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System Overview

Background

The W. M. Keck Observatory has two optical spectrographs with the capability of taking multi-slit observations: LRIS, in use on Keck I, and DEIMOS, deployed on Keck II. Both instruments use custom-manufactured slitmasks made of aluminum sheet metal to sample the spectra of multiple targets in the telescope focal plane. LRIS can hold up to 9 slitmasks, each typically sampling 50 targets, while DEIMOS can hold 11 masks with up to 150 targets per mask.

Keck has chosen to manufacture all LRIS and DEIMOS slitmasks in-house using a slitmask manufacturing facility based at the summit, as described below. Two factors keyed this decision:

1. **Maximizing slitmask quality:** by manufacturing slitmasks in-house, we retain complete control over the quality of the resulting slitmasks. Masks must be milled to exacting tolerances in order to generate the clean slitlets required for accurate subtracting of background light, and by training our own dedicated personnel to manufacture the masks we ensure consistently high-quality output.
2. **Enabling "just-in-time" masks:** although most of our slitmasks are received and milled well in advance of the planned use date, a significant number of masks must be milled in the last days before a run in order to accommodate time-critical observations such as newly-discovered supernovae. Furthermore, masks are occasionally found to be damaged or lost on the day of a run. In both cases, having the ability to mill a mask rapidly at the summit is essential.

System Setup

The summit slitmask milling system consists of the two key components, the mill which cuts the masks and the separate computer which is used to coordinate the milling process.

Slitmask PC

The computer (slitmaskpc) for the slitmask system is a garden-variety desktop PC which runs the Linux operating system. It features a GUI interface for all slitmask operations so that no keyboard interaction is required. The only notable peripheral device attached to the system is a handheld laser barcode scanner which is used for reading the barcode labels on the slitmasks. The functions performed by this PC include:

- Receiving new slitmask design files from the database on waiaha, which is updated twice daily from the master database that resides at Lick.
- Running the MillMasks GUI, which allows the operator to view the list of milled and un-milled masks, select new files for milling, generate corresponding mill code for these masks, and write the data to floppy disk. This floppy is then transferred to the mill for cutting the mask.
- Reading the barcode scanner to associate a certain mask design with a certain barcode and report this information to the database server for inventory purposes.

As of May 2006, the original machine was replaced with an updated model (slitmaskpc2) and the original was retired but retained as a ``hot spare'' in case of a failure in the new machine.

Slitmask Mill

Slitmasks are cut on a 3-axis Computer Numerical Control (CNC) mill manufactured by Milltronics Manufacturing Company of Waconia, MN. The mill has a dual-axis (X,Y) table to hold a blank slitmask, which is milled using a single-axis (Z) milling head, typically fitted with a 0.015-in endmill capable of milling slits as small as 0.52 arcsec in width. The milling head features a high-speed spindle manufactured by Precise Corp. of Racine, WI and an alcohol-flood system to keep the tiny endmills from overheating during the slitmask milling process.

The system can typically mill an LRIS mask in 10 minutes, while a standard DEIMOS mask may take up to 40 minutes to complete. Experimental DEIMOS masks of up to 1500 slits have been manufactured, requiring up to 2 hours to complete.

Mask designs are currently transferred from the PC to the mill via a private network connection. The network is configured as follows:

>   127.0.0.1 - mill
>
>   192.168.22.2 – slitmaskpc
>
>   192.168.22.3 – slitmaskpc2

The M: drive on the mill is mapped to \\slitmaskpc2\slitmasks

The L: drive on the mill is mapped to \\slitmaskpc\slitmasks

The mill will still be able to accept floppy discs through the A: drive. This will be an available option if there are problems with the network.

When starting the mill the program will ask the user which slitmask pc they used to generate the mask files. Selecting slitmaskpc or slitmaskpc2 will make the corresponding drive (L: or M:) the default drive to the mill. If no selection is made the default selection is slitmaskpc2 (M:).

