

Revision 3 – 1 June 2001

Test Protocol

Define a working volume as a cube, 2 meters on each side. Position the tracker at the best position to measure marker positions within this volume.

1. Place a single marker at the extremities of the working volume and one at the center. Measure 2000 samples and calculate the variability. All 9 marker positions can be measured simultaneously with 9 markers, or positions can be tested one at a time with a single marker.

Marker noise should be less than 0.5 mm RMS in any direction for markers situated within the working volume.

2. Attach 3 markers to a rigid object (plane), spaced 20 cm apart (approximately). Move it slowly through the workspace and measure data at 200 Hz. Measure the variability of the distance between pairs of markers as a function of distance, speed, orientation with respect to the camera line-of-sight, etc. Repeat for moderate and fast speeds.

Inter-marker distances should vary less than 2 mm peak-to-peak for markers oriented not more than 60° of the sight-line.

3. Place the rigid, planar object in the center of the field, perpendicular to the line of sight of the camera. Slowly turn it around the vertical axis until all markers are hidden. Record data at 200 Hz. Measure the variability of the distance between pairs of markers as the angle of incidence changes. Repeat for rotations around a horizontal axis in the plane of the cameras.

Inter-marker distances should vary less than 2 mm peak-to-peak for markers oriented not more than 60° of the sight-line.

4. Attach 2 markers to a rigid bar spaced 50 cm apart or more, move it slowly throughout the workspace. Acquire data at 200 Hz. Measure the variability of the distance between the two markers.

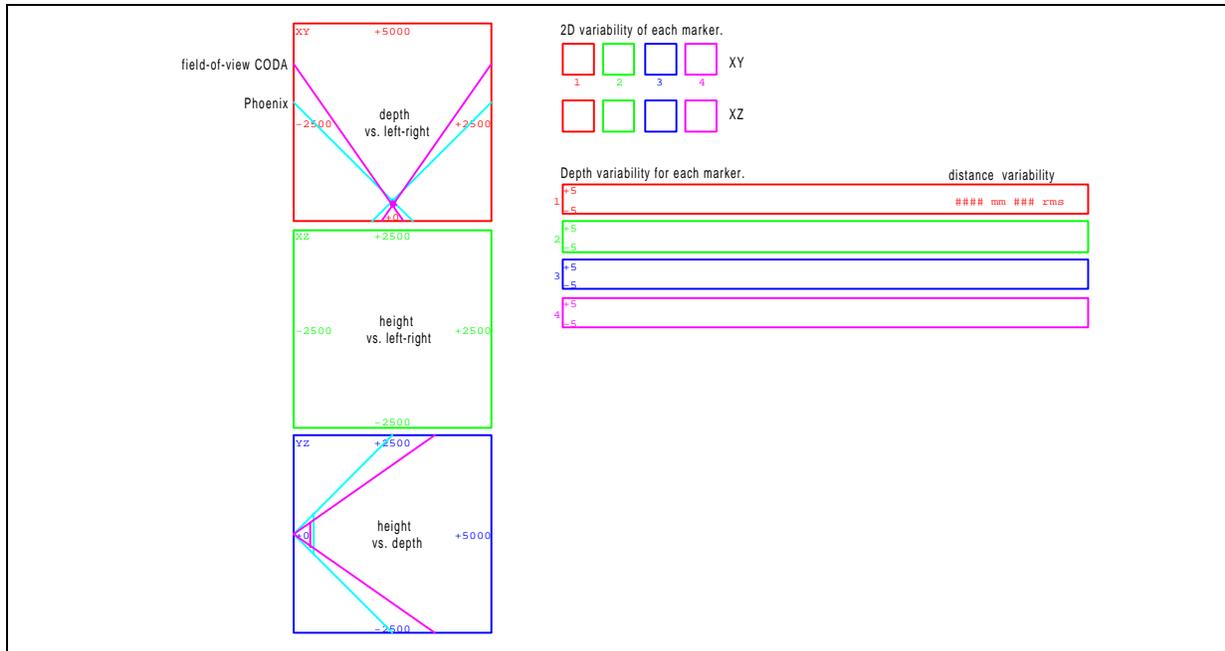
Inter-marker distances should vary less than 2 mm peak-to-peak for markers oriented not more than 60° of the sight-line.

If the inter-marker distances vary more than 2 mm peak-to-peak, a full calibration data set shall be generated and delivered with each instrument. Variations greater than 5 mm peak-to-peak are not acceptable in any event.

Test #1 is designed to assess the static resolution of the 3D measurements, as a function of position within the workspace. Tests #2 and #3 are designed to assess the variability of measurements as a function of marker orientation, workspace location and speed of movement. Test #4 is designed to test the absolute accuracy within the entire workspace.

