Articulograph AG500 Quality Measurement

New calibration unit "Circal"

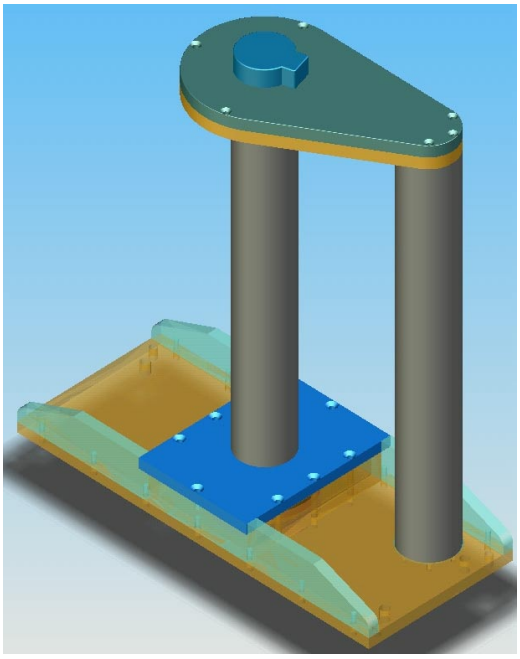

Figure 1: Circal CAD model

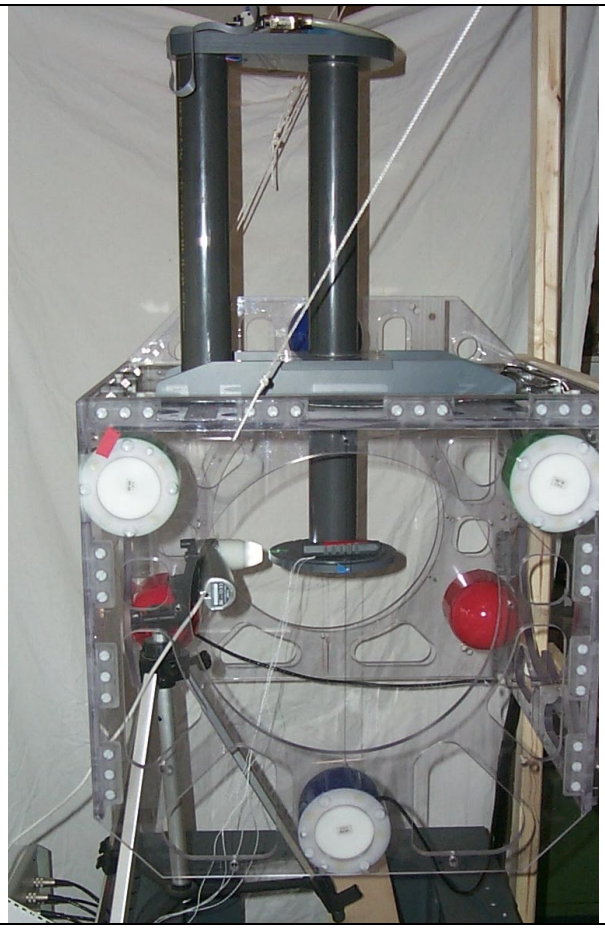

Figure 2: Circal mounted on EMA-Cube

The lower part from the Circal is removable. So the main part of the Circal can stay mounted during a measurement session.

The previous AG500 calibration method with AutoKal did not deliver calibration factors that were valid for all sensor orientations. With the AutoKal method the sensors are moved in x, y and z directions with constant orientations phi and theta.

The new Circal calibration device runs the sensors on a circle with constant z, but with changing x, y, phi and theta.

Results with the new calibration method

For all following results, the calibration factors were calculated with the new Circal calibration method.

The AutoKal device is now used to move the sensors with defined distances in x y and z directions.

First measurement to check right angles and straight lines

One sensor was calibrated and fixed on the AutoKal with its axis parallel to the y axis. The AutoKal performed the following moves see Figure 3:

- 80mm in positive x-direction (orange)
- 80mm in positive y-direction (green)
- 80mm in positive z-direction (blue)

The data have been recorded continuously during this moves.