Acknowledgements

Most of the work that has gone into developing the Keck slitmask system hardware, software, and milling procedures was done by the dedicated staff of UCO/Lick Observatory, including Steve Allen and De Clarke of the Scientific Programming Group and Jeff Lewis and Matt Thompson of the Lick Instrument Laboratory. At Keck, Bill Mason was responsible for commissioning the CNC mill and guiding the local development of the system. Currently, Dwight Chan serves as milling support expert and is responsible for key enhancements.

This document has been revised based on the original web document written by Dr. Greg Wirth. Updates to the procedure were added and clarified. This document has also been added to the 114 series documents.

Milling Procedures

Daily Startup Procedure

1. **Start-up computer and put new files on \slitmasks**
   o If needed, power on and log into slitmaskpc. (Normally this computer is always on and logged in, so this should not be necessary)
   o On the Slit Mask Milling window, click on the red QUIT button to kill the current window.
   o Verify that the corresponding slitmaskpc (1 or 2) is selected on the serial switch for the bar-gun.
   o On the desktop, click the Mask Mill (Swiss army knife) icon to launch a new window and re-read the slitmask status list to get new mask data.
   o Check for un-milled masks, which are listed in black at the top of the list. If none are present, no milling is needed. If black (un-milled) masks are present, continue with the following steps to mill the masks.
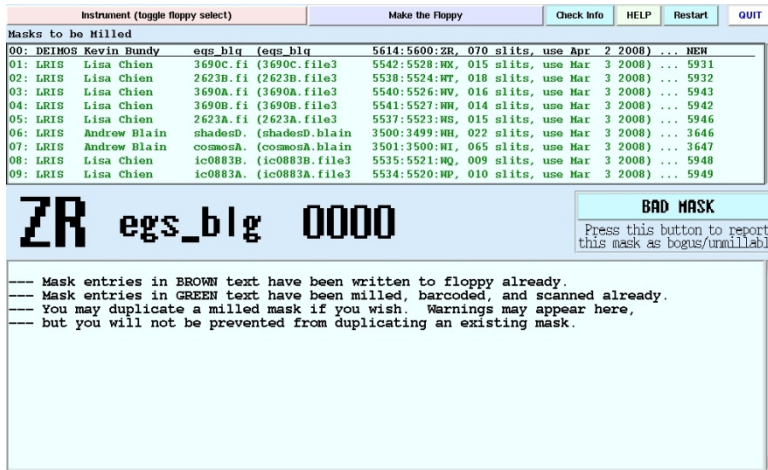
Figure 1 - Milling GUI

2. **Start up the mill.**
   o Locate the ON/OFF throw switch on the back of the mill and turn it clockwise to the ON position. The system will power up.

Figure 2 - Power ON switch

   o Verify proper air pressure on the gauges at the back of the mill:
     ▪ White gauge (supply) should read about 7.0 = 70 PSI

- Black gauge (spindle) should read about 50 PSI

Figure 3 - White gauge

Figure 4 - Black gauge

- o At the front of the mill
  - The program will ask for the user to select which slitmask pc to look for the mask files. If no selection is made, after 15 seconds, the mill defaults to option #2 – slitmaskpc2 (M:).
    1. Option #1 – slitmaskpc (L:)
    2. Option #2 – slitmaskspc2 (M:)
  - After the software starts, check the video screen for errors. It is normal to see

