

# ALIGNMENT OF THE INSTRUMENT AND THE INSTRUMENT SUPPORT BOX

## Spartan IR Camera for the SOAR Telescope

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### 1 Purpose

This note addresses the question of transferring the coordinate system of the cryo-optical box (COB), to which the optics refer, to the surface of the instrument that attaches to the instrument support box (ISB) of the telescope. The COB is tied to A-frame struts. The struts are bolted onto the bathtub of the vacuum enclosure. Finally, the bathtub bolts onto the ISB.

The requirements<sup>1</sup> for transferring the coordinate system of the optics to the ISB are that

1. The optical axis of the instrument and the principal ray of the telescope are coincident to 2 mm.
2. The optical axis of the instrument and the principal ray of the telescope are parallel to  $\pm 0.5$  mrad.

We measured the A-frame struts and the bathtub, and we invented a procedure for assembly that minimizes the errors for transferring the coordinate system of the optics to the ISB.

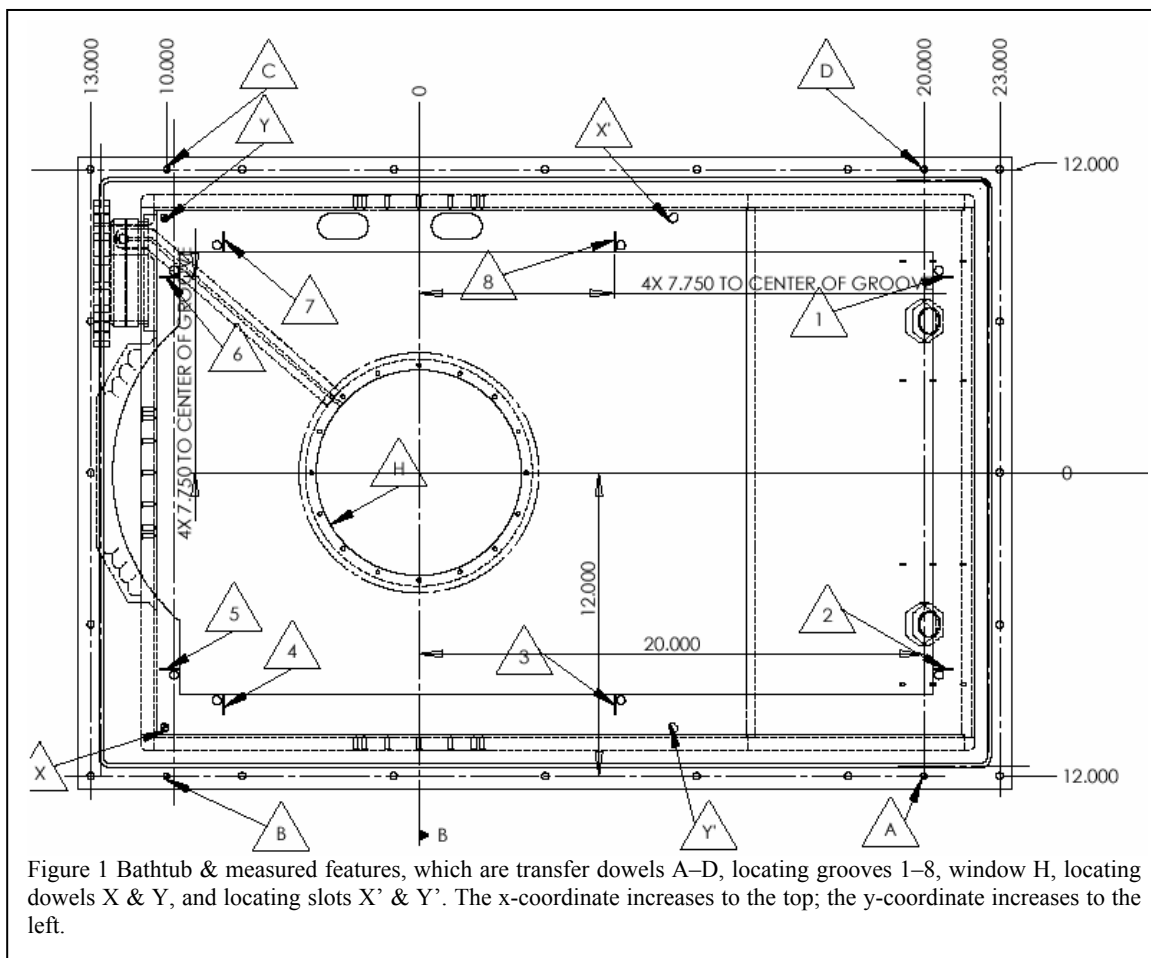
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<sup>1</sup> Loh, E., March 2003, "Requirements for Instrument Assembly, Spartan IR Camera."

## 2 Measurement of the Bathtub

The features that define the transfer of positions are (1) grooves 1–8 for locating the A-frames and (2) dowel hole and slot pairs, X, X' and Y, Y' that mate to dowel holes on the ISB. (See Figure 1.) In order to transfer from the grooves to the dowel holes and slots on the other side of the bathtub, we use the transfer dowel holes A–D.

The features of the bathtub were measured with a DEA Iota 0102 coordinate-measuring machine. For the grooves, these features define the coordinate system: (1) the plane of the flange is the x-y plane, (2) the origin is the projection onto the x-y plane of the center of dowel hole D, and (3) the x-axis is parallel to the line between dowel holes A and D. For the features X, X', Y, Y', and the window, the plane x-y plane is offset by 1.000 in from the flange.



