ALIGNED VISION

LG2 Expected RMS Specifications

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For a more complete understanding of the conditions that should produce the most favorable registrations, the Targeting and Accuracy Guide should be understood and followed. The information below provides a scheme that may be helpful to set projector registration accuracy expectations.

TOOL TARGET SPAN INFORMATION (IN)

TOOL A - CDS CERTIFICATION PLATE: 44X - 44Y

NOTE: WHEN REGISTERING AT DISTANCES 30 FEET OR GREATER, THE TARGET SEPARATION ON TOOL A IS LESS THAN THE MINIMUM RECOMMENDED TARGET SEPARATION. WHEN WORKING ON **COPLANAR** TARGETS THAT ARE **NORMAL** TO THE PROJECTOR, THE LACK OF TARGET SPACING TENDS TO HAVE THE GREATEST EFFECT IN THE CENTER OF THE PROJCETION FIELD.

TOOL B: 117X - 120Y

TOOL C: 224X - 99Y

MODEL: LG2A-LT

DISTANCE(FT)	5	10	15	20	25	30	35	40	45
TOOL A	0.006	0.008	0.010	0.013	0.017	0.024	0.033	0.042	0.044
TOOL B	-	0.006	0.008	0.011	0.014	0.019	0.023	0.029	0.034
TOOL C	-	-	-	0.013	0.018	0.021	0.024	0.028	0.031

MODEL: LG2A-LTE

DISTANCE(FT)	5	10	15	20	25	30	35	40	45	50
TOOL A	0.004	0.007	0.009	0.011	0.016	0.021	0.027	0.038	0.040	0.047
TOOL B	-	0.005	0.006	0.009	0.012	0.016	0.021	0.026	0.029	0.033
TOOL C	-	-	-	0.011	0.011	0.014	0.018	0.021	0.025	0.029

When setting expectations for RMS from registrations, the general rule is that registration RMS can be 0.010" or less when the projector is closer than 15 feet from the tool. At longer distances, **the expected RMS increases at a rate of 0.00125"/ft for LG2A-LT and 0.001"/ft for LG2A-LTE.**

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Overview

LASERGUIDE scans a minimum of four retro-reflective targets with each projector in order to establish the relationship between the projector and the surfaces where patterns will be displayed. Establishing the relationship between the projector and the projection surface involves many steps and opportunities for error.

This document describes the factors related to accurate patterns and the accuracy data which the LASERGUIDE system reports.

Sources of Error

The accuracy of dimensional patterns projected by the LASERGUIDE laser projector is a function of several factors:

- The angular accuracy of the LASERGUIDE beam aiming system.
- The ability to accurately locate the center of the retro-reflective targets.
- The accurate definition of the retro-reflective targets relative to each other and the projection surface.
- The accurate definition of the points on surfaces where pattern projections occur.
- The arrangement of the targets on the tool surface.

Number of Targets

The LASERGUIDE projector scans at least four targets in order to establish the spatial relationship between the projector and the projection surface defined in the same coordinate system as the targets. **At least 6 targets are strongly recommended.** 4 or 5 targets can cause registration failures and/or inconsistent results if 1-2 of the target/s are inaccurately defined.

Target Placement and Projection Surfaces

Four requirements must be met in order for the targets to optimally define the relationship between the projector and the projection surface:

1. **The targets must encompass the projection field.** Calculating angles from the projector to the projection surface will be a result of interpolation if the targets encompass the projection field. Calculating angles from the projector to the projection surface with the projection surface not encompassed by the targets will be the result of extrapolation. **Interpolation is much more accurate than extrapolation**. Small errors within the field of the targets can be amplified through extrapolation to regions outside the field encompassed by the targets.

2. **The targets must not be collinear, and preferably not coplanar, in 3D space.** The transformation "engine" utilizes triangles to calculate rotations-about and translations-along each axis. Three points on a line make a poor triangle and very small variations in target accuracy factors result in large apparent rotations about the three target line.

3. **Targets must be properly spaced on the tool.** If the angles from the projector to each target are too similar, it will not be possible to generate accurate transforms. This means that the projection distance and the spacing between the targets must be taken into consideration. For a projector to tool distance of 10', the targets must be spaced at least 10 inches apart on the tool with at least two of the targets spaced at least 20 inches apart. As a general rule, the minimum target spacing should not be less than 4 degrees relative to the projector.

