K-Series Training

A guide for using the K-series camera system

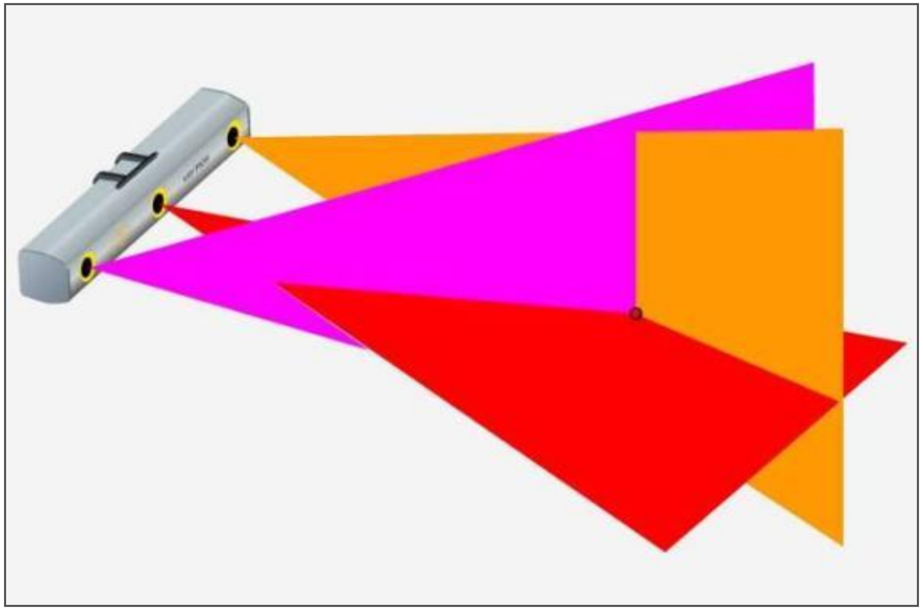
Contents

The Hardware – Camera

- There are three K-series models, the K-500, K-600 (pictured) and K610.
- Each consists of three individual linear CCD cameras mounted within a housing. The three cameras are rigidly held using a carbon fibre beam to minimise temperature variance
- The camera system measures the position of LEDs relative to itself
- The K-500 can take measurements up to 5 metres away from itself, the K-600 and K-610 can take measurements up to 6 metres away with the K-610 being more accurate, especially at larger ranges due to a larger separation of the cameras.

The Hardware – Theory

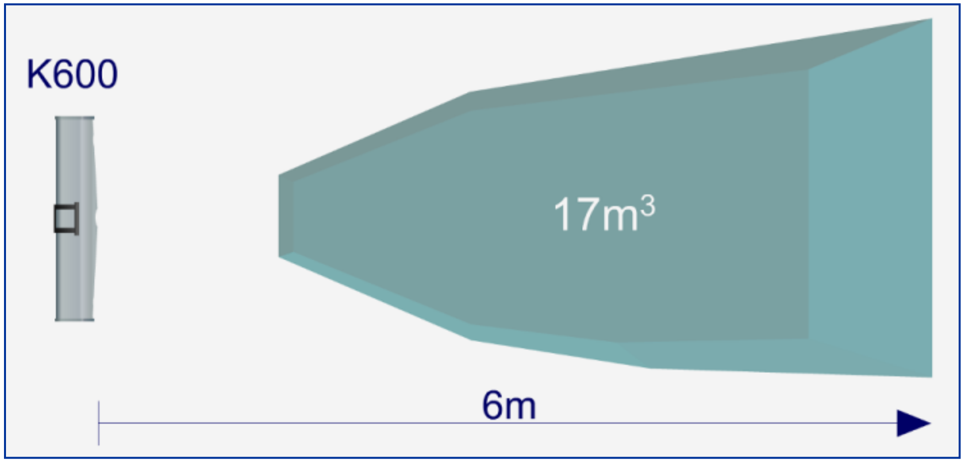
- Each of the 3 linear CCD (Charged Coupled Device) cameras situated inside the camera housing, measure only a single angle to an LED (position on a plane)
- The two outside cameras measure on the same, vertical axis, the central camera measures at 90° to the other two
- The 3 angles, when put together with the distance between the cameras, allow the controller to calculate a LED position

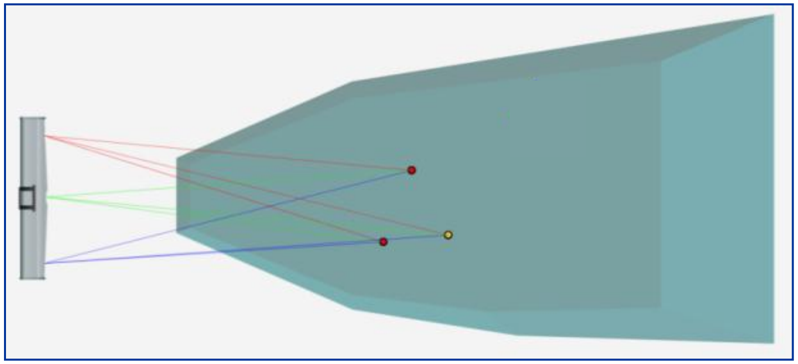


- Multiple LEDs can be tracked simultaneously with each LED being strobed sequentially
- LEDs can be attached to objects to track their position or mounted into a probe to take measurements and perform inspections

The Hardware –Measurement Volume

- The K-Series measurement volume varies based on the type of camera used
- Typically when using K600 or K610 cameras, LEDs are visible from 1600mm to 6000mm from the camera
- Camera volume is roughly pyramidal, going from ~1000 x 500mm to ~3000 x 2500mm
- Accurate volumes can be found in the K-Series Hardware Manual
- For a LED to be visible, it has to be inside this volume and also have line of sight to all 3 cameras





The Hardware – Controller

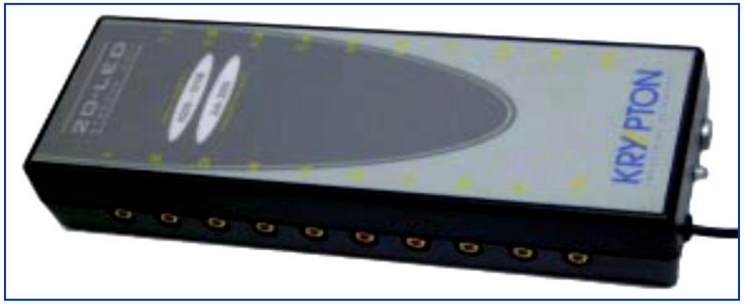
- A controller is used to connect together all of the components in the K-Series system
- It provides power and communication to the camera, synchronises the LEDs through connections to strober units, connects to probes and communicates back to the measurement PC through ethernet ports for data capture and analysis

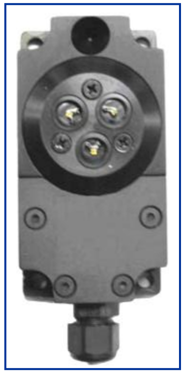
The Hardware – Space Probe

- The space probe is a measurement device that comes with the K-Series camera.
- It consists of 3 LED islands (9 LEDs in total) attached to a handle with 5 buttons (4 triggers and a function button)
- Different probe tips and lengths can be attached to the end of the SpaceProbe for different measurement situations
- The 9 LEDs are calibrated to each tip, allowing the position of the centre of the tip sphere to be determined
- Two sets of indicator LEDs on the probe provide visual feedback to the user. There is also audio feedback in the form of “beeps”.

