Terrestrial Calibration of CM-10000

S/N 13-017-CM1-017 50mm lens

Calibration Report

Special Note:

Terrestrial Calibration Data was collected on May 8,2015 at Teledyne Optech

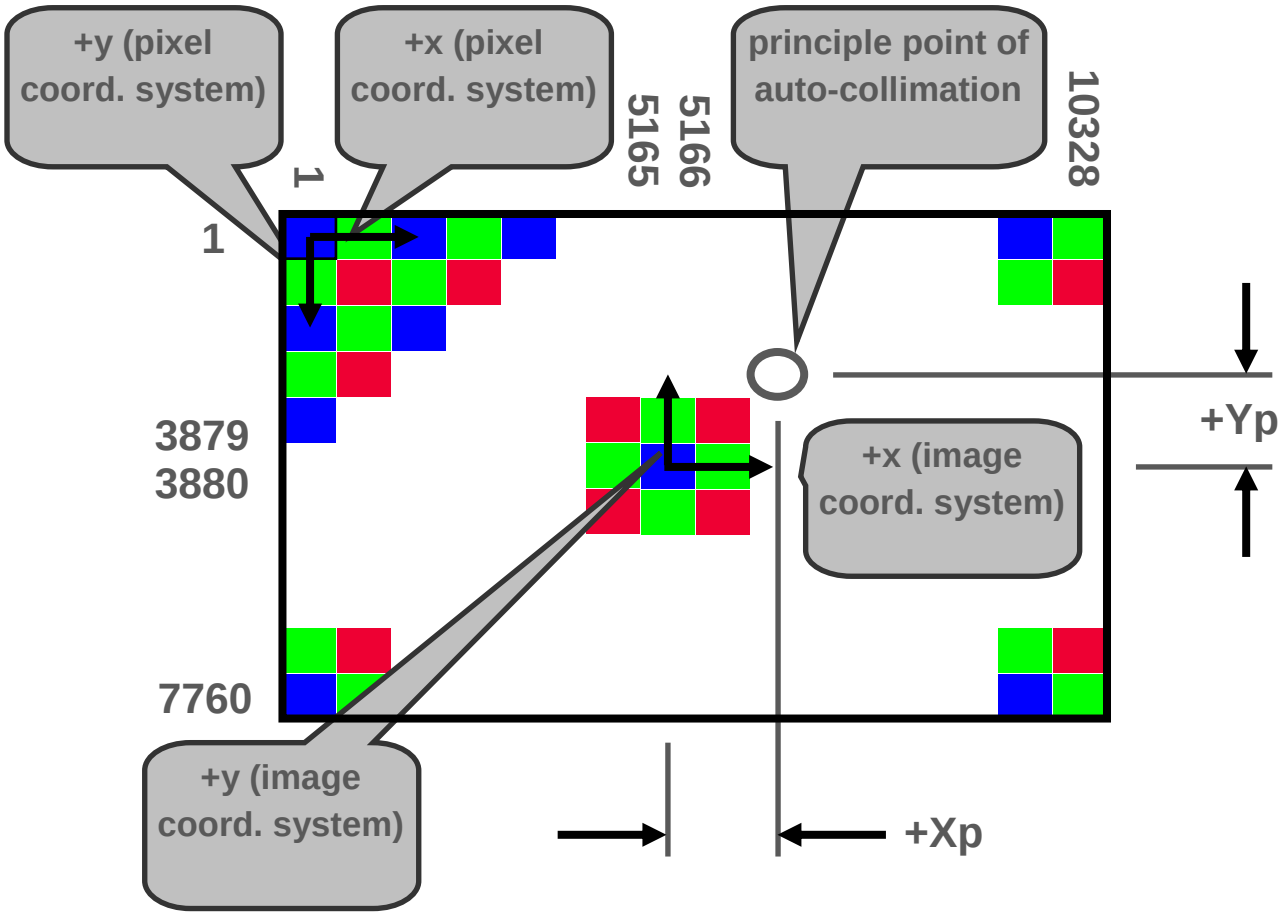
Document **TCS-10000-01**

Serial Numbers of CM-10000 Components

Component	Type	Serial Number
Camera Head	CM-10000	13-017-CM1-017
Lens focal length (mm)	50	
Filter	RGB	N/A