4. **The target layout must be asymmetrical.** A symmetrical layout of target points is identical when viewed from different positions which could cause the projector to misinterpret the coordinate system of

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the tool. An asymmetrical layout has a unique view from any location. This allows the projectors to interpret the coordinate system of the tool properly.

The most accurate projections will result from the most normal projection surfaces. Small errors in surface definition result in large projection errors when the projection surface is not normal to the pattern beam. This is the result of a cosine effect. The intersection of the laser beam and the surface will be translated by large amounts as small errors in surface definition are combined with laser beams approaching an ideally defined, tangent surface.

In summary, the targets locations should adhere to the following requirements:

1. Encompass the projection area
2. Adequate separation
3. Asymmetrical pattern
4. Not collinear
5. Not coplanar

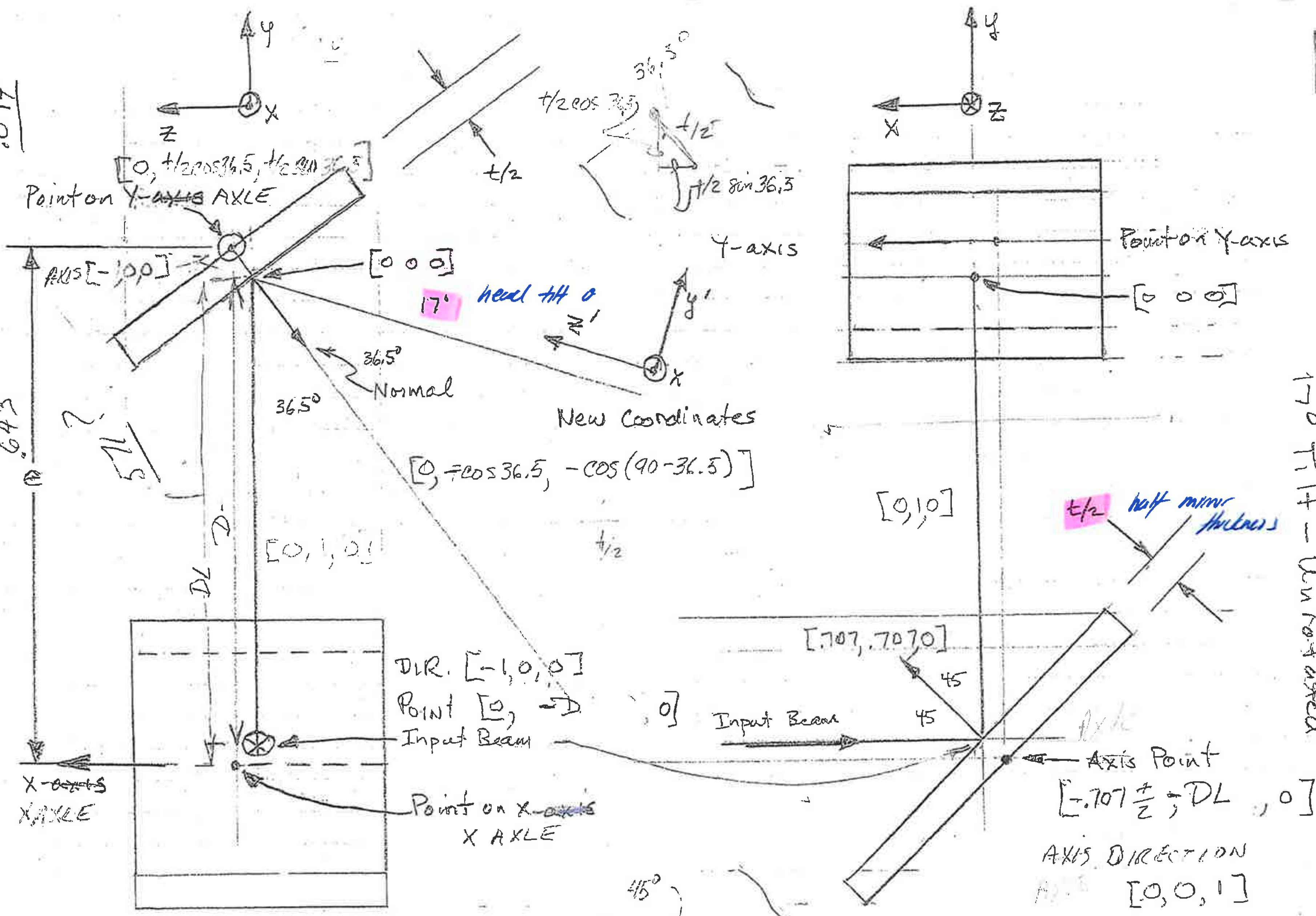
pretty much always true

These requirements should go away

3 requirements should be removed and then the calibration movement would actually be possible to moved around in order to generate piecewise transform if necessary?

Need to use that system to average the measure

17° Tilt – Unrotated



$$D = e - \frac{t}{2}\cos(36.5) - \frac{t}{2}\cos(45)$$

$$DL = e - \frac{t}{2}\cos(36.5)$$

2.0. Specifications

Note: All angles are in mechanical degree unless stated otherwise.

Scanner MODEL NO.	6860	Tolerance	Units/Notes
Mechanical Specifications			
Rated Excursion, Rotor	40	Max	degrees p-p
Optical Aperture, Two-Axis, Std	5 or 10	-	millimeters
Rotor Inertia	0.6	+/-10%	$gm\text{-}cm^2$
Recommended Load	0.3 - 6.0	-	$gm\text{-}cm^2$
Torque Constant	9.3E+04	+/-10%	dyne-cm/amp
Coil Resistance	1.4	+/-10%	ohms