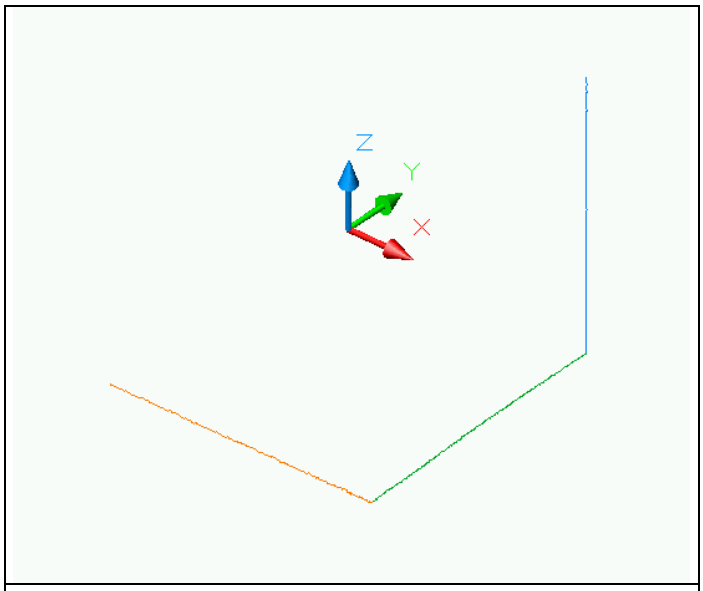

Figure 3: three 80 mm lines in x, y and z

For all three moves, we calculated the best fitting line to measure the angles between them. The lines were moved parallel to have a common starting point (Figure 4)

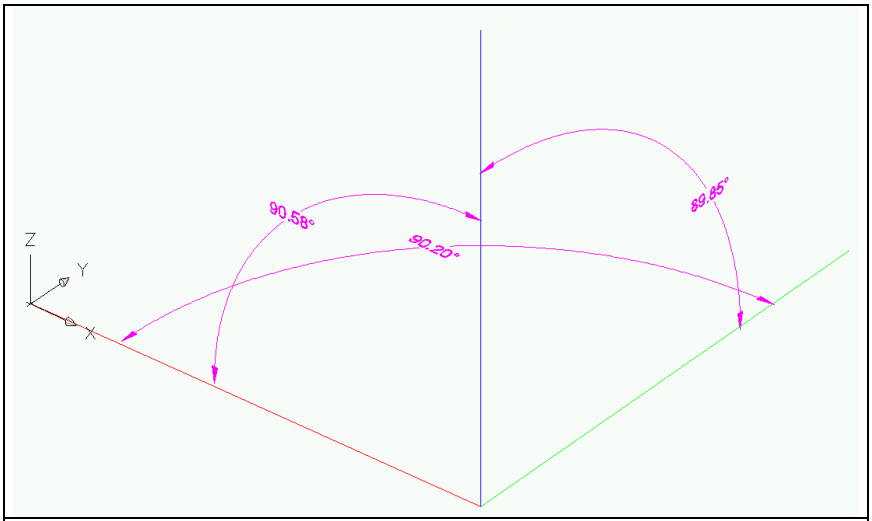

Figure 4: measured angles: xy= 90.20° xz= 90.58° yz= 89.85°

Second measurement with three sensors

Here we moved three sensor parallel on straight lines in x, y and z direction in two measurings.

Three sensors were fixed on a plastic board. The sensor axis were aligned parallel to the AutoKal Y-axis for the first measurement and parallel to the X-axis for the second.

All data are presented in a way as they came out of the machine. There has been done no smoothing or other processing.

Each measurement is performed as one sweep. The data was continuously recorded while the AutoKal was moving.

The first measurement "py-cube80.txt" was done with the sensors parallel to the Y-axis as shown in Figure 5.

