Understanding Your Calibration Results

The PixelTraq process outputs two key pieces of information:

1. A calibration certificate
2. A calibration parameter file

Calibration Certificate

Camera Information

The camera information section includes the following important information:

Part Number/Serial Number– Numbers assigned for uniquely tracking the camera assembly.

Calibration IDN – A tracking number assigned for the specific calibration of the camera assembly

Date Recorded – Date of calibration generation

Camera Information – Detailed information about the camera sensor including manufacturer, model number, serial number, etc.

Lens Information – Information about the lens including part number and serial number

Reprojection Error – A metric that represents the mean of the magnitude residual errors in the image plane following convergence of the calibration parameter optimization routine.

Model Type – Describes the type of model used for representing the camera projection function. More details on this can be found in our white paper “Introduction to Camera Models”.

Calibration Summary

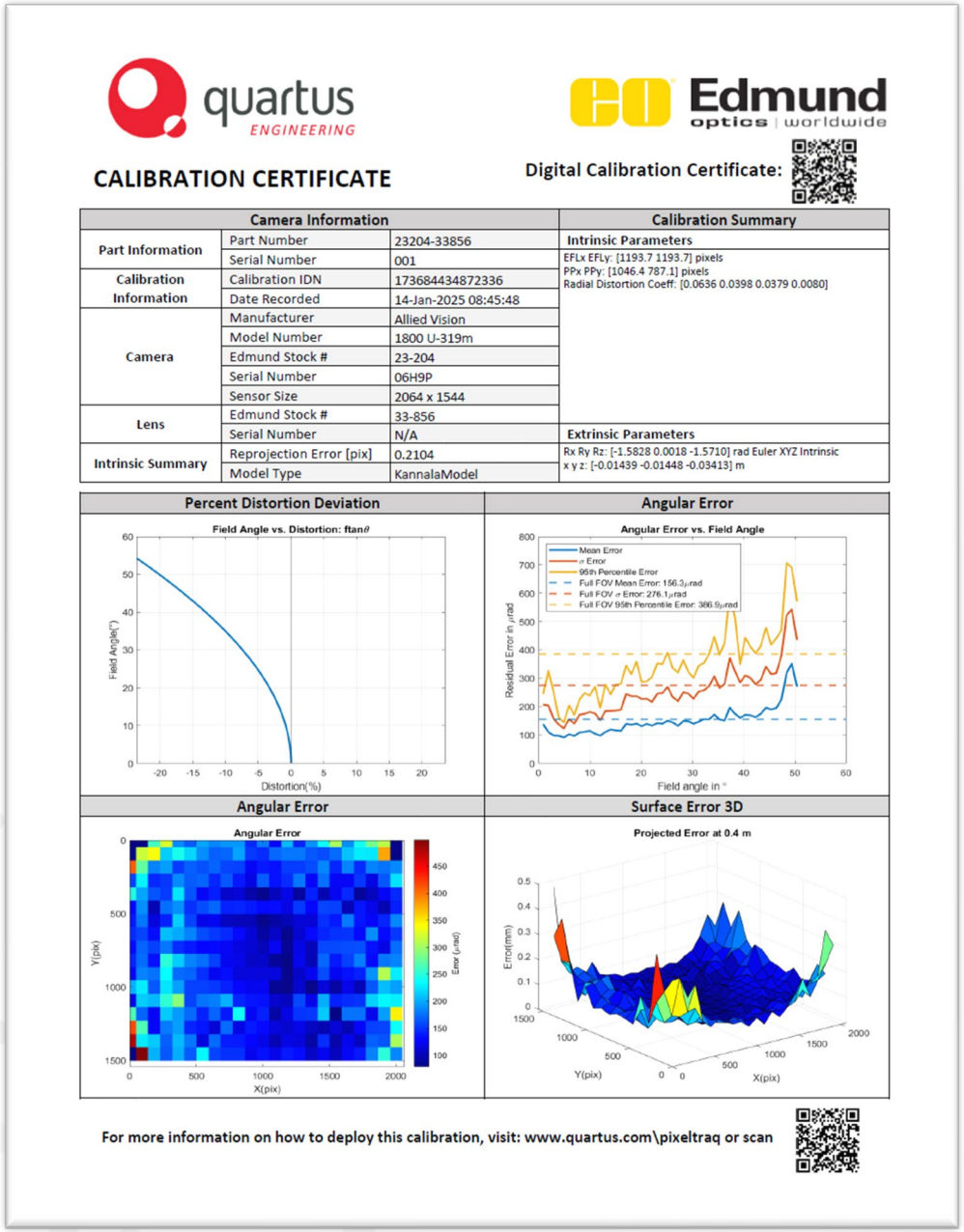
This section lists the parameters determined by the calibration routine that best fit the calibration data. These parameters are rounded to a reasonable decimal place and are shown here for reference. For full double precision parameters values, only the calibration parameter file contents should be used.

Intrinsic Parameters

This section lists the intrinsic parameters that define the internal projection function of the camera determined by the calibration.