Nominal focal plane layout and conventions

- The illustration below is of the radiometric processed TIFF-image
- 10328 active columns, 7760 active rows
- Pixel coordinate system row and column coordinates are taken at the center of each pixel (see example for pixel [1, 1] below)
- Column 1, row 1 is at the upper left corner of the image
- Image center is between columns 5165 and 5166, and between rows 3879 and 3880
- Pixel coordinate system coordinates of image center 5165.5 and 3879.5
- Positive Xp or Yp places the principle point of auto-collimation closer to the [10327, 1] pixel
- Pixel coordinates of principle point of auto-collimation = [5165.5+Xp, 3879.5-Yp]



Sensor and Lens Data

Focal Plane Data

Parameter	Value
Pixel Size [µm]	5.2
Sensor Size [Pixel]	10328 x 7760
Sensor Size [mm]	53.71 x 40.35 (67.18 diagonal)

Interior orientation parameters

Interior orientation parameters below reflect a static (i.e., terrestrial) calibration.

Parameter	Symbol	Value	Standard Deviation
Offset of principle point of focus [mm]	Xp	-0.0919	3.62E-03
	Yp	0.3634	3.77E-03
Focal length (mm)	Cb	51.45	2.11E-03
Radial distortion coefficients[1]	K0	0	0
	K1	-1.57E-05	2.13E-08
	K2	3.92E-09	1.85E-11
	K3	-1.61E-17	1.94E-16
Tangential distortion coefficients[2]	P1	4.42E-07	3.58E-07
	P2	-3.16E-07	3.59E-07

[1] The radial distortion parameters are defined according to the standard odd-power polynomial equation (Brown, 1971) defined below:

$$dr = K0*r + K1*r^3 + K2*r^5 + K3*r^7$$

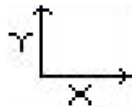
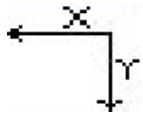
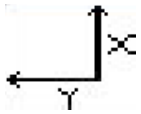
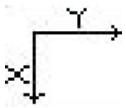
[2]The tangential distortion parameters are defined according to

$$dx = P1*(r^2 + 2x^2) + 2*P2*x*y$$

$$dy = P2*(r^2 + 2y^2) + 2*P1*x*y$$

where $r^2 = x^2 + y^2$

The above table is for the “Right X” orientation of images. Many software packages may use other image orientations and the principal point coordinates need to be appropriately translated according to the orientation used. Use the table below to find the axis system for your software and the correct way to enter the principal point values

Coordinate orientation	Principal Point
“Right X” 	X = -0.0919 Y = 0.3634
“Left X” 	X = 0.0919 Y = -0.3634
“Up X” 	X = 0.3634 Y = 0.0919
“Down X” 	X = -0.3634 Y = -0.0919

Lens distortion table

This table is provided for users of photogrammetric software packages that do not allow direct input of the distortion coefficients provided in the preceding table. The table below is generated by plotting the distortion values using the coefficients in the preceding table and is therefore redundant information.

Radial Distance (mm)	Radial Distortion (microns)
0.0	0.0
1.0	0.0
2.0	-0.1
3.0	-0.4
4.0	-1.0
5.0	-1.9
6.0	-3.4
7.0	-5.3
8.0	-7.9
9.0	-11.2
10.0	-15.3
11.0	-20.2
12.0	-26.1
13.0	-33.0
14.0	-40.9
15.0	-49.9
16.0	-60.0
17.0	-71.4
18.0	-83.9
19.0	-97.7
20.0	-112.8
21.0	-129.0
22.0	-146.6
23.0	-165.3
24.0	-185.3
25.0	-206.5
26.0	-228.7
27.0	-252.0

28.0	-276.4
29.0	-301.6
30.0	-327.6
31.0	-354.4
32.0	-381.7
33.0	-409.4
34.0	-437.5
35.0	-465.6
36.0	-493.7
37.0	-521.5
38.0	-548.8
39.0	-575.3
40.0	-600.9
41.0	-625.2
42.0	-648.0

Boresight

Boresight angles were calculated using images collected on May 05, 2015 at Optech.

Flight details: nominal 900 AGL, 3 lines North-South, 3 lines East-West, 60% endlap, 60% sidelap

The bore sight angles are defined as Tx, Ty, Tz where Tx is the bore sight roll angle between the optical axis and the IMU reference plane; Ty is the bore sight pitch angle; and Tz is the bore sight heading angle.

Tx	6.5880 arc minutes
Ty	-17.5380 arc minutes
Tz	-0.1740 arc minutes