



Building Your Own 3-D Calibration Fixture for use with ProAnalyst®

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Abstract

A 3-D calibration fixture is an integral component in the 3-D analysis process. While ProAnalyst is optimized to use a standard Xcitex 2-panel fixture, any arbitrary construct can be substituted, and there is no specific size or configuration that must be used. This document will describe the necessary components an arbitrary fixture must possess, as well as a method for generating a calibration file recognizable by ProAnalyst.

Overview

A calibration fixture is any object or set of discrete points (that may or may not be physically attached to one another) that can be imaged by two cameras. These images are then used by the ProAnalyst 3-D Manager to create an accurate representation of a 3-dimensional space in which an event is occurring.

Almost any object or structure can be used as a calibration fixture. The metal box shown in Figure 1 is a basic example. The dimensions of the box are easily measured (155 mm x 155 mm x 155 mm), and the corners of the box serve as a perfect set of points for calibration purposes. Two images of the box captured from different positions can be used by ProAnalyst to recreate the position and orientation of the cameras by correlating the location of the corners of the box in each image. This information is then used by the software to generate a 3-dimensional representation of an event taking place in that same field of view.

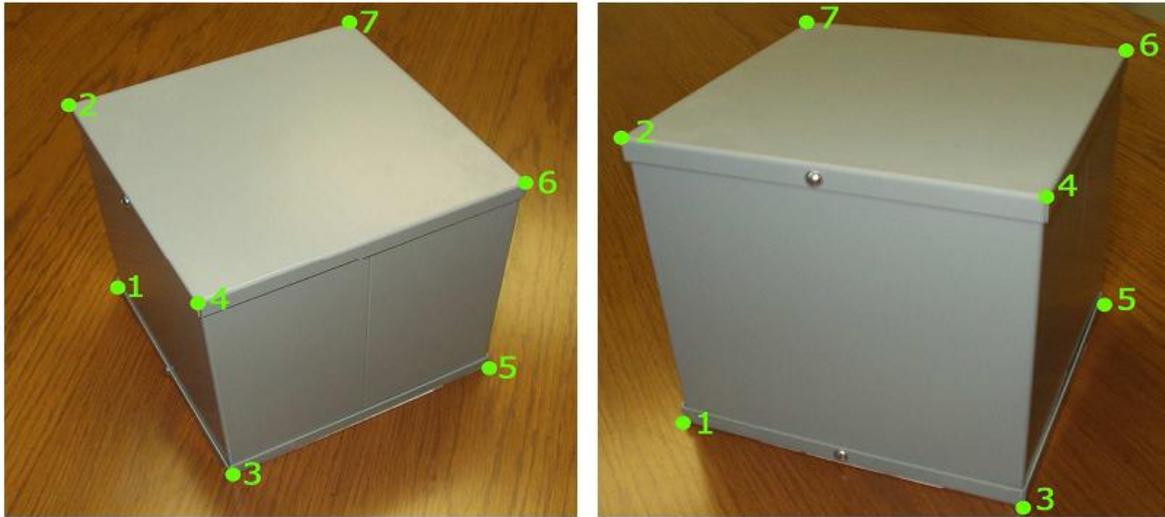


Figure 1. Metal box used in examples (155 mm x 155 mm x 155 mm)

Fixture Requirements

Any object or combination of objects used as a 3-D calibration fixture must conform to a certain set of requirements:

- A fixture must consist of a minimum of six (6) discrete points. A greater number of fixture points will improve calibration accuracy, with the best results generally achieved from fixtures that contain 20 or more points.
- All fixture points cannot be located on the same plane. For this reason, a single flat object cannot be used as a calibration fixture. It is recommended that fixture points be equally distributed over two or more planes.
- The real-world X, Y, Z coordinates of every fixture point must be accurately known to a degree at least as high as the measurement accuracy desired by the analysis. These coordinates will be loaded into ProAnalyst via a calibration file described below.
- The origin and orientation of the coordinate frame used to measure the X, Y, Z coordinates of the fixture points is arbitrary. However, all of the coordinates must be measured relative to the same (unique) origin and orientation of the coordinate frame you have defined.
- When capturing calibration images of the fixture, each and every point on the fixture *must* be visible within the field of view of both cameras.

Creating a Fixture File

Non-standard fixtures require the creation of a custom fixture file. A fixture file is a specially formatted text file containing the X, Y, Z positions of the calibration points on a custom fixture. Lines containing notes and comments are preceded by a percent (%) symbol.