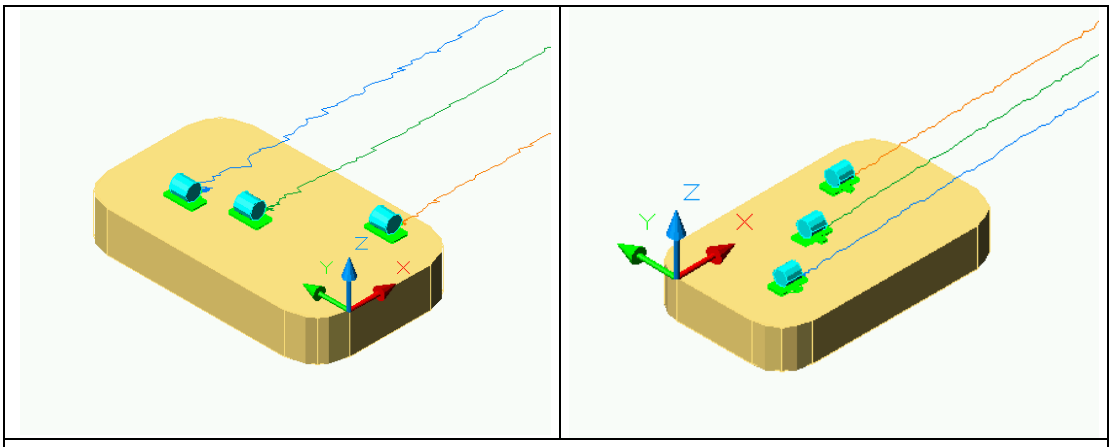

Figure 5: schematic arrangement of the three sensors – parallel y and x

The board was fixed on the AutoKal and the following movements were performed (Figure 6):

- 80mm in positive x-direction
- 80mm in negative y-direction
- 80mm in negative x-direction
- 80mm in positive z-direction
- 80mm in positive y-direction
- 80mm in positive x-direction
- 80mm in negative z-direction

The board with the sensors was rotated by 90° around the AutoKal Z-axis and the same measurement is done again (Figure 7).

The following figures show the measurement with sensors parallel to the y-axis on the left side and on the right side the corresponding result with sensors parallel to the x-axis.

The co-ordinate system for the plots was defined by the first two sections (+x and -y) from the center sensor.

This was done without checking if other co-ordinate systems orientations would fit better. Perhaps another orientation would show less deviations from an ideal system.