The Hardware – LEDs and strobers

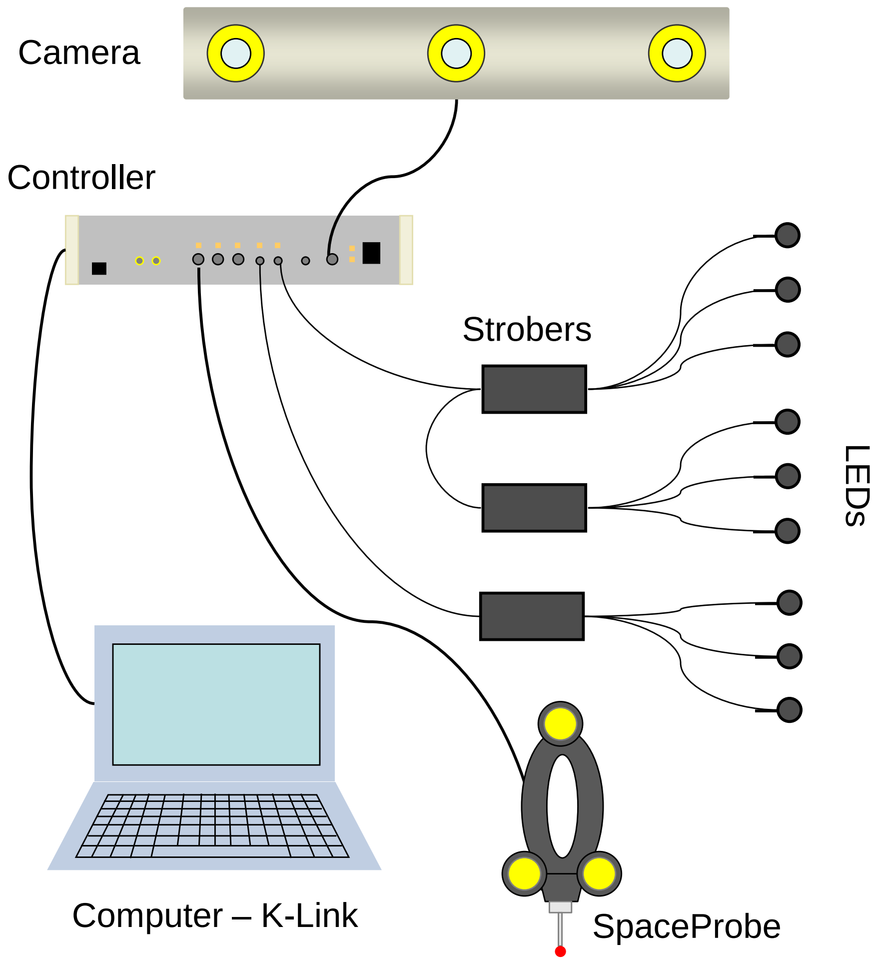
- Strobers control the flashing and sequencing of the LEDs and connect directly to the controller
- Standard plug-in LEDs come in set 1.2m or 2m cable lengths
- These plug into 3 or 20 port strobers
- 3 LED islands are in a more industrial housing and can be installed with custom length wires (up to 5m) into 18 port strobers with screw terminals or sub-D connector
- Strobers can be daisy chained, but limit of 6 strobers (3, 18, 20 or combination) per strober port before signal loss





The Hardware – Connections

- The different connections on the front of the controller are labelled
- Each cable type can only be plugged into the relevant port
- The controller has 2 ethernet ports (one front, one rear) to connect to the measurement PC and/or other devices/networks
- There are 4 strober ports:
  - 1 and 2 are for specialist strobers and probes
  - 3 and 4 are for general strobers



The Hardware – Switch On

- When turning the controller on and off, ensure that all cables are attached as needed, do not plug in or unplug the camera or Space Probe when the controller is on, as this can damage the system.
- When the controller is first switched on, there are a 3 beeps and all the lights above the ports switch on.
- When the controller has booted, all the lights above the ports go out and the running light turns on.
- When the controller has first been switched on, leave approximately 30 minutes for the camera to warm up.
- When the system is in use, lights above the relevant ports will be lit.

The Software – Measurement PC

- The measurement PC is used to collect the LED positions coming from the camera via the controller and process the information
- Various software can communicate with the K-Series system from Nikon’s own range of measurement and analysis software to 3rd party off the shelf and even bespoke software
- Depending on the software used, the system can be used for:
    - Tactile inspection
    - Laser line scanning
    - Dynamic tracking (points and frames)
    - Dynamic correction
    - Robot calibration
    - Robot correction
    - Robot scanning
    - ....
- The main interface to the system is through K-Link and K-CMM

The Software – K-Link

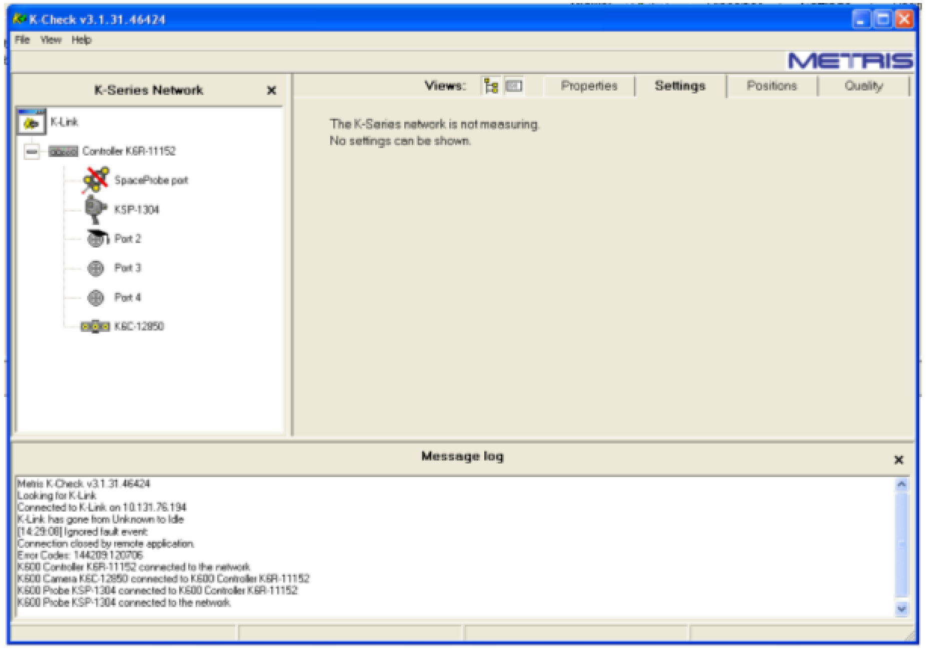
- K-Link is the interface between the PC and the camera. (Rocal and DMM Modular, use K-Link 2.7 if measurements are being taken) All other programs use K-Link 3
- K-Link is used to configure the controller (LEDs, probes, timings) and process the raw LED data coming back from the camera using the camera calibration file (.vsg) sending the measurements to other software either directly (dynamic tracking) or indirectly through K-CMM (probe measurements)
- If K-Link is running, it appears in the system tray.

