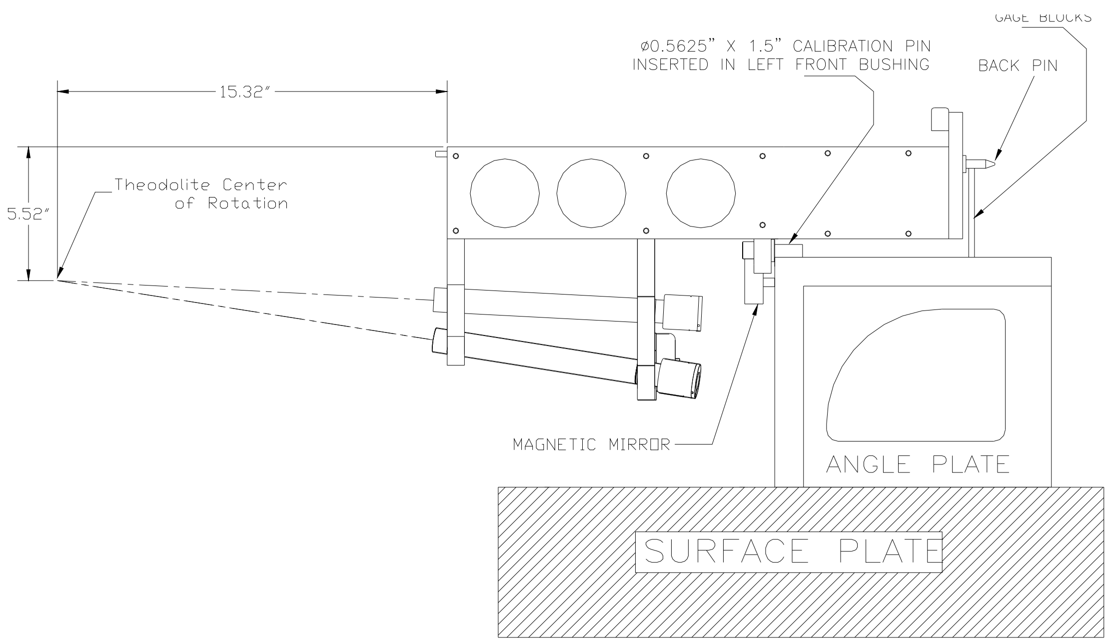

Figure 4. Side view of HUD Simulator in upright position

C. Set up the angle iron on the granite table. Turn the HUD Simulator upside down (so that the collimators are facing down). Set the HUD Simulator with the Calibration pins on top of the angle iron and gage blocks under the Round Back Pin. See Figure 4. The gage block size is calculated below.
   C.1 Back Pin Gage Block: = 3.75 + ((A.1 + A.2)/4)-(B.1/2) =__________
D. The flanges of the front bushings should be pressed hard up against the front face of the angle iron.
E. Put the Magnetic mirror on the front face of the angle iron and up into the circular cutout between the HUD Simulator front bushings. See Figure 4.
F. Check the level of the granite table.
G. Set up the Theodolite at the position indicated in Figure 4. Level the Theodolite. Set the Theodolite Azimuth Circle to ~ 90°.
H. Turn on the Autocollimator light source and autocollimate on the Magnetic mirror through the clearance holes in the HUD Simulator. Measure the position of the autocollimator crosshair and record below.
   H.1 _______________ Horizontal
   H.2 _______________ Vertical
I. Rotate the theodolite ~9° down, 6° left and find the crosshair of the left collimator. Measure the position of the crosshair. Repeat for the right crosshair. (~9° down, 6° right)
   Original Face
   Left Crosshair
   I.1 _______________ Horizontal Line.
   I.2 _______________ Vertical Line.
   Right Crosshair
   I.3 _______________ Horizontal Line.
   I.4 _______________ Vertical Line.
J. Now rotate the theodolite to the opposite face (Plunge and Reverse) Measure the position of the autocollimator crosshair and record below.
   J.1 ________________Horizontal
   J.2 ________________Vertical
K. Find and measure the position of the left crosshair. Repeat for the right crosshair.
   Left Crosshair
   K.1 _______________ Horizontal Line.
   K.2 _______________ Vertical Line.
   Right Crosshair
   K.3 _______________ Horizontal Line.
   K.4 _______________ Vertical Line.
L. Compute the average Readings:

Left Cross Horizontal Line average. = {(I.1 – H.1) + (J.1 – K.1)}/2
   ={(_________ - _________) + (_________ - _________)}/2
   L.1 =_________________

Left Cross Vertical Line average. = -{(I.2 – H.2) + (K.2 – J.2)}/2
= -{(________ - ________) + (________ - ________)}/2
L.2 =_________________

Right Cross Horizontal Line average. ={(I.3 – H.1) + (J.1 – K.3)}/2
={(________ - ________) + (________ - ________)}/2
L.3 =_________________

Right Crosshair Vertical Line average. = -{(I.4 – H.2) + (K.4 – J.2)}/2
= -{(________ - ________) + (________ - ________)}/2
L.4 =_________________

M. Calculate the Roll component from the left and right averages .
= Arctan((L.3-L.1)/((L.4-L.2)*COS 9°)
= Arctan((________ - ________) / ((________ - ________)*0.9877)
M.1 =______________°

N. Calculate Great circle correction. 9 * (1-COS((L.4 – L.2)/2))
N.1 = 9 * (1 – COS((__________-__________)/2)) = _____________°

O. Skew Angle = (L.4+L.2)/2
O.1 = (__________+___________)/2 = ______________°

P. Skew Roll = (O.1 * π/180*9°) = (____________* 0.1571)
P.1 = _______________°

Q. Final analysis:
Mounting Pins to Boresight :
Q.1 Azimuth = (L.2 + L.4) / 2 =______________°
Q.2 Altitude =(L.1+L.3)/2 + N.1 = ______________°
Q.3 Roll:=M.1 + P.1 = _____________°

R. Target position:
Mounting Pins to Boresight:
R.1 Azimuth = -0.0407°[2]
R.2 Altitude = 9.0219°[3]
R.3 Roll = 0.0000°

S. Deltas:
S.1 Azimuth = R1 - Q1= _________________°
S.2 Altitude = R2 - Q2 =_________________°
S.3 Roll = R3 - Q3 =_________________°

T. Convert to calibration command:

LAS S.1 S.2 S.3 STRING DueDate 1001 SerialNumber
LAS _____ _____ ______ STRING _______ 1001 ______

Where:

LAS = Spectron Command Language "Load Alignment String"
Q.1 = The Azimuth offset in signed decimal degrees, i.e. -0.1234
Q.2 = The Altitude offset in signed decimal degrees, i.e. 0.4321
Q.3 = The Roll correction in signed decimal degrees, i.e. 0.2468
STRING = Indicates the data type.
DueDate = The date that this calibration will become invalid, usually one year from the current date. The format for the due date is YYYYMMDD with no spaces or delimiters.
"1001" = Indicates that this is a first principle calibration.
SerialNumber = The serial number of the unit being calibrated. Note: Leading zero's are not required and will not be displayed.

Possible Sources of error:

Tool	Setup error	Resultant error
Micrometer	± 0.0002 inch.	≈ 0.0007° in altitude/azimuth ≈ 0.0020° in roll
Precision Master Level	0.0005 inch/10 inch	≈ ± 0.0028° in altitude/azimuth
Theodolite Level	±1/2 division	≈ ± 0.0028° in altitude/azimuth
Theodolite, using both faces	±1 arc-second	≈ ± 0.0003° in altitude/azimuth

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Certification

Item	Part Number	Serial Number

Date Completed________________ Completed By___________________________

Date Shipped__________________ Shipped To

Reference

P.O. Number_________________
Line Item(s)__________________
Lot Number__________________

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Notes:

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1 For the purposes of this procedure, convert all Theodolite readings to decimal degrees.
2 Azimuth offset 1'19" = 0.38 mR = 0.0219˚ Left
3 Elevation offset 2'26.5" = 0.71 mR = 0.0407˚ Up