    ERROR 450: Emergency stop condition

on startup, but other errors should be investigated.
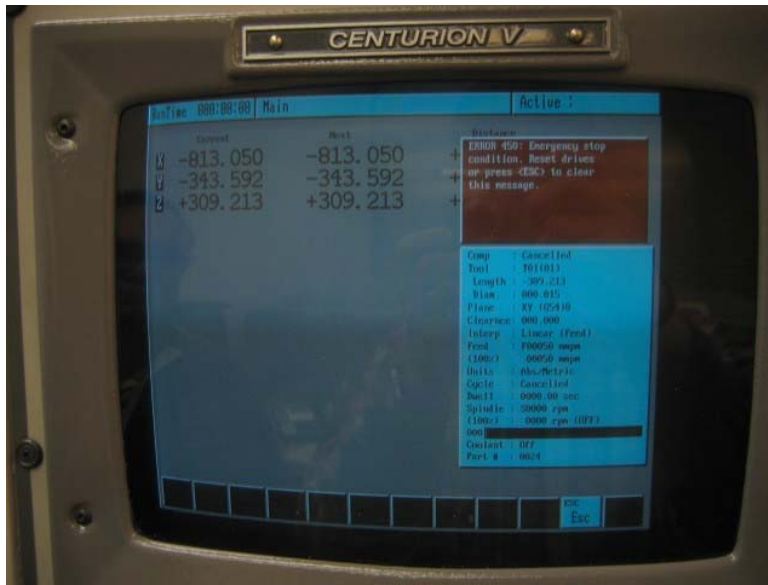
Figure 5 - Milltronics video screen

o Press the green RESET button on the mill control panel to bring up the main menu on the video screen.

Figure 6 - Reset button

o Press the F1 key to select HOME. The CYCLE START light will flash. Press CYCLE START to home the mill.
o A green popup window on the mill video screen says Homing... The mill platform will slew horizontally to the home position (unless it was already at home).

3. **Park the table.**
   o Run the "park" file saved on the mill.
      - From the home menu press F10 to select Util.
      - Press F6 to select DNC.
      - Press F4 to select RUN.
      - Press F2 to select FILE.
      - Use F7/F8 (Up/Down arrows) to highlight the ENGR directory.
      - Press F5 to select ENTER.
      - Use F7/F8 (Up/Down arrows) to highlight the PARK file.
      - Press F5 to select ENTER.
      - Press F1 to select START.

- Press CYCLE START button.
4. **Warm up the spindle.**
   o Press the CW button to power on the Precise spindle control unit atop the mill in the clockwise direction.

   o

Figure 7 - CW spindle button

   o Turn the red dial on the Precise unit to 1.

Figure 8 - Precise spindle controller

   o Press the green START button on the Precise unit to start the spindle rotating. Slowly turn the red dial to 2.5 (10,500 RPM)
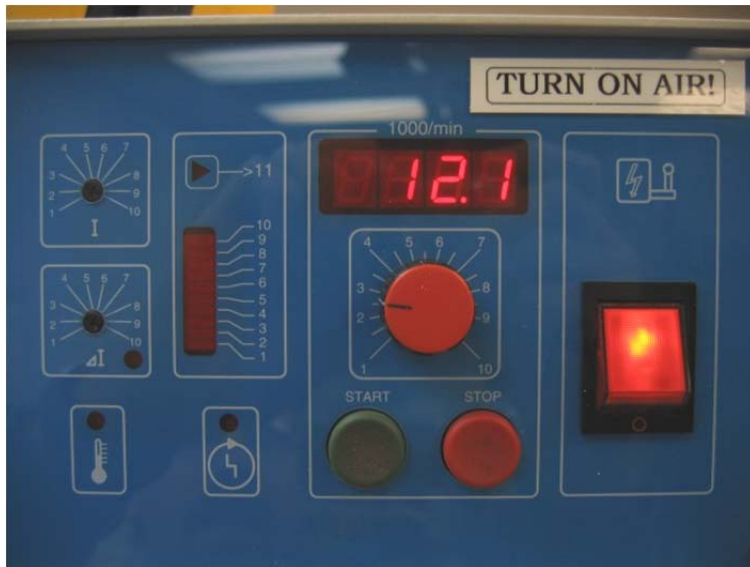
Figure 9 - Precise spindle controller (detail)