- There are two indicators on the K-Link system tray icon
  - The indicator on the left represents the connection of the PC to the controller and the one on the right represents the connection of the controller to the camera. A green light shows a connection, a red light means there is no connection.

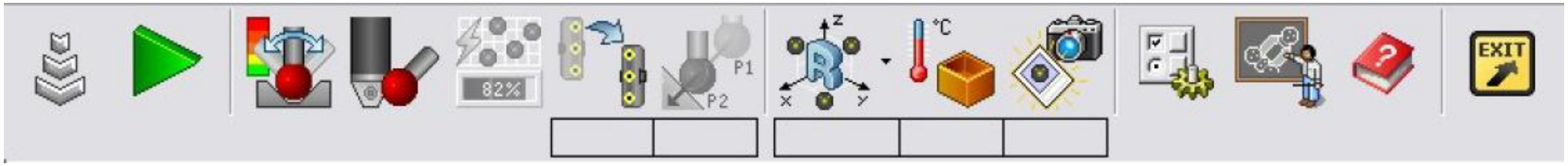
- If several controllers are connected to the same PC, more indicators will appear in pairs on top of the K-Link icon.

The Software – K-Check

- K-Check is a program that can be accessed by double-clicking on the K-link icon. It is a diagnostic tool for the whole system.
- It shows what is connected to the controller and can give details of serial numbers and firmware/software versions.
- If the system is in a measuring state, it will show how many LEDs are visible and what is happening on the controller
- It can be used to troubleshoot problems with the system or LED visibility



The Software – KCMM

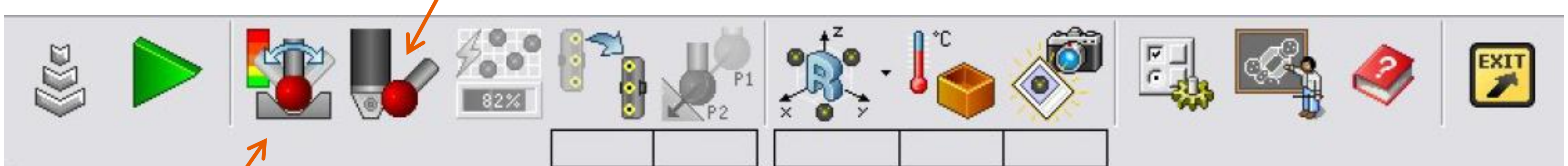


- K-CMM is the interface for tactile or non-contact measurements using the K-Series probes
- Inspection and measurement software communicates through this interface either directly (TCP-IP) or through the HHAPI
- KCMM appears as a menu bar at the top of the computer screen and provides links to various functions for calibration and referencing
- Feedback is also provided for probe visibility and K-Reference status

The Setup – Calibration and Referencing

- In order to use the camera system, it needs to be referenced
- This is achieved by performing measurements of a scale bar in multiple orientations and positions in front of the camera
- This referencing allows the default camera geometry to be adjusted to account for temperature and orientation changes
- 2 types of referencing are available:
  - Automatic – Uses an LED embedded scale bar
  - Manual – Uses a scale bar with measurements using the Space Probe
- In order to use the SpaceProbe, the tip position needs to be calibrated to the LEDs
- Both referencing and probe calibration are launched from K-CMM

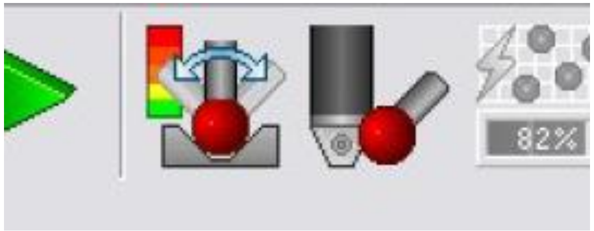
K-Reference



Probe Calibration

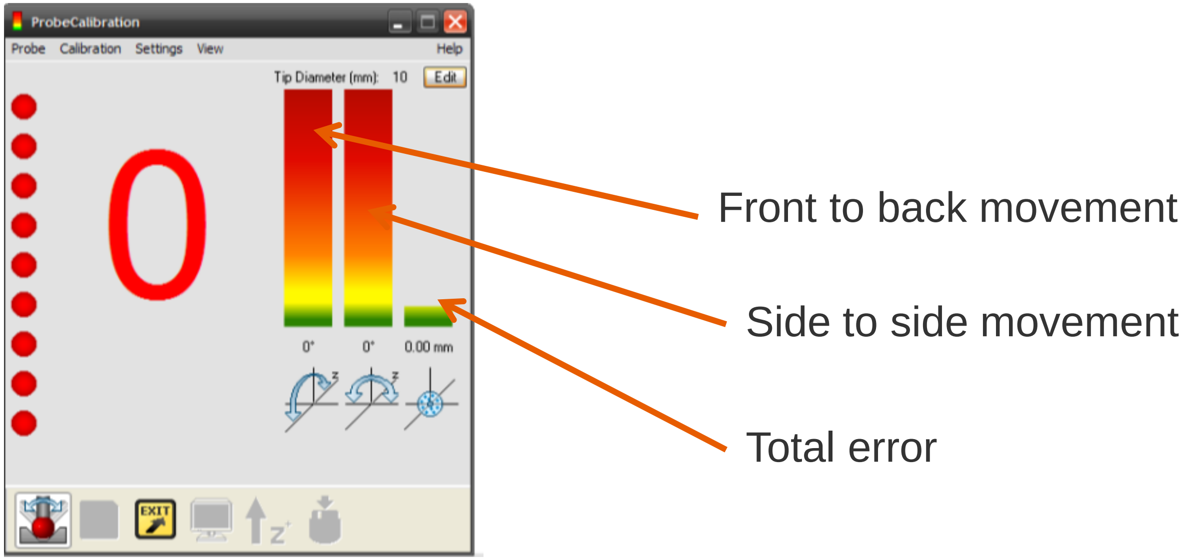
The Setup – Space Probe Calibration

- To calibrate the space probe, measurements are taken around a fixed tip position (usually a cone or small hole)
- The aim is to get a range of movement of approximately 160° from left to right and 110° from front to back over about 20 measurements
- The three LED islands built into the space probe need to be facing the camera whenever a measurement is being taken (indicated by a green LED on the probe)



The Setup – Space Probe Calibration ctd.