Coil Inductance	160	+/-10%	µhenries
Back EMF Voltage	170	+/-10%	µv/degrees/s
Thermal Conductivity, Coil-to-Case	1.50	Max	°C/watt
Maximum Coil Temperature	110	Max	°C
Maximum RMS Current	4.60	Max	amps
Maximum Peak Current	25	Max	amps
Maximum RMS Power	40	Max	watts
Fuse rating	5	-	amps,fast-blo
Settling time	500	Typ	µsec.*
Scanner Weight	260	-	grams
Position Detector, PD			
Linearity	99.9	Min	% over 40°
Scale Drift	50	Max	ppm/°C
Zero Drift	15	Max	µrad /°C
Long Term Drift	200	Max	ppm/year
Repeatability, Short Term	8	Typ	µrad
Output Signal, Diff. Mode {	14.5	+/-5%	µA/° diff.@
Output Signal, Common Mode {	585	-	µA
PD Power Requirements (AGC) {	10	+/-20%	volts, DC@
{	26	+/-40%	milliamps

what scale drift
possibly from temperature variation

Mounting requirements: The scanner mount must dissipate 4.0 watt/°C. for a mount temperature of 40°C. In an XY mount, it must dissipate 8.0 watt/°C for a mount temperature of 40°C. See section 3.2 for more information.

* Setup for settling time: 0.3 $gm\text{-}cm^2$ load moving through a 0.5 deg. step and settling to within 99% of final position.

3.2. Mounting Scheme

Special attention should be given to the mechanical integration of the scanner into the optical system. The customer must provide an adequate path for conducting away the heat generated by the scanner body. The maximum temperature that the scanner body should be allowed to attain is 50°C. This is below the temperature at which a person feels pain, thus the scanner should **never** get too hot to touch! The XY mount should ideally have very low thermal resistance to ambient temperature. Refer to the specifications section for the minimum heat sinking requirement.

Note: The heatsinking required is affected by the ambient temperature of the optical enclosure. At an ambient temperature of 50°C the scanner mount's thermal resistance would have to be zero to run the scanner at its maximum rating.