Extrinsic Parameters

The extrinsic parameters section lists the six parameters necessary to define the three dimensional pose of the datum frame with respect to the camera frame. The convention used to represent rotation is intrinsic XYZ Euler angles (rotations about first the X followed by Y followed by Z axes with respect to the transformed frame’s axes rather than a fixed frame).



quartus ENGINEERING

Edmund optics | worldwide

CALIBRATION CERTIFICATE

Digital Calibration Certificate:

Camera Information			Calibration Summary
Part Information	Part Number	23204-33856	**Intrinsic Parameters**
	Serial Number	001	EFLx EFLy: [1193.7 1193.7] pixels PPx PPy: [1046.4 787.1] pixels Radial Distortion Coeff: [0.0636 0.0398 0.0379 0.0080]
Calibration Information	Calibration IDN	173684434872336	
	Date Recorded	14-Jan-2025 08:45:48	
Camera	Manufacturer	Allied Vision	
	Model Number	1800 U-319m	
	Edmund Stock #	23-204	
	Serial Number	06H9P	
	Sensor Size	2064 x 1544	
Lens	Edmund Stock #	33-856	
	Serial Number	N/A	**Extrinsic Parameters**
Intrinsic Summary	Reprojection Error [pix]	0.2104	Rx Ry Rz: [-1.5828 0.0018 -1.5710] rad Euler XYZ Intrinsic x y z: [-0.01439 -0.01448 -0.03413] m
	Model Type	KannalaModel	

Percent Distortion Deviation

Angular Error

Angular Error

Surface Error 3D

For more information on how to deploy this calibration, visit: www.quartus.com\pixeltraq or scan

Plots

Several useful plots of calibration results are provided that illustrate the quality of the calibration

Percent Distortion Deviation

This plot provides information about distortion percentage with varying field angle of the camera's FOV. This result is comparable to results provided with a lens spec sheet except that the y axis is in terms of actual camera's field angle. The percent deviation is measured relative to an $ftan\theta$ or $f\theta$ projection of the same focal length (depending on the application).

Angular Error vs. Field Angle

This plot shows how the residual error of the calibration varies with field angle. The plotted data is based on binning of measurement points over the field of view starting from the camera principal point. The mean, sigma, and 95th percentile errors over a rolling bin window and the same metrics measured over the entire FOV are plotted.

Angular Error

This plot shows binned residual errors of the calibration data set in terms of angular coordinates. This plot helps visualize how the error residuals vary over the field of view.

Surface Error 3D

This plot shows how the residual errors are propagated and amplified by projecting them back through the resulting camera model and into 3D space. This can be useful when assessing accuracy of subsequent algorithms that the calibrated camera will be used for.

QR codes

There are two QR codes provided on each calibration document. The top QR code leads to the digital calibration record for this camera. The bottom QR code leads to the informational content on camera calibration on the Quartus website.

Calibration Parameter File

The second piece of documentation that comes with a PixelTraq camera calibration is the calibration parameter file. This file, typically a JSON type text file, includes all of the calibration parameters for the resulting model up to double precision. This is the file that should be consumed by any software that will utilize the calibration.

MetaData

The MetaData section of the parameter file contains information that is helpful for traceability and determining camera specifications. Information such as the camera and lens part numbers, calibration date, and a Calibration ID number is contained here. This information is in many ways identical to the formatted information in the Calibration Certificate document.

Intrinsics

The Intrinsics section contains the actual camera parameters that describe the projection function of the camera. These parameter lists vary depending on the type of camera model used. The “class_name” field describes the type of model used. The coordinate convention describes where the origin of the image plane is for determination of the principal point coordinates. “TL0_0” means that the center of the top left pixel is the origin of the image plane coordinate frame. “TL1_1” means that the center of the top left pixel is the [1,1] of the image plane coordinate frame. These conventions may vary depending on the intended use case of the model and the coordinate convention preferences of the user. Any parameters listed as an empty list “[]” refer to parameters that are offered by the model, but aren’t used in this implementation.

Extrinsics

The extrinsic parameters describe the three dimensional pose of a reference feature (typically a physical datum feature) relative to the camera center frame. The orientation information contained in the “rotation” section is expressed as intrinsic XYZ Euler angles (rotations about first the X followed by Y followed by Z axes with respect to the transformed frame’s axes rather than a fixed frame).


```
{
  "MetaData": {
    "CameraManufacturer": "Allied Vision",
    "ManufacturererModelNumber": "1800 U-319m",
    "EOCatalogNumberCam": "23-204",
    "CameraSerialNumber": "06H9P",
    "EOCatalogNumberLens": "33-856",
    "LensSerialNumber": "N/A",
    "AssemblyPartNumber": "23204-33856",
    "AssemblySerialNumber": "001",
    "CalibrationIDN": 173684434872336,
    "CalibrationTimestamp": "14-Jan-2025 08:45:48",
    "class_name": "EOCalibrationMetadata"
  },
  "Intrinsics": {
    "mu_mv": [
      1193.7465204100752,
      1193.6985255571476
    ],
    "principal_point": [
      1046.4227296486965,
      787.0520875062731
    ],
    "radial_distortion_coeff": [
      0.063585875557823815,
      0.039806883667631396,
      0.037870334292141788,
      0.0080035462637151923
    ],
    "radial_asym_poly": [],
    "radial_asym_fourier": [],
    "tangential_asym_poly": [],
    "tangential_asym_fourier": [],
    "image_size": [
      2064,
      1544
    ],
    "class_name": "KannalaModel",
    "coordinate_convention": "TL0_0"
  },
  "Extrinsics": {
    "rotation": [
      -1.5827719275637417,
      0.0018464075466663207,
      -1.5710266415910252
    ],
    "translation": [
      -0.0143911350096617,
      -0.014480004027854987,
      -0.03413487137983736
    ],
    "class_name": "RealObject"
  }
}
```