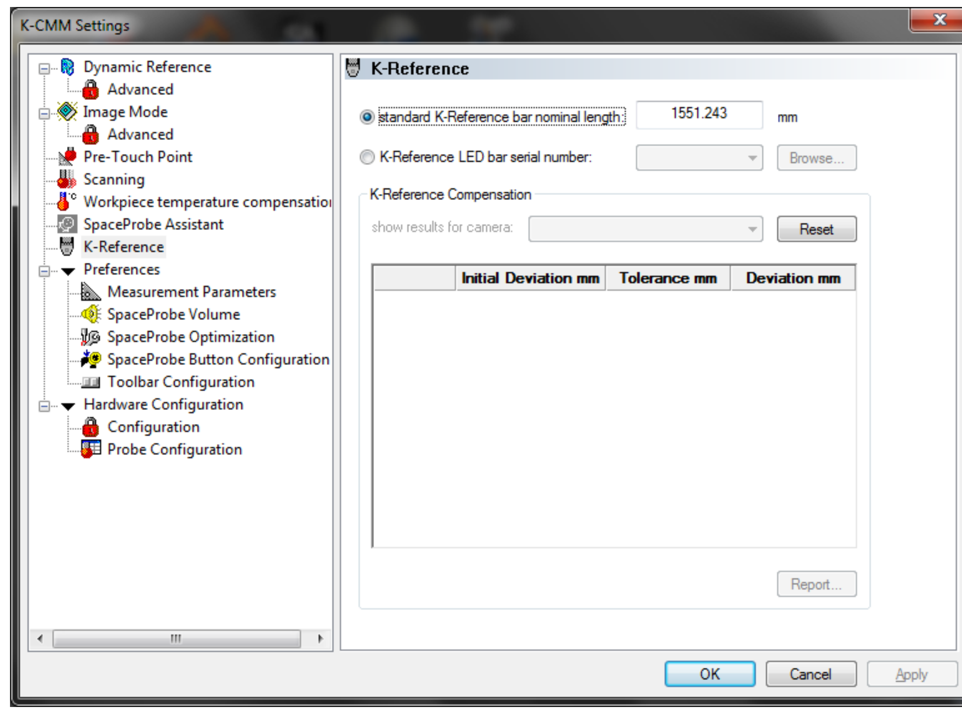
- The probe calibration window shows the visibility of the LEDs and measurement progress
- To take a measurement, press one of the 4 buttons on the inside of the probe handle; an audible beep and a flash of the lower red indicator LEDs will indicate a measurement has been taken.
- As measurements are taken, the indicator bars will decrease (movement bars should disappear). 0.03mm or less is an ideal value for total error for a probe tip with no extension piece



The Setup – SpaceProbe Calibration extremes

The Setup – K-reference

- K-Reference is started from the K-CMM toolbar
- Right clicking on the icon brings up the settings dialogue where the user can choose between the manual or LED bar (length or A-Kref probe file)
- This also shows the result of the last reference to be applied



The Setup – K-Ref Bar

- The standard K-Ref bar comes with a tripod on which it is to be mounted during temperature compensation. The tripod should be placed approximately 3 metres away from the camera and there are 7 Orientations of the bar that need to be measured.

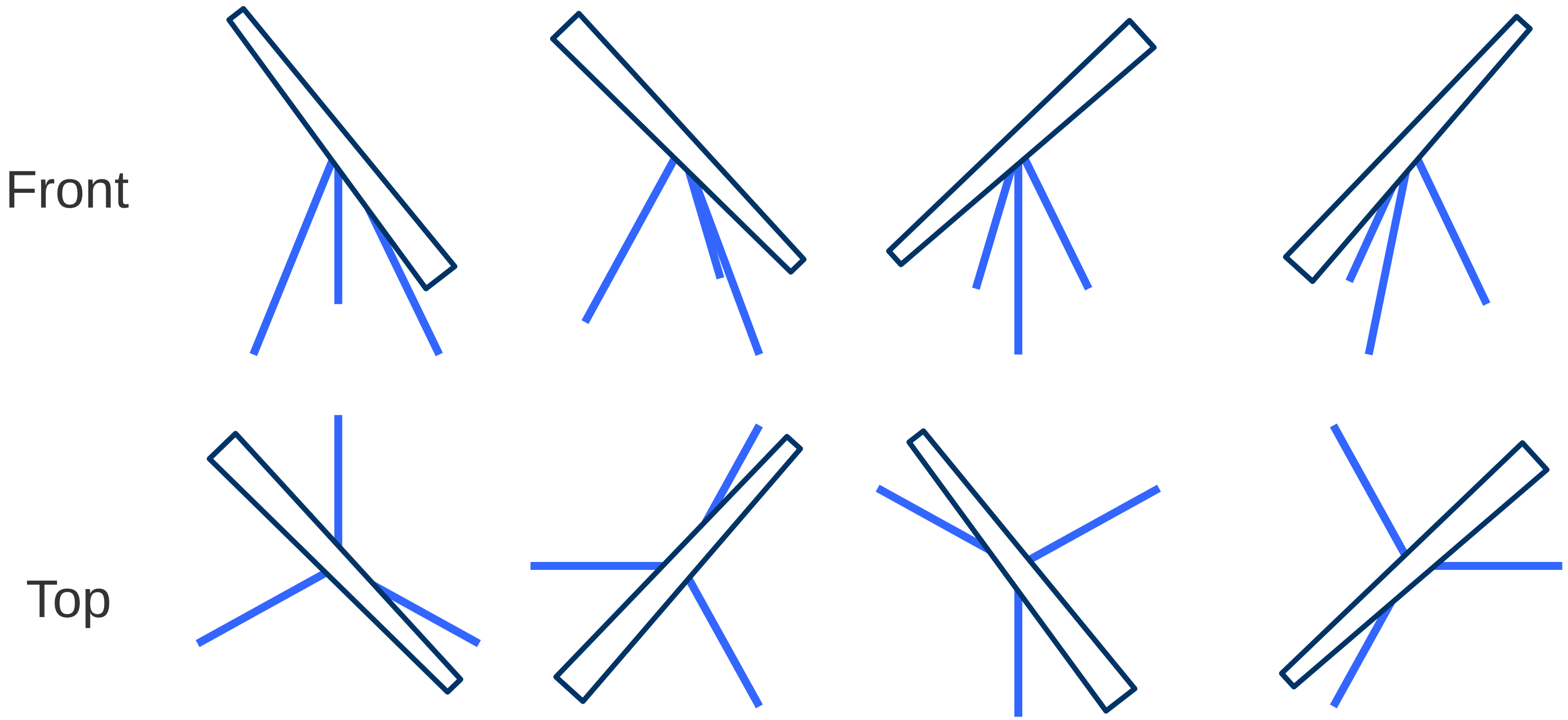
- For each orientation, a diagram will appear on the monitor, however it is worth noting for the diagonal orientations, there are 4 measurements, so each one is simply at 90° to the previous.

- In each orientation, a measurement is taken in the cones at each end of the K-Ref bar using the space probe.

- Diagrams of each position appear on the next slide.