The fixture file for the 7-point metal box fixture is shown below:

```
% units: millimeters
% number of points
7
% Cartesian points
0, 0, 0
0, 0, 155
155, 0, 0
155, 0, 155
155, 155, 0
155, 155, 155
0, 155, 155
```

The first line of the file indicates what measurement units (i.e. inches, feet, meters, etc) the fixture point coordinates are defined in. Note that this first line *should* be a commented line, and this is the only commented line that is processed. Acceptable units are the same as those listed in the 3-D Manager **Units** drop-down box.

```
% units: millimeters
```

The next non-commented line indicates how many reference points are located on the fixture.

```
% number of points
7
```

The remainder of the file consists of comma delimited numbers representing the X, Y, and Z coordinates of the fixture reference points.

```
% Cartesian points
0, 0, 0
0, 0, 155
155, 0, 0
155, 0, 155
155, 155, 0
155, 155, 155
0, 155, 155
```

For the example shown in Figure 2, a consistent set of X, Y, and Z coordinates is determined for the fixture. One point is selected to be the origin of the fixture. The coordinates of this point are (0, 0, 0). From the origin, a direction on the object to be the positive X-direction and positive Y-direction is selected. Next, the Z-direction is defined as perpendicular to both the X- and Y- directions. The positive Z-direction is determined by the right-hand-rule. This establishes the coordinate frame. Once the X-, Y-, and Z- directions are selected, the coordinates for the remaining points on the fixture must be measured from the origin along each of these directions.

Figure 2 shows the metal box with the origin placed at point 1 and the coordinate axes defined as shown.

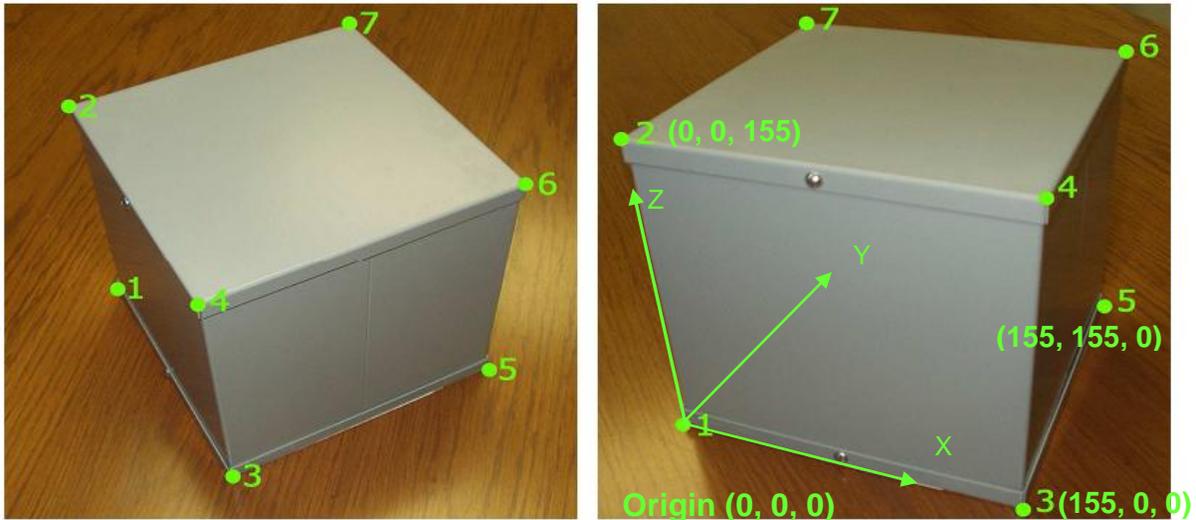
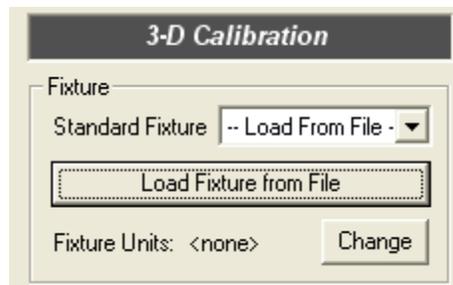


Figure 2. Metal box with origin at point 1 and coordinate axes defined.

Using the origin and coordinate axes that have been selected, the X Y Z coordinates can be easily determined. For example, the coordinates for points 2, 3, and 5 are shown in Figure 2. Next, a list of X Y Z coordinates for all seven points is compiled and written into the fixture file. After the fixture file is created, the **Load Fixture from File** function in the 3-D Manager Calibration panel loads the fixture points from the file.



Note: Please refer to the ProAnalyst User Guide for more information on manually selecting fixture points, editing points, and calibrating.

Examples of Custom Fixtures

Following are some example images of custom fixtures and portions of their corresponding fixture files.

Rocket Nose Cone: This customer built a truss structure and placed LEDs on several rods to serve as fixture points. The LEDs were strategically placed so that they would cover the space that the nose cone would fly into when separated from the rocket. A Theodolite system was used to measure the exact location of the LEDs. A few of the fixture points are circled in Figure 3.