o   Visually verify that the spindle is rotating. *Note: do not touch!*
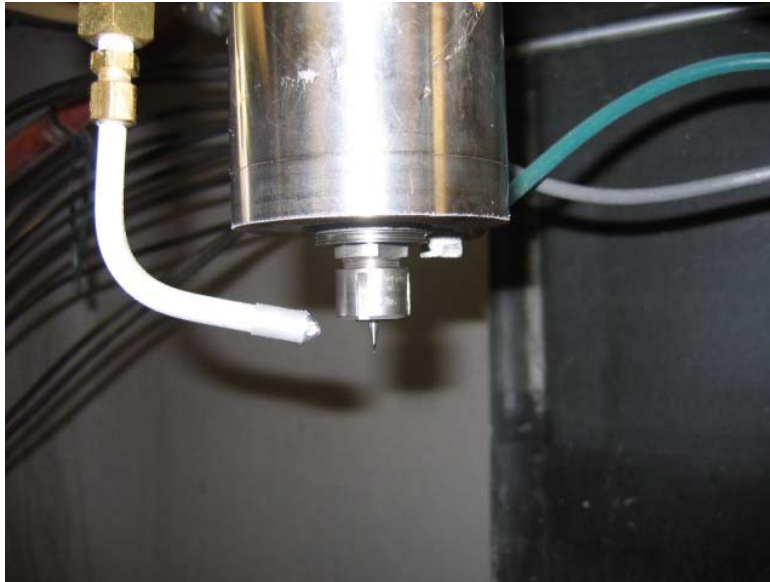
Figure 10 - Rotating spindle

o   Allow the spindle to run following these guidelines:
-   Daily use
    1.   10 minutes at 25% (10,500 RPM) or 2.5 on the red dial.
    2.   10 minutes at 50% (24,500 RPM) or 5.0 on the red dial.
-   Idle for > 1 week
    1.   30 minutes at 25% (10,500 RPM) or 2.5 on the red dial.
    2.   60 minutes at 50% (24,500 RPM) or 5.0 on the red dial.

Slitmask Milling Procedure

1. **Generate slitmask files to /OBSR directory. (Option #1)**
   - Select masks to mill by clicking on the corresponding lines in the mask list and then click the "Send Files to Mill" button to generate the data. In the top of the Slit Mask Milling window, the masks being written to disk turn blue. (NOTE: Technically the files reside on the pc. They do not get transferred to the mill. So if you create the files on one pc they will not be available on the other pc until your re-create the files.)
   - Wait for the files to save to the hard drive. When the files are written, a list of the contents of the disk is printed in the dialog area at the bottom of the Slit Mask Milling window, the lines for the masks written to disk will turn red, and their status will be indicated as FLOPPY.
   - The files will now be available on the mill. You can select the appropriate drive on the mill menu. The files should be located in the /OBSR directory.

2. **Generate a new floppy. (Option #2)**
   - Insert a floppy disk into the disk drive on the slitmaskpc. Floppies are stored in the beige plastic box on the desk.
   - Select up to 10 masks to mill by clicking on the corresponding lines in the mask list and then click the Make the Floppy button to generate the data. In the top of the Slit Mask Milling window, the masks being written to disk turn blue.
   - Wait for the disk to be written (*NOTE: can take 5-10 minutes depending on the number of slits to be milled*). When the disk is written, a list of the contents of the disk is printed in the dialog area at the bottom of the Slit Mask Milling window, the lines for the masks written to disk will turn red, and their status will be indicated as FLOPPY.
   - Remove the floppy disk from the drive on slitmaskpc.
   - Insert the floppy disk into the drive at the back of the Milltronics unit.

Figure 11 - Milltronics floppy drive

3. **Prepare the table for a new mask blank.**
   Note: This is recommended before every mask, because leftover crud from a previous mask can cause slits to be milled improperly.
   - Remove the spacer from the mill platform.
   - Use brush and air hose to clean the table and spacer.

Figure 12 - Cleaning table

o   Insert the appropriate adapter plates and spacer plates. See 'Milling A Spacer Plate Procedure'
    if a new spacer plate is needed and not available.