The Setup – K-Ref Bar Orientations

- 4 diagonals, vertical, horizontal and pointing at the camera.
- Diagonals shown below



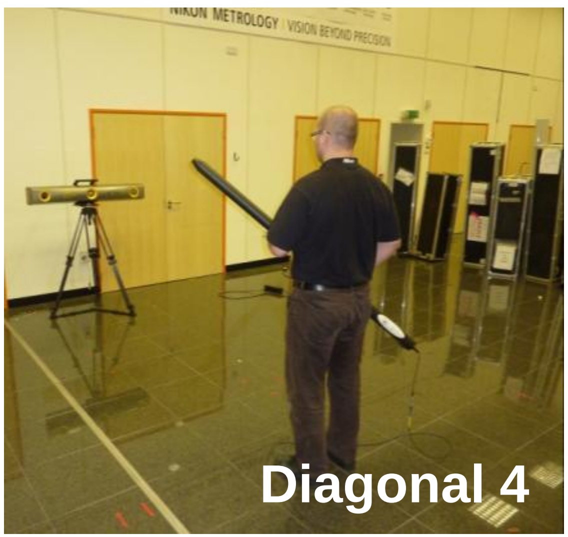
The Setup – A-KRef LED Bar

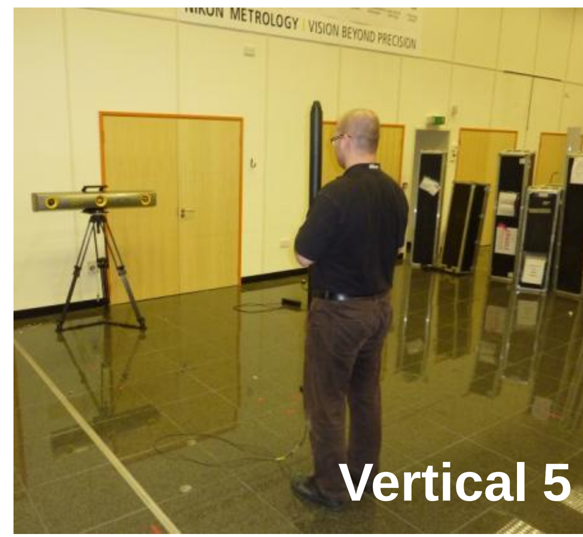
- The K-LED Bar serves the same purpose as the space probe and bar, however instead of using the probe, there are LEDs built into this bar. There is no need to use the tripod, as the bar is simply held by the user in front of the camera in several positions.

- The Bar must be held in the correct position while the camera measures the location of the LEDs over a short period of time (in order to take averages). On the monitor, a green bar will increment once the bar is in the correct place, until it is complete and then the next position will appear on screen.

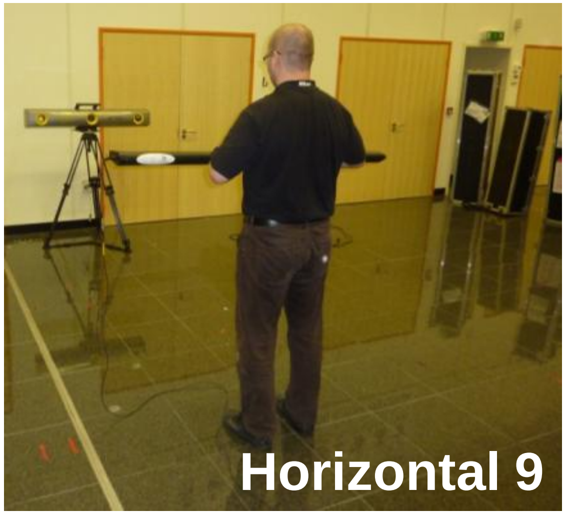
- There are 23 different measurements that need to be taken and these are shown on the next few slides.