Since the dowel holes are not perpendicular to the flange, the location of the holes at the midpoint of the ½-in flange is defined to be the location of the hole. Hole D is cut most precisely; hole A is next best. Hole B is greatly oversized. Hole A is tilted the most.

The grooves are measured with a  $\phi$ 1-mm ruby probe. This probe touches both sides of the groove; a larger one would touch the corners of the groove instead. The probe is inserted down in the approximate center of the groove and then moved horizontally until it touches the walls of the groove. The center of the two walls is defined to be the location of the groove.

The measurements are in Table 1. The measurements of the transfer dowels, ISB dowels, and ISB slots repeat to 0.007 mm (peak-to-valley). The measurements of the grooves repeat to 0.016 mm (peak-to-valley). The grooves are more difficult to measure because they are so small.

Table 1 Measured location of features. The cells in grey are zero because of the definition of the coordinate system.

Feature	Meas [mm]		Nominal wrt datums A & B		Meas-Nom [mm]			Meas-Nom [mil]		
	x	y	x	y	x	y	z	x	y	z
A Transfer Dowel	-609.846	0.000	-12	-20 in	-0.246	0.000		-10	0	
B Transfer Dowel	-609.894	762.120	-12	10 in	-0.294	0.120		-12	5	
C Transfer Dowel	-0.103	762.150	12	10 in	-0.103	0.150		-4	6	
D Transfer Dowel	0.000	0.000	12	-20 in	0.000	0.000		0	0	
H Window	-304.748	508.109	0	0	0.052	0.109		2	4	
X ISB Dowel	-560.894	764.069	-256	256 mm	-0.094	0.069		-4	3	
X' ISB Slot	-48.629	252.262	256	-256 mm	0.171	0.262		7	10	
Y ISB Dowel	-48.731	764.226	256	256 mm	0.069	0.226		3	9	
Y' ISB Slot	-560.673	252.143	-256	-256 mm	0.127	0.143		5	6	
1 Groove	-107.937	-18.385	7.75	in	0.013		0.067	0		3
2 Groove	-501.843	-18.603	-7.75	in	-0.193		-0.055	-8		-2
3 Groove	-536.978	311.168		-7.75 in		0.018	-0.017		1	-1
4 Groove	-536.563	704.855		7.75 in		0.005	0.040		0	2
5 Groove	-501.919	758.578	-7.75	in	-0.269		0.028	-11		1
6 Groove	-107.963	757.771	7.75	in	-0.013		-0.030	-1		-1
7 Groove	-72.998	704.918		7.75 in		0.068	-0.028		3	-1
8 Groove	-72.878	311.167		-7.75 in		0.017	-0.004		1	0

Note: Origin of coordinate system is Feature D. Line between features A & D defines x-axis.

### 3 Measurement of the A-frame Struts

The A-frame struts were measured in February. Their characteristics are in Table 2.

## 4 Installing the COB

First bolt the A-frames to the bathtub according to Table 2. Install one #18 copper wire in one groove of each A-frame to locate it. Because the A-frame that attaches to grooves 5 and 6 conforms to the other three A-frames, it does not have a locating wire.

Next lower the COB onto the A-frames. Three shim plates have pins; the fourth conforms.

## 5 Locating the Cryo-Optical Box

How accurately can the features on the bathtub position the cryo-optical box (COB) on the telescope? Dowel pins in hole X and slot X' locate the instrument on the ISB of the telescope. Alternatively, features Y and Y' may be used.

With dowel pins in either location, the optical axis is offset from the axis of the ISB by about 0.04–0.16 mm (Table 2). The requirement is to align the optical axis of the telescope with the optical axis of the instrument. The shift, which translates to at most 6.6 pixels at the focal plane in the f/21 channel, meets the requirement.

The bathtub flange serves to align the instrument and ISB. The bathtub flange is a good proxy for the coordinate system of the optics, since the coordinate frame of the COB is rotated by about 0.01 mrad from that of the bathtub flange. The plane of the flange is accessible through the holes for transfer dowels or through holes in the lid of the vacuum enclosure.

Table 2 Alignment of the coordinate systems of the instrument (internal) and ISB (external) and alignment of the cryo-optical box (COB) and the bathtub, which is the part of the vacuum enclosure that bolts onto the ISB. The pair, Groove 6 and A-frame 3 (cells in grey), is not defining; it conforms to the other three pairs of grooves and A-frames.

	x	y	z
Grooves			
1	0.013		0.006 mm
4		0.005	0.011 mm
6	-0.013		-0.001 mm
8		0.017	-0.016 mm
Dowel pairs			
X&X'	0.020	0.184	mm
Y&Y'	0.104	0.191	mm
A-frame			
1	-0.128		0.074 mm
2	-0.144		0.052 mm
3	-0.153		0.024 mm
4	-0.165		0.049 mm
Grooves A-frame			
1	4 c'bore out	0.178	0.055 mm
4	2 c'bore in		0.149
6	3 c'bore in	0.140	0.023 mm
8	1 c'bore out		0.145
Alignment of internal & external coord systems			
Origin wrt X&X'	0.157	-0.037	mm
Origin wrt Y&Y'	0.073	-0.044	mm
Alignment of COB wrt Bathtub			
Origin	0.178	0.147	0.059 mm
Rotation	-0.012	0.012	-0.008 mrad