For the 6860, the only valid mounting surface is the long cylindrical section of the body. The scanners must be mounted by this surface to adequately transfer the heat out. A close fitting, cylindrical, compression-style mount made of aluminum is preferred for a scanner mount. The mount should attempt to contact as much of the mounting surface as possible to minimize the thermal resistance. The mount should be designed to bolt to another thermally conductive plate to conduct the heat away to the ambient temperature. **Never mount the scanner by any other surface than just described or serious damage will occur!!**

Caution!!! **Never run the scanner without a heatsink attached. The scanner body will heat very quickly and irreparable damage will occur, thus voiding the warranty.**

Note: Because of the 6860 capacitive position detector sensor, the scanner body needs to be electrically isolated from chassis ground and from each other in the XY mount for best performance. This scanner comes with a thin mylar insulator to enable the customer to mount the scanner isolated from chassis ground. Even if the XY mount is isolated from ground, the mylar insulator must be used when using the XY mount or poor thermal contact with the mount may result.

3.4. XY Mounts

There are four standard XY mount designs built for the 6860. They are specifically designed for maximum heat dissipation into the mounting surface the XY mount is bolted.

The XY mounts are designed to accept a 5 or 10mm clear aperture. The 5mm XY mount is designed to scan through an angle of +/-15° mechanical in each axis. The 10mm scans through +/-12°. Both systems come in two variations: Right- and Left-Handed. This is to accept beams from either the right or the left and project the beam straight ahead. Their numbers are:

	5mm	10mm
Right-handed	6108505R	6108610R
Left-handed	6108505L	6108610L

Note: Because of the 6860's capacitive position detector sensor, the scanner body needs to be electrically isolated from chassis ground and from each other in the XY mount for best performance. This scanner comes with a thin mylar sheet to enable the customer to mount the scanner isolated from chassis ground. Even if the XY mount is isolated from ground, the mylar sheet must be used when using the XY mount or poor thermal contact with the mount may result.

Note: CTI XY mounts are designed with the X-scanner tipped back to minimize the inertia of the Y-mirror. The beam still exits the XY mount parallel to the bottom mounting surface. See the four XY Mount Interface Dwg. in appendix 5.1.

5.0 Appendix

5.1. Schematics and Mechanical Drawings

The following drawings are included in this section

1.	Series 6000 Position Demodulator Components	D01747
2.	6860 Outline Drawing	D02671
3.	6850/60 Preferred Mounting Block	D03120
4.	6850/60 Right Handed 5mm XY Mount Interface Dwg	D02762
5.	6850/60 Left Handed 5mm XY Mount Interface Dwg	D02990
6.	6860 Right Handed 10mm XY Mount Interface Dwg	D03691
7.	6860 Left Handed 10mm XY Mount Interface Dwg	D03825

Owen Lu

From:	SteveSlavsky <steve@steveslavsky.com>
Sent:	Tuesday, July 25, 2017 1:23 PM
To:	Owen Lu
Cc:	Matthew Zmijewski
Subject:	Beam Location Model

Owen,

I hope this email finds you well and enjoying the summer. Hot and steamy here, except lately its cold and clammy. Oh well.

Matt and I have discussed the issue your having relating to matching your observations with Doug's calculations and the SolidWorks model. I suggested that you be sent an assembly that was used to confirm Doug's numbers that is similar to the model you have, but specifically set up to measure beam location at specific mirror angle placement.

The model only uses the X- and Y-Scanners. There are no other parts in the model. I have created an amount of reference geometry to control the model. This reference geometry is in Folders in the Feature Tree called REF GEO, REF GEO1 and REF GEO2. There should be no reason for you to go into those folders.

What follows is the description of how to work the assembly, and especially highlight the location of three specific points that change relative to each other with the movement of the mirrors.

In the model (sent to you at X-mirror angle of 45 degrees from input beam, and Y-mirror angle of 36.5 degrees from optics bench surface, or the Orthogonal Neutral Position (ONP)) you will be able to see the three points;

- 0,0,0 ABS (the point in space where the beam hits the Y-mirror in the ONP)
- 0,0,0 REL (the point on the Y-mirror where the beam hits the Y-mirror in the ONP) ← not used
- Y POINT (the location where the beam hits the mirror at any position of the Y-mirror) ← general

not used

In the ONP, all of these points are at the same location. Once either mirror is rotated the three points diverge. The 0,0,0 ABS is fixed in space and does not move. The 0,0,0 REL is always at the same location on the Y-mirror (if you look down the axis of the Y-scanner and rotate the Y-mirror 360 degrees you would see 0,0,0 REL circumscribe a circle around 0,0,0 ABS). The Y POINT will be that point on the mirror where the beam hits the Y-Mirror and will move about the mirror surface in various directions as the two mirrors are rotated.