The Setup – A-KRef bar poses 1



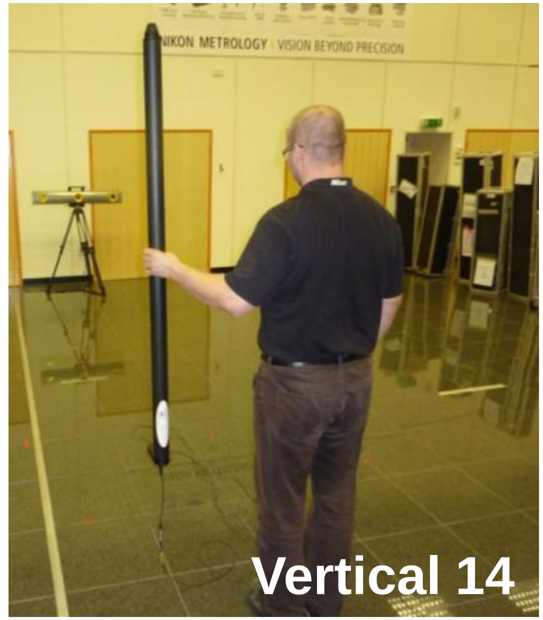


The Setup – A-KRef bar poses 2



The Setup – A-KRef bar poses 3

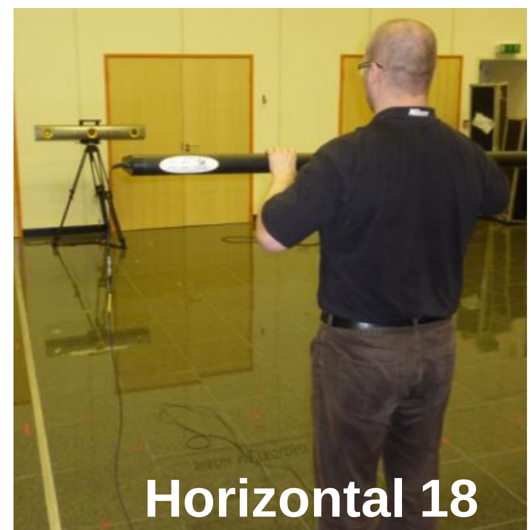

End on 13


Vertical 14

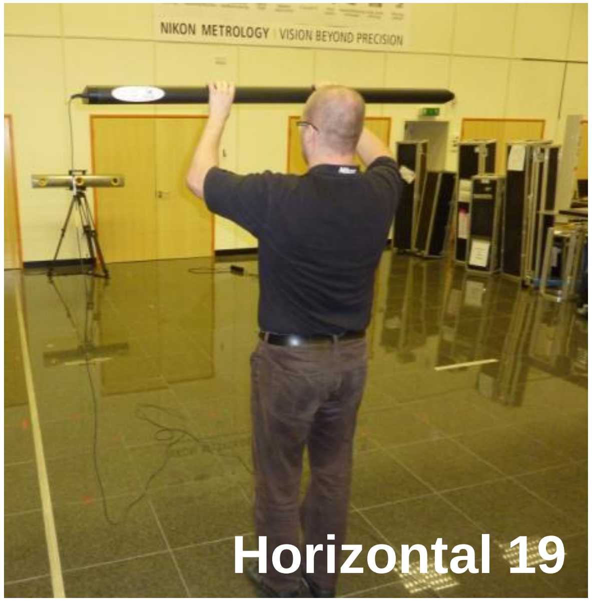

Vertical 15

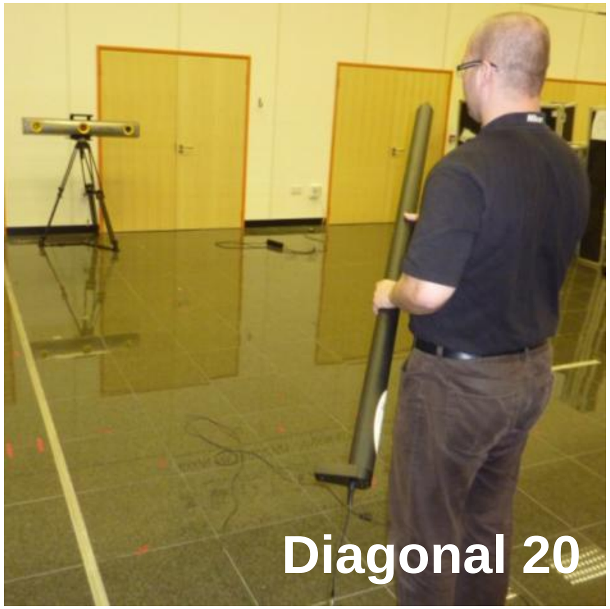

Vertical 16


Horizontal 17


Horizontal 18

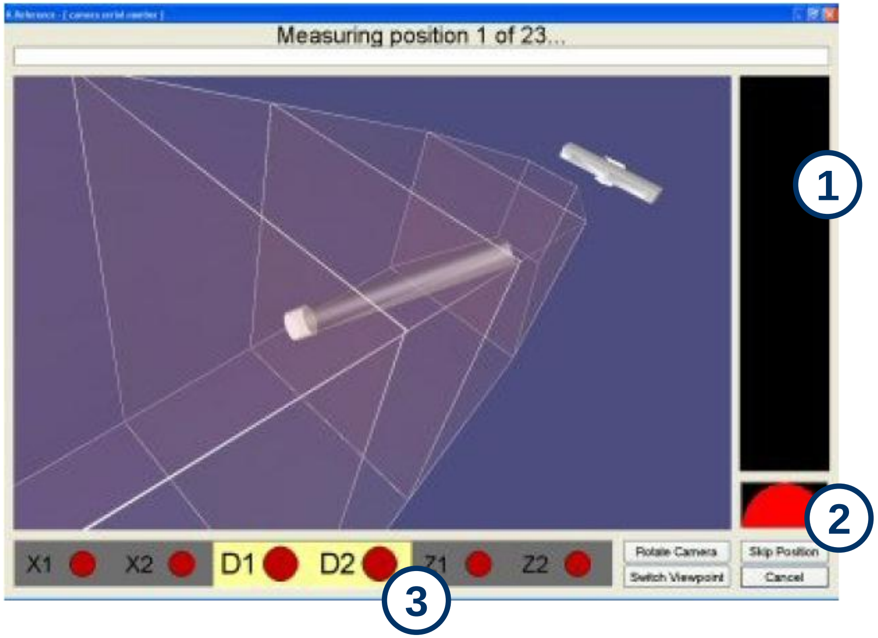
The Setup – A-KRef bar poses 4





The Setup – A-KRef interface

- The interface shows the user the expected orientation of the bar in a 3D window
- There are 3 indicator sections to guide the user to the correct position
    1. The bar indicator shows the error in position (up, down, left, right, forwards, backwards)
    2. The semi circle indicator shows the error in overall orientation (rotation)
    3. The LED indicators show the error in LED angle to the camera of required highlighted LEDs (twist)
- All 3 sets of indicators need to be green in order to take a measurement for that position
- When the bar is visible, a live representation will also be shown in the 3D window and should be matched to the ghost image shown



Geoloc – Features

- Once calibration of the system has been completed, measurements can now be taken
- Geoloc is a basic feature inspection program launched independently or through DMM
- It can be used to measure static geometric features for inspection or to create reference frames
- LEDs can be measured relative to these frames to allow for automatic recreation of the frames or for dynamic tracking (DMM or other software

- As well as measuring frames (with a minimum of 3 LEDs), measuring a path is a useful feature of Geoloc; It enables the camera to track one or several LEDs as it moves along a path. This series of measurements can then be fitted to or exported and used elsewhere to serve a number of purposes.

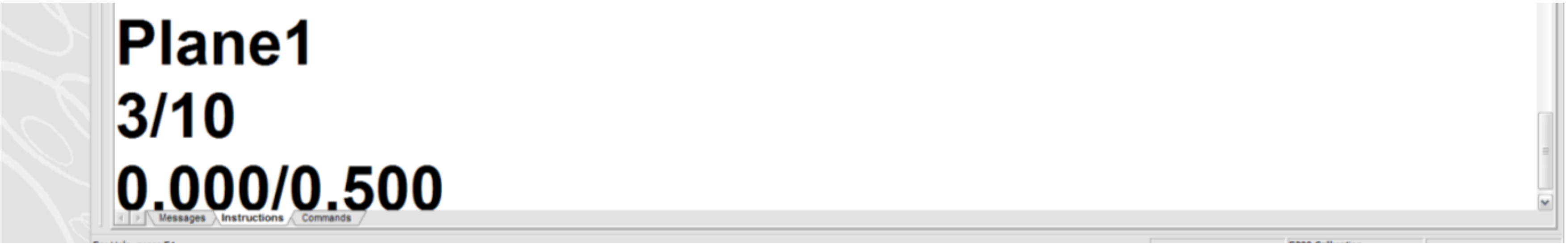
- The program menu allows the user to import, export or manually define features within the system.

Geoloc – Measure Menu

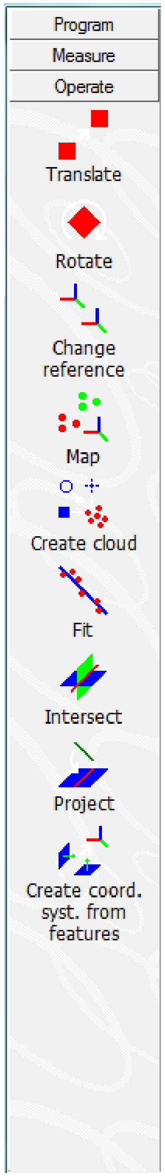
- Used to measure points in space, either for defining origins or measuring a position.
- Can both be used in the making of a frame to define axes.
- Circles can be useful if a centre point of a circle needs to be found, they can also be used in defining axes for frames.
- Measuring a sphere, a hole or a cylinder is an extremely accurate way of repeatedly defining a point in space, as the centre point is unlikely to move due to measurement error. Spheres, holes and cylinders are very good for Datums.
- Measuring a path is a very useful feature of Geoloc and was explained previously.
- Dynamic frame and make frame are explained on later slides.
- Path, Dynamic frame and Make frame take direct measurements of LEDs, rather than using the space probe.

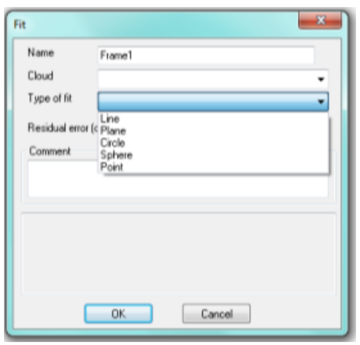
Geoloc – Measuring Features

- Below is a screen shot of the instructions tab of the Information Pane of Geoloc when a feature is being measured.
- Geoloc shows the maximum number of points to be measured for each feature(configurable)
- When the points have been measured or the user ends the measurement early (by pressing the outside button of the space probe), a fitting error for the geometry will be shown
- The 0.500 to the right of the slash is the predefined tolerance.
- If the error is greater than the tolerance, the text becomes red. The tolerance and maximum number of points can be changed in Tools>Options>Measurement Options.