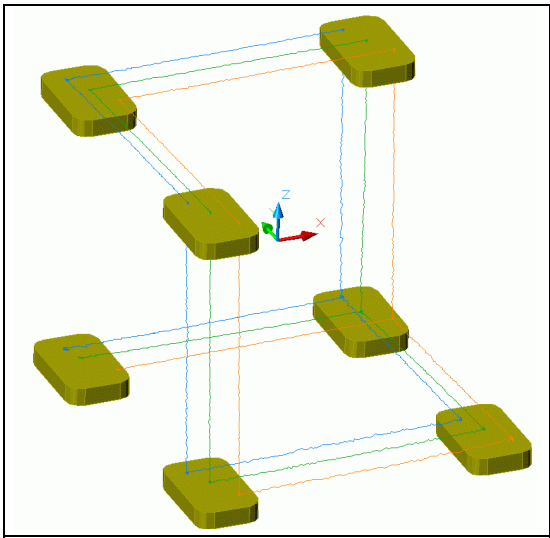

Figure 6: sensors parallel Y

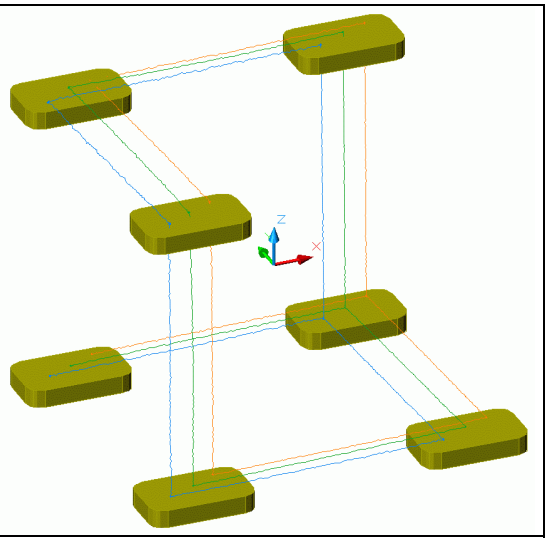

Figure 7: sensors parallel X

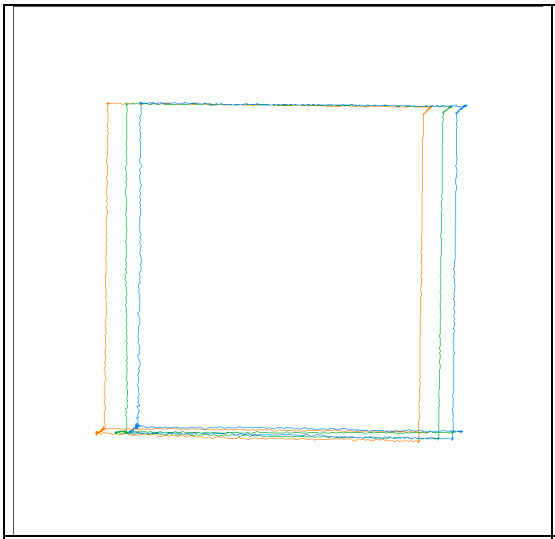

Figure 8: py-cube80_y – view from +y

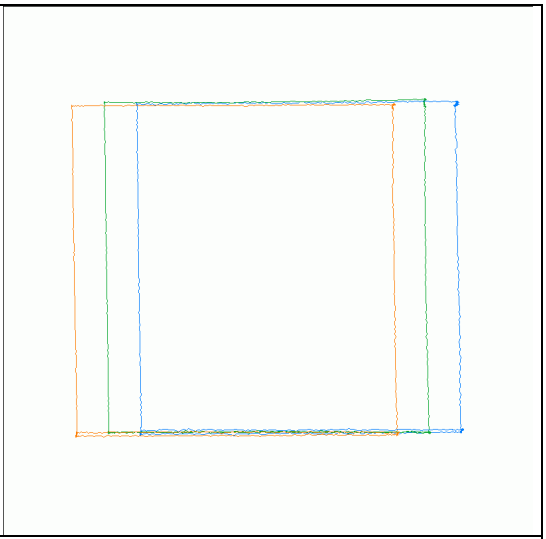

Figure 9: px-cube80_y – view from +y

Figure 8 and Figure 9 show a perpendicular view on the x-z plane and the Figure 10 and Figure 11 show the corresponding perspective view.

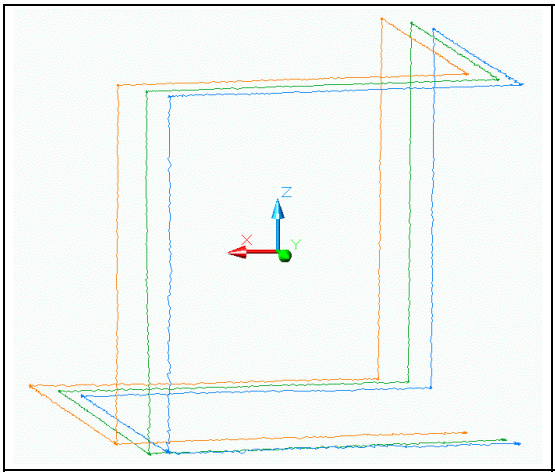

Figure 10: py-cupe80_y2

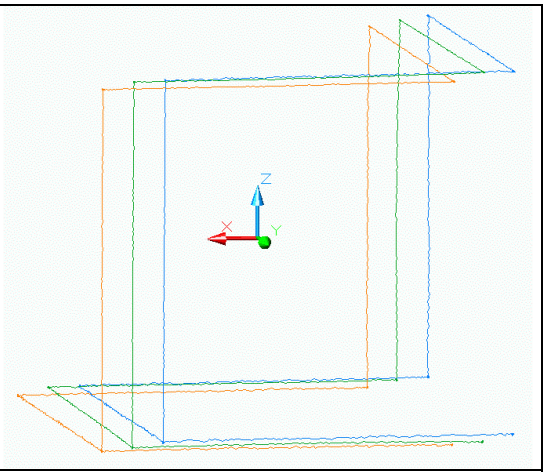

Figure 11: px-cupe80_y2

In Figure 12 and Figure 13, the lower left and upper right corner the movements in z-direction are seen. In an ideal systems this movements should appear as single points. Also in an ideal system the upper parallel lines would be projected at the same place.

In a correct aligned co-ordinate system, this deviations would show the measurement errors.