Revision 3 – 1 June 2001

Static Analysis



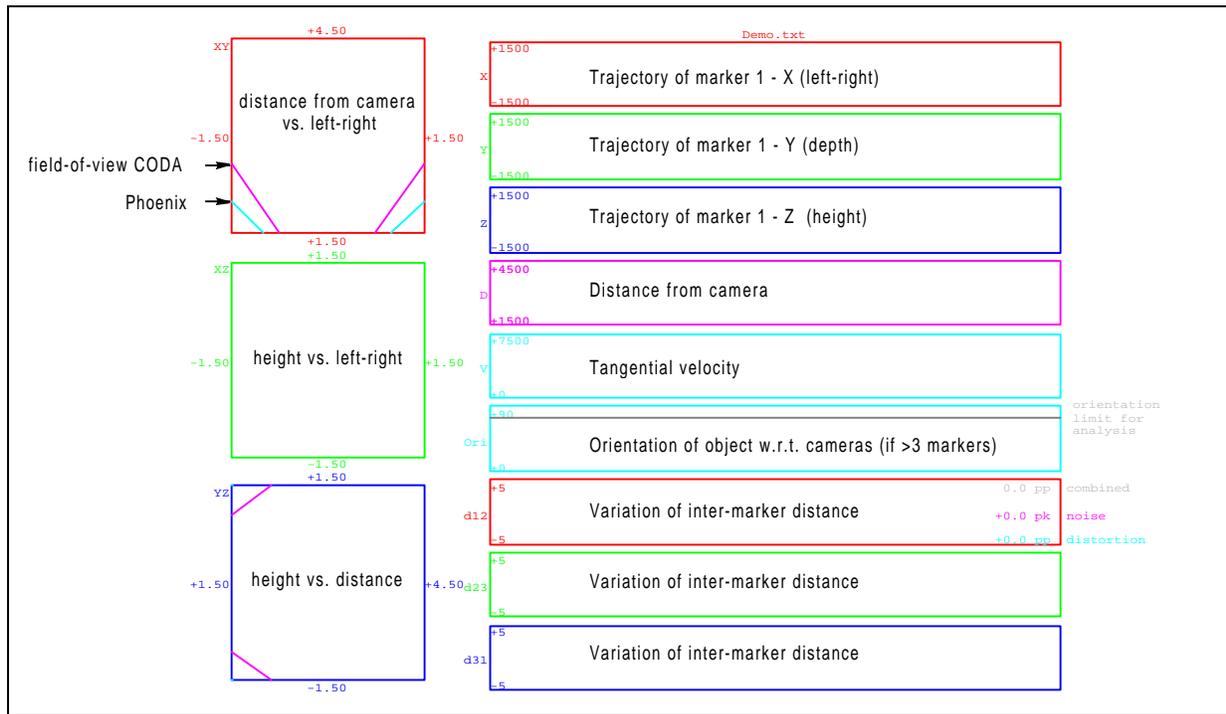
Left: Panels on the left side show the workspace from three different views. Marker positions are shown as dots (none shown here) indicating the position of each static marker within the working volume. Diagonal lines indicate the limits of the workspace for each tracker. The intersection of the two lines in the XY plane indicates the closest possible position of a marker to the cameras. In the YZ plane, this position is indicated by a short vertical line connecting the two diagonals. In the XZ plane, the limits of the workspace depend on the depth and so are not shown.

Upper Right: Variations of each marker position around the mean are shown on an expanded scale (± 5 mm).

Lower Right: Variations in the Y measurement vs. time are shown for each marker on an expanded scale (± 5 mm). Numbers to the right of each plot indicate the average distance of the marker from the camera and the variability in the Y component.

Revision 3 – 1 June 2001

Dynamic Analysis



Left: Panels on the left side show the workspace from three different views. Marker positions are shown as scatter plots (none shown here) indicating the trajectory of each marker within the working volume. Diagonal lines indicate the limits of the workspace for each tracker. Note the change of scale versus the static analysis. Each plot is an expanded view of a 3x3x3 meter cube centered at a distance of 3 meters from the cameras.

Right: Plots of measured or computed values versus time.

- X,Y,Z*** The coordinates of the object within the cube.
- D*** The distance of the object from the cameras.
- V*** The computed tangential velocity of the object.
- Ori*** The orientation of the tangent to the plane containing the first 3 markers of the object. The orientation is the angle between the tangent vector and the Y axis (cyan) or the line-of-sight from object to cameras (yellow). The grey horizontal line indicates the maximum allowed orientation away from the line-of-sight for data to be included in the subsequent analysis.
- d12, d23, d31*** Variations of the computed distance between marker 1 and 2, 2 and 3 and 3 and 1. Four traces are superimposed: raw variations (unfiltered, light grey), steady state distortions (low-pass filtered, light blue), noise (high-pass filtered, dark grey), noise envelope (rectified and smoothed high-pass, magenta). Three values are computed: raw peak-to-peak variations (upper value), peak noise (center value) and peak-to-peak distortion (lower value). Outlying points (points falling below the 1st or above the 99th percentile) are

Revision 3 – 1 June 2001

excluded. For an object having 3 markers, computed values include data only for orientations from the line-of-sight within the limit indicated in *Ori*.