Geoloc – Operate Menu

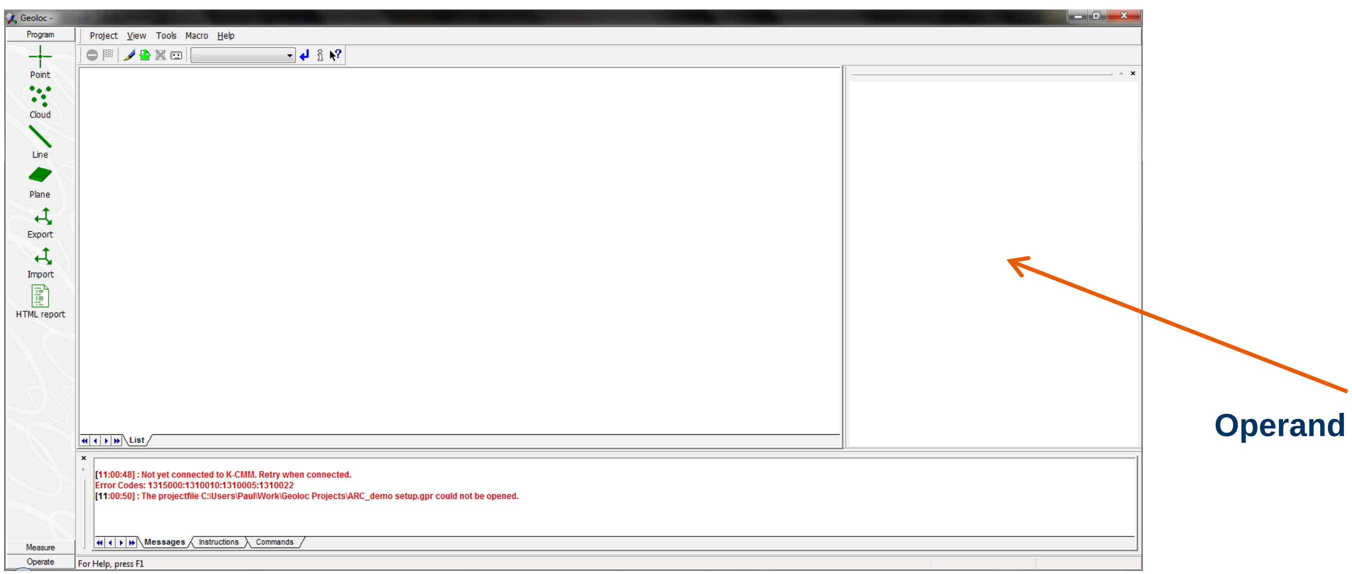




- The Operate menu allows the user to perform various operations on features, clouds and objects.
- Create Cloud enables several measured points or shapes to be grouped together in order to have another operation performed on them. To create a cloud, all features must first be dragged into the operand window on the right hand side of the screen.
- Fit enables a cloud to be mapped to a particular form. Clicking on fit opens up another window in which the user can choose form the cloud data should be fitted to, either a line, plane, circle, sphere or plane.

Geoloc – Operand Window

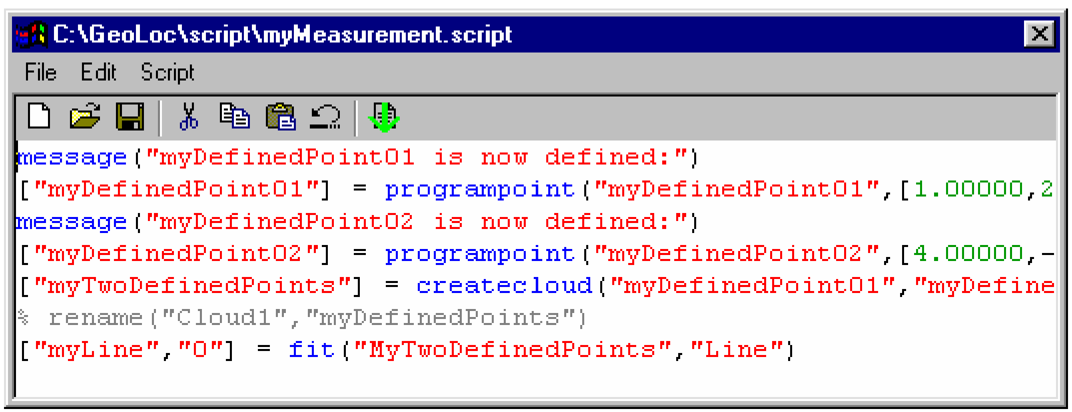
- The window to the right of the features window is called the operand window
- It is used as a shortcut to filling in the forms and for certain operations by dragging elements into it before clicking the relevant button
- If creating a cloud, the elements need to be arranged in order
- Certain functions can give added functionality by using the operand window. E.g intersections of 3 elements



Operand Window

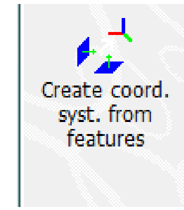
Geoloc - Scripting

- Scripting provides a way of automating measurement jobs by defining a set series of measurements
- Through scripting, names can be automatically set, elements adjusted, frames created etc
- Messages can also be shown to the user to help with the measurements
- Scripts can either be written from scratch or recorded from an actual measurement (macro) and edited later

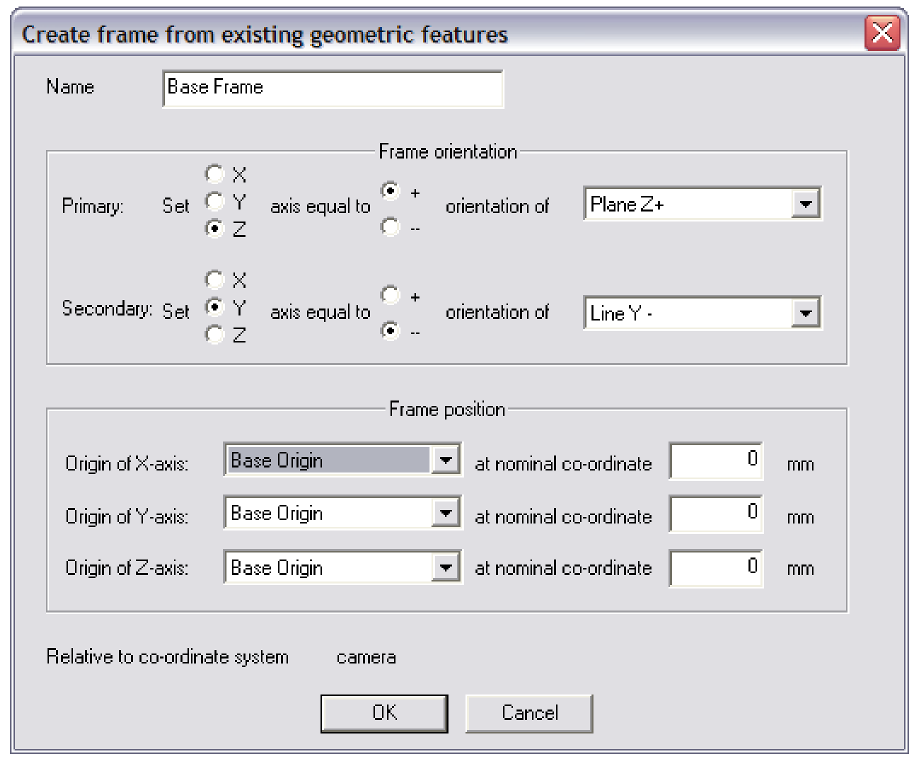


Geoloc – Direct Measurement of Frames

- There are two methods to creating a reference frame: Direct measurement and indirect measurement.
- For direct measurement, Geoloc requires 2 different directions (plane, line, cylinder) and a known point in the frame as inputs into the ‘Create coord syst. from features” function