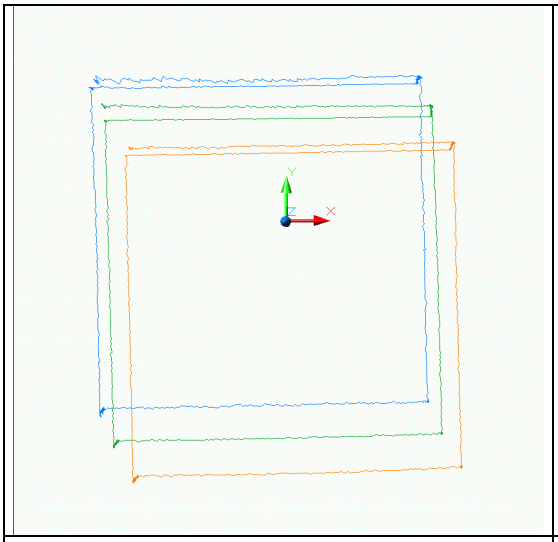

Figure 12:PY_top.gif – view from +z

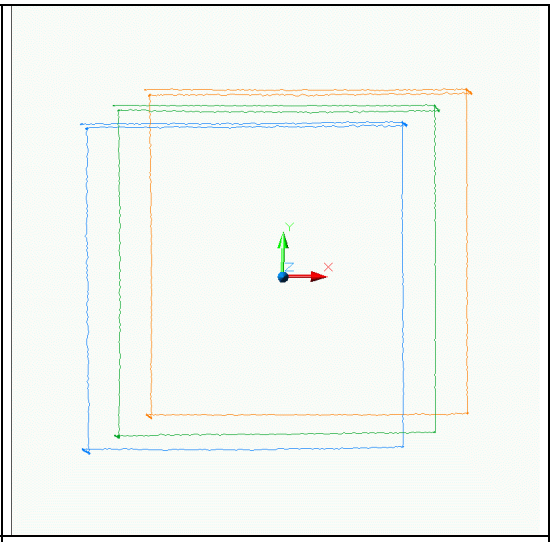

Figure 13:PX_top.gif – view from +z

The upper and lower parallel lines in Figure 14 and Figure 15 are different distances because the sensors have different distances in both board alignments (see Figure 5).

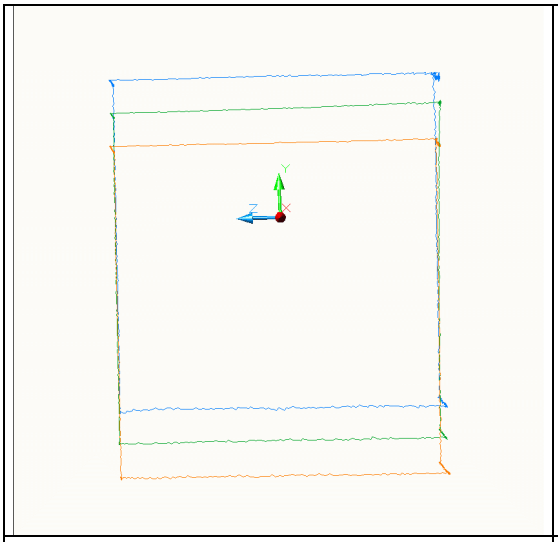

Figure 14:PY_right.gif – view from +x

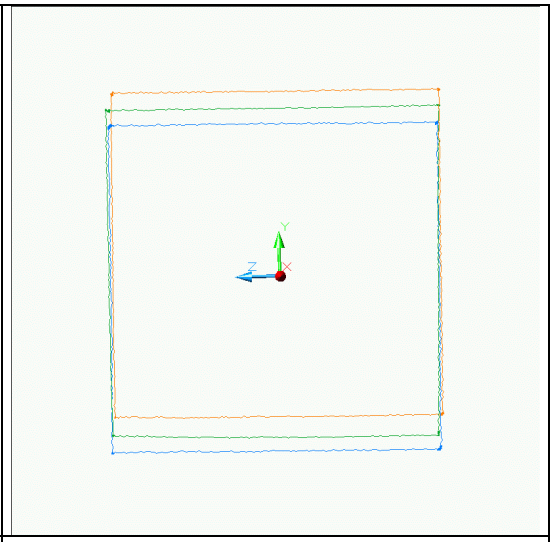

Figure 15:PX_right.gif – view from +x

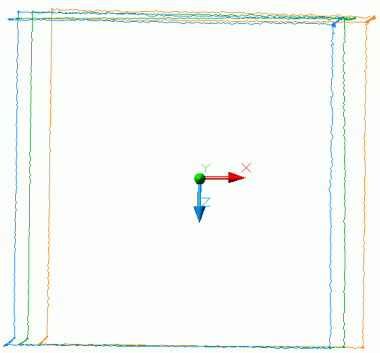

Figure 16:PY_bhind.gif – view from +y

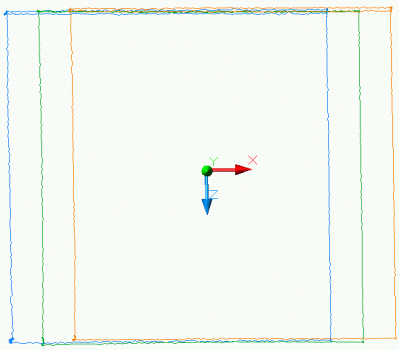

Figure 17:PX_bhind.gif – view from +y

These are the first measurements with the new calibration concept. We should expect some improvements by software procedures.