Doug defines the location of the beam at a given distance as the distance from 0,0,0 ABS to the point in space where the beam intersects the projection plane at that specified distance (PROJ POINT). Therefore, once the model is oriented as desired, the Measure command is used to find the intersection of the beam and the Projection Plane from 0,0,0 ABS.

To work the model, go to the Assembly Level Mates. The first two mates are:

- Y ANGLE
- X ANGLE

The angular conditions are the ONLY things you will need to modify to set the mirrors and beam in the configuration of interest. I have set up the model to adjust the rest. Once you put in the desired angles (30 to 60 degrees for the X-mirror and 21.5-51.5 degrees for the Y-mirror), REFRESH the assembly. Then, in the feature tree highlight the 0,0,0 ABS and the PROJ POINT (last two items on the Feature Tree). While highlighted, select the Measure command (Evaluate/Measure) and the location of the point of interest (PROJ POINT) in X, Y and Z, with respect to 0,0,0 ABS will be provided both in the Measure window and in the model space. The values will be absolute values, so you will have to determine if they are in the positive or negative X, Y, or Z direction. If you get confusing numbers REFRESH the model again.

If you want to change the distance of the Projection Plane you can edit the distance parameter to the desired setting.

I hope this helps you understand both the model and the thinking. I am available at the number below to walk you through the model if you would like.

I have set up a folder in DropBox provided the link below. Let me know if there are any problems accessing it.

https://www.dropbox.com/sh/e39df89n99qczsp/AAAIRBus22YokCDNIlnXEx1Ea?dl=0

Regards,

Steve

Steve Slavsky
steve@steveslavsky.com
508.561.0844

VALIDATION OF NOMINALS

referencetest.txt

2017 9/8 10:13:51

halfMirrorThicknessInches mirrorSeparationInches headTiltAngleDegrees windowFace1ZInches windowThicknessInches windowIndexOfRefraction
0.047000 0.643500 17.000000 -2.000000, 0.000000, 1.500000

TestMirrorAnglesXYZ
Round Trip Test

axIn	ayIn	z	xFound	yFound	axRT	ayRT	
-30.000000	30.000000	-24.000000	16.331044	-13.857762,	-30.000000,	30.000000	y+15, X-15
0.000000	30.000000	-24.000000	0.000000	-13.857762,	-0.000000,	30.000000	y+15
30.000000	30.000000	-24.000000	-16.325992	-13.857762,	30.000000,	30.000000	y+15, x+15
-30.000000	0.000000	-24.000000	14.188780	0.000000,	-30.000000,	0.000000	y=0, x-15
0.000000	0.000000	-24.000000	0.000000	0.000000,	-0.000000,	-0.000000	y=0, x=0
30.000000	0.000000	-24.000000	-14.183728	0.000000,	30.000000,	-0.000000	y=0, x+15
-30.000000	-30.000000	-24.000000	16.330387	13.853512,	-30.000000,	-30.000000	y-15, X-15
0.000000	-30.000000	-24.000000	0.000000	13.853512,	-0.000000,	-30.000000	y-15, x=0
30.000000	-30.000000	-24.000000	-16.325334	13.853512,	30.000000,	-30.000000	y-15, x+15

Owen Generated nominal

z	xFound	yFound	axRT	ayRT	y	x
-24	16.33104411	-13.85776189	-30	30	15	-15
-24	4E-15	-13.85776189	0	30	15	0
-24	-16.3259919	-13.85776189	30	30	15	15
-24	14.18877984	3.32438E-09	-30	0	0	-15
-24	3E-15	3.32437E-09	0	0	0	0
-24	-14.18372763	3.32437E-09	30	0	0	15
-24	16.33038663	13.85351194	-30	-30	-15	-15
-24	2E-15	13.85351194	0	-30	-15	0
-24	-16.32533442	13.85351194	30	-30	-15	15