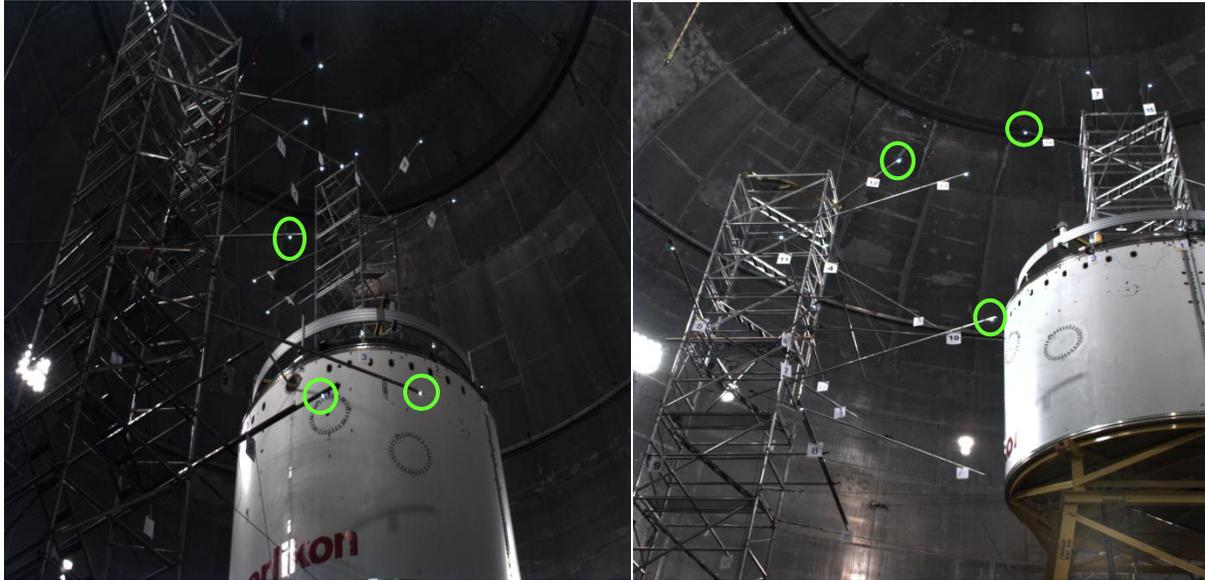


Figure 3. Rocket nose cone with some fixture points circled

[Fixture File for Rocket Nose Cone]

% units: millimeters

% Number of Points

14

% Point Coordinates

28.6834, 2714.2011, 204.6424

1357.6609, 2345.4980, 229.9279

2362.1252, 1351.1503, 228.4836

5475.9633, 2512.6130, -13.3015

7374.5343, 3752.2269, -1321.7113

5610.9451, 2009.5384, -1247.3661

1057.7044, 2532.3837, 6256.1464

5378.2543, 2442.1722, -3982.8056

-22.6858, 2748.1173, 5305.1016

2896.3445, 2669.1643, -2140.4190

6178.5380, 2678.9549, 52.3889

4487.4674, 2751.3705, 2425.1643

3396.2891, 1639.4572, 3272.3090

2273.8642, 1370.9408, 5266.3014

LEGO Bricks: This customer wanted to build a very small fixture in order to study the motion of insect legs. They assembled a group of uniformly sized LEGO bricks in a certain pattern, and used the centers of the pegs as fixture points. Since the dimensions of each LEGO brick are well known, the coordinates of each point can be easily determined. A few of the points are circled in Figure 4.

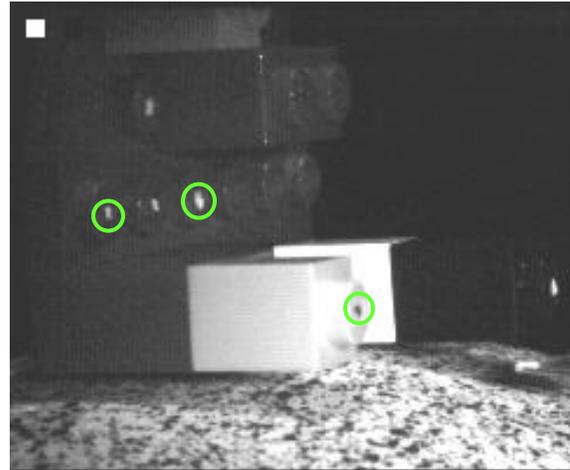
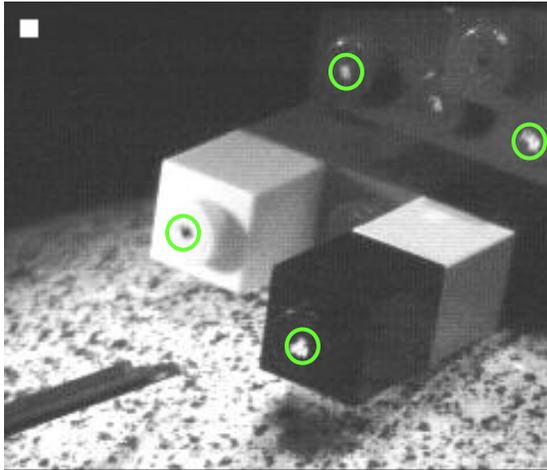


Figure 4. LEGO bricks with some fixture points circled.

[Fixture File for Lego Bricks]

% units: millimeters

% Number of Points

7

% Point Coordinates

0.0000, 0.0000, 20.0000

15.6200, 0.0000, 30.0000

0.0000, 7.8100, 0.0000

7.8100, 7.8100, 0.0000

15.6200, 7.8100, 0.0000

7.8100, 15.6200, 0.0000

15.6200, 15.6200, 10.0000

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