Figure 13 - DEIMOS adapter plate

Figure 14 - LRIS adapter plate

4. **Insert mask.**
   - o Remove a new mask blank from the supply drawer.
   - o Remove the protective plastic sheet from the blank.

Figure 15 - Removing plastic sheet from blank

   - o Inspect the blank for flatness and remove any kinks using the mallet.
   - o Check mask for unusually sharp edges, smooth with hand file as necessary.

○ Lay the mask blank on the mill platform atop the spacer.

Figure 16 - Laying a new blank on the table

○ Ensure that the blank is totally snug against the defining pins. For DEIMOS, snug the blank against the three pins in the order indicated in the following photos.

Figure 17 - DEIMOS defining pins

Figure 18 - DEIMOS defining pin

o   For LRIS, ensure that the defining pin in the table fits snugly into the notch in the blank.

Figure 19 - LRIS defining pin

Figure 20 - Plastic tape dispenser

5. **Refill alcohol reservoir.** The alcohol reservoir located above the endmill has a relatively small capacity and will need to be refilled every couple of masks. If the supply runs out in the middle of a mask, the endmill will probably overheat and break, so it's best to refill if in doubt.
   o Rotate the yellow valve atop the reservoir to the 3 o'clock position to shut off the air supply.

   NOTE: failure to turn off the valve is a major safety issue because it would result in alcohol being sprayed all over the place.

Figure 21 - Reservoir with lever at "off" (3 o'clock) position

   o Rotate the container clockwise (as seen from above) to loosen.
   o Remove and refill the container with denatured alcohol from a 1-gal metal container.

Figure 22 - Filling reservoir

o   To re-install the reservoir, support the container from below as you spin it counter-clockwise onto the threads. Don't over-tighten!

Figure 23 - Re-installing reservoir

o   Turn the yellow valve to the 12 o'clock position to re-enable the air supply.

Figure 24 - Filled reservoir

6. **Run up the spindle.**
   o On the Precise unit, rotate the red speed knob in *small increments* until reaching 40.0 ± 0.1.
   o Monitor the acceleration graph closely and do keep the acceleration at or below 3 at all times to ensure that the high-speed spindle unit is not damaged by accelerating too quickly.

Figure 25 - Spindle acceleration graph

7. **Slitmask files from network. (Option #1).**
   o Selecting the file from the network drive (L:, M:)

      ▪ From the home menu press F10 to Util.
      ▪ Press F6 to select DNC.
      ▪ Press F4 to select RUN.
      ▪ Press F2 to select FILE.
      ▪ Note: If not in the M: directory
          1. Press HELP to select DRIVE
          2. Press F5 to select M: drive (slitmaskpc2)
      ▪ If not in the parent directory select '..' to move up one directory
      ▪ Slitmask files will be located in the OBSR directory.
      ▪ Use F7/F8 (Up/Down arrows) to highlight the OBSR directory.
      ▪ Press F5 to select ENTER.
      ▪ Use F7/F8 to highlight the mask file.
      ▪ Press F5 to select ENTER.
      ▪ Press F1 to select START.

8. **Load file from floppy (Option #2).**
   o On the Milltronics control panel, press ESC 1-3 times to bring up the menu.
   o Access the listing of contents on the floppy disk by pressing:

      ▪ F10 = UTIL
      ▪ F6 = DNC
      ▪ F4 = RUN
      ▪ F3 = DISK
      ▪ Press the F7=Up Arrow and/or F8=Down Arrow keys as needed to select the next mask file to mill.
      ▪ Press F5=ENTER to load the mill program. On the display, a green window flashes the message

