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This procedure is dedicated to defining the 2S Automated Metrology Routine. This hopefully will not have to be utilized in the future, however until we have a more permanent solution to the “shifting reference needle” issue, this step will be mandatory each time the needles move relative to each other. The numbers in parentheses refer to the step in which that feature was created, and not necessarily the number assigned within the program.

Begin by starting up the SmartScope and place the carrier with the prefixed needles onto the stage. **Place the carrier rubber feet side down. After flipping in step 24, the rubber feet should be facing upwards.**

Defining the program takes an experienced user about 40 minutes. First try for someone new took ~80 minutes.

All Steps should be done at or near Maximum Zoom

1. **Measure** a **Point** by aligning the manual crossheir with the bottom left needle point

   The bottom left needle refers to whatever needle is in the south-westernmost position as seen from above by the camera. It should not matter which specific orientation is chosen, however it is important to stay consistent. Currently, I have been aligning the stump-bridge along the southernmost edge. ***This should be changed in the future to match the functional orientation of the module.***

2. **Construct** a **Datum Origin** at point (1)
3. **Measure** a **Point** by aligning the manual crossheir with the bottom right needle point
4. **Construct** a **Line** by connecting points (1) and (3)
5. **Construct** a **Datum Axis** along line (4)
6. Set the top lighting to 0%, ring lighting to 0%, and the backlight (green light) to approximately 40% of maximum as read by the lighting dial (i.e., the lighting dial on the pedestal is turned ~40% of the way to maximum) such that there is a nice contrast between the needle and the backlighting.
7. **Focus** on the Bottom Left Needle Point.
8. **Construct** a **Line** with **Feature Finder** along the northernmost edge of the needle

    a. NOTE: the search window is not exactly square. Thus, to ensure robustness, do not search for a line in the extreme x direction; keep it localized to the center of the screen. There is a “circle target” feature in the crosshairs selections. This is good to get an idea of how “rectangular” the camera is, and thus how much room you have to work with.
9. **Construct** a **Line** with **Feature Finder** along the southernmost edge of the needle
10. **Construct** a **Line** with **Feature Finder** along the “tip” edge of the needle
11. **Construct** an **Intersection** between **lines** (8) and (10)
12. **Construct** an **Intersection** between **lines** (9) and (10)
13. **Construct** a **Midpoint** between **Intersections** (11) and (12). Enable the radio boxes next to ‘X-Location, Y-location, Z-location’. Enable ‘Print’ and ‘Stats’. There will be a prompt the name the *Output File Name*. This will only happen once when defining the program. This is not terribly important; rerunning the program one will have to re-enter the name anyways.
14. Drive the camera to the Bottom Right Needle. Repeat Steps 7-13.
15. Drive the camera to the Top Right Needle. Repeat Steps 7-13.
16. Drive the camera to the Top Left Needle. Repeat Steps 7-13.
17. Drive the camera to the Bottom Left Fiducial Mark.
18. **Focus** on the fiducial mark.
19. Select the **Advanced Centroid Target** function. Change the box size such that the search area covers the fiducial entirely with perhaps a bit of wiggle-room on any side.
    a. Adjust the top lighting to about 25%.
    b. Click outside the search area. Examine what the program is picking up as the middle of the fiducial. If it looks okay, skip to step 19.d
    c. If the program did not pick an acceptable spot, adjust the two sliders in the settings window. You will want the program to look for the “dark” areas, so set the upper limit (“bottom slider”) after the first “hump” that appears in the profile. This is telling the program to *exclude* all points above a certain lighting threshold. After adjusting, click again outside the search area and examine what the program picks up. If it is still not correct, adjust the lighting and repeat this step until you are satisfied.
    d. Move the camera *slightly* and see what the program picks as the centroid. If it picks a good spot, repeat this step a few more times. If it ever fails, refer to step 19.c. You may move on when you feel comfortable that it will pick up the center of the fiducial without fail.

> *What we are doing in this step is testing the robustness of the program. During actual runs, the lighting may be a bit different, or the camera might not center exactly on the fiducial. We are writing it such that we allow for some leniency in this step.*

e. When you are satisfied, recenter on the fiducial, click outside the search area so that the program searches for the centroid again. Select the radio boxes for ‘X-location, Y-location, and Z-location’, Make sure to enable ‘Stats’ and ‘Print’.

20. Drive to the Bottom Right fiducial marker, repeat step 19
21. Drive to the Top Right fiducial marker, repeat step 19
22. Drive to the Top Left fiducial marker, repeat step 19
23. Drive the camera up in Z by about 1 foot. Flip the Module over its Right edge. **Measure** a **Point with the manual crosshair** anywhere high in Z. Do NOT report the position of this point. Leave all boxes unselected.

    We do this step to allow for the user to flip the module without risk to the camera. By making this a manual step, it will require user input to continue. We can create a prompt here saying something like “flip the carrier over”, however this is not required.

24. Repeat steps 1-23 on the reverse side of the module. It is all the exact same. **Note: This procedure by definition Roughly aligns the X axis on both modules. This should not introduce a systematic, but this has yet to be confirmed.**

After this program has been written, test it. Flip the Module such that the original side is facing up, and run it. In all, it should require 5 manual inputs (BL needle, BR needle, manual input to continue the program after flipping the module, BL needle, BR needle). It should produce 16 points (BL, BR, TR, TL Needle, BL, BR, TR, TL Fiducial; all twice). It should take an experienced user about 3-4 minutes to run. If all these conditions are met, save the program and title it accordingly. This naming convention is TBD.

If there are any problems, contact the author of this procedure for help.