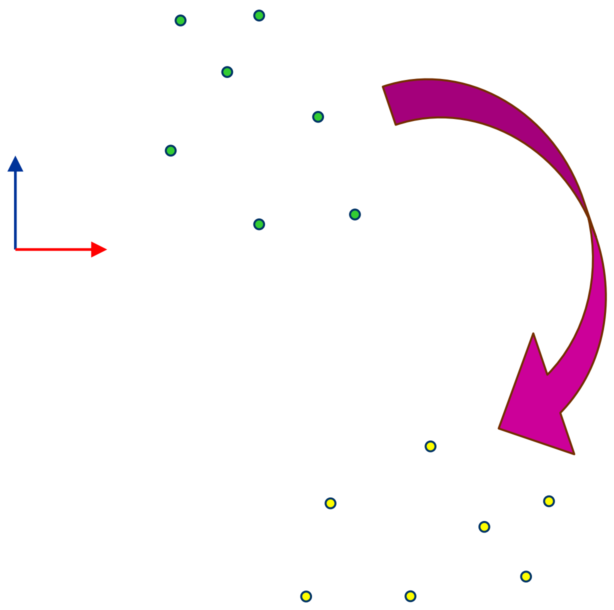


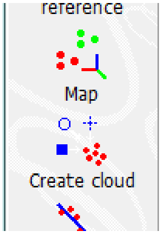
- One of the element directions is used as the fixed primary axis with the other axes orthgonalised to this
  - The tertiary axis is created from a cross product of the primary and secondary element directions with the secondary axis created from the cross product of the new tertiary and original primary
- The known point locates the frame in space (x, y, z position)
- This point does not have to be at 0,0,0 nor does the same element need to be chosen for each axis origin



Geoloc – Indirect Measurement of Frames

- Indirect measurement involves measuring nominal points/datums with predefined positions relative to a reference frame
- The group of nominals and the group of measured points are then mapped together to reproduce the reference frame relative to the measured points
- The nominals can be generated from a CAD file, inspection report or previous measurement
- In Geoloc, the nominals can be manually input (Program), or imported from a text or previous measurement to create a point cloud
- The measured point cloud can either be measured directly or created from measured elements using the operand window and the Create Cloud option
- The Map function then performs the mapping
- Make frame is an automated form of this method using the LEDs from a Dynamic Frame





- Dynamic Frame - The dynamic frame function measures the positions of the LEDs relative to a measured frame. This is the step used after creating a coordinate system from features or mapping.

- Make Frame – Make frame does the inverse of Dynamic frame; It takes the known positions of the LEDs and maps the frame to them. This will only work if a dynamic frame has already been created. If the LEDs have moved relative to each other, then there will be a large mapping error.

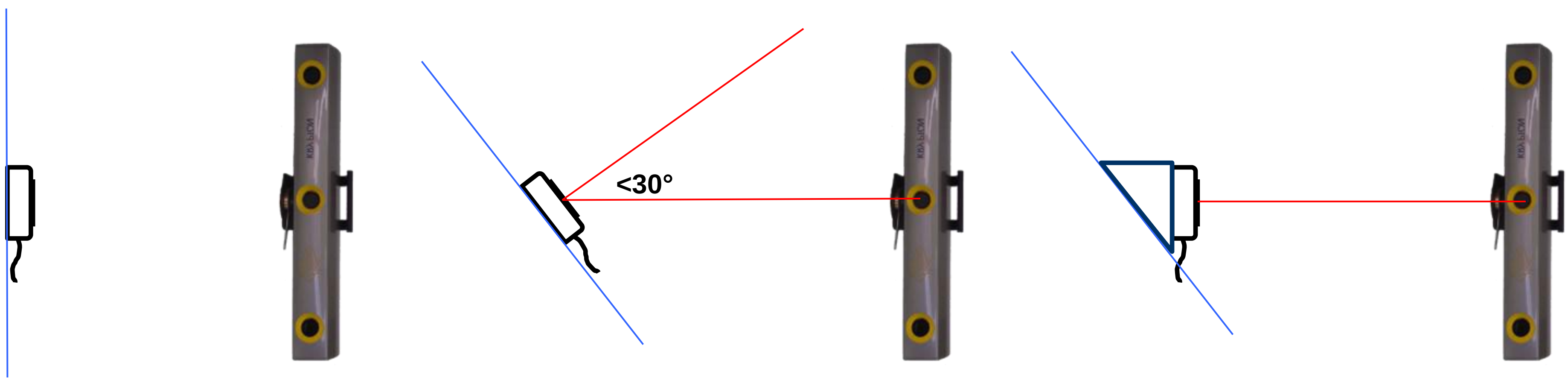
Geoloc – LEDs and Strobers

- Strobers are plugged into the controller via strober cables, the cable carries the signal from the controller to the strobers, giving timing signals to activate each LED
- Strobers can be daisy chained together to enable multiple LEDs to be distributed across an object or multiple objects
- Strober chains can be physically separated between ports 3 and 4
- Any combination of strobers and LEDs can be combined but for a Dynamic Frame the LEDs must be sequential



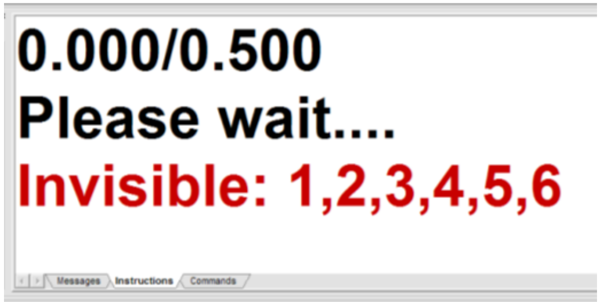

Geoloc – Placement of LEDs

- It is worth noting that for greater accuracy and more robust measurements, LEDs should be placed relatively far from each other, covering as much of the object as possible.
- The camera can reliably pick up LEDs that are angled less than 30° to it, any more than this and there is a shift in reported position and errors can appear. If the surface is at an inconvenient angle, angle blocks can be used as shown below:



Geoloc – LED visibility

- Until a Dynamic Frame is measured, the reference frame object and camera cannot be moved therefore the all LEDs must be visible
- Their visibility can be checked using a Geoloc trick.
- When Geoloc is told to measure a Dynamic Frame, it will wait until all LEDs are visible and then will take a reading and stop flashing the LEDs
- By adding an extra ‘false’ LED to the Dynamic Frame window, Geoloc will continuously flash the LEDs as this last LED will never be visible
- This gives the user time to modify and optimise the LED positions and K-Check can be used at this time to identify errors and their causes



Geoloc – Dynamic Frames

- Dynamic Frames are used as the input to DMM or other frame tracking software
- In DMM they can be tracked or used as a global dynamic reference frame
- Multiple frames can be tracked simultaneously as long as their LED sequences do not overlap
- Static frames can also be used as global references but are fixed relative to the camera position

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