      OPENING FILE
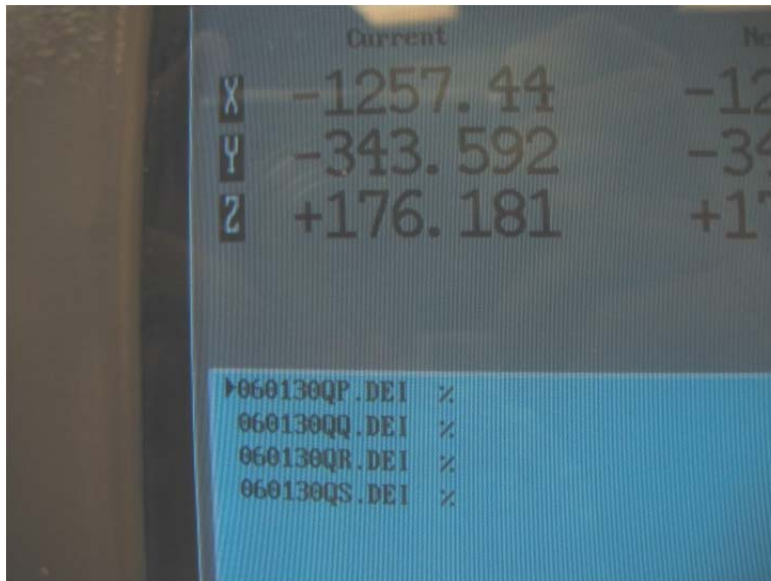
Figure 26 - Selecting files

- Press F1=START to enable the mill. The green window now displays.

9. **Begin milling.**
   - Press the CYCLE START button to begin milling. The mill table will slew to the starting position and begin cutting slits. Each slit is cut in two passes, one to mill the ``shoulders'' and one to mill the slit opening.
   - Use the alcohol squirt bottle to wet the entire mask surface.
   - Verify that the automated alcohol bath is operating and that the stream is directed at the base of the bit.

Figure 27 - Alcohol stream on endmill

   - Optionally, you can flush the alcohol system by rotating the flow valve counter-clockwise several turns to flush the system, then rotating clockwise until the flow is reduced. NOTE: if the alcohol bath has not been run lately, test the flood by pressing the FLOOD button on the Milltronics control panel and verify that the unit squirts alcohol as designed.
10. **Monitor milling.** Periodically check to ensure that the endmill (bit) hasn't broken off the spindle. If the mill is no longer cutting slits in the mask, the endmill has probably broken. If this happens, follow the

procedure for changing out the endmill and restart the mask with a new blank. Also keep an eye on the alcohol system during milling. If the supply gets low, follow these steps to refill:

- o Do not halt the system in the middle of a slit; wait for a slit to complete and the table to begin a slew.
- o Press the red FEEDHOLD button on the Milltronics control panel to halt the mill.

Figure 28 - Feedhold button

- o Refill the alcohol reservoir as described above .
- o Press the FEEDHOLD button again to re-enable the mill.
- o Press the CYCLE START button to resume milling.

11. **Inspect and clean mask.** After cutting all of the slits, the mill will cut additional standard mask features ("hot dog" cutout and alignment puka) and the mask labels. The mill will then retract and stop. At this point, do the following:

- o Check that the label, puka, and cutout were milled.
- o Also check that the label was not milled entirely through the bottom side of the stock, which indicates foreign matter under corner.
- o Remove and discard tape.
- o Use brush to clean off filings.
- o Use air from compressed air hose to blow the slitmask dry.
- o Remove the mask from the mill table.
- o Use the air hose to dry off all sides of the mask and to eject shavings from the slits.
- o Set the mask down on the wooden table.
- o *Note: if desired, begin the process of milling the next mask while you continue.*
- o Use a paper wipe to dry the mask on both sides.

Figure 29 - Toweling off the mask

- o Inspect all slits, especially those in the 4 corners of the mask, to ensure that the slits are completely cut and that the ``shoulders'' are not milled through. *Note: if any slits are bad, the entire mask should be re-milled!*
12. **Inventory mask.** Follow these steps to check the mask into the slitmask database:
    - o Select a barcode label and apply it securely to the edge of the mask in the marked place. *Note: although any barcode will be acceptable, we tend to use one sheet for LRIS and one for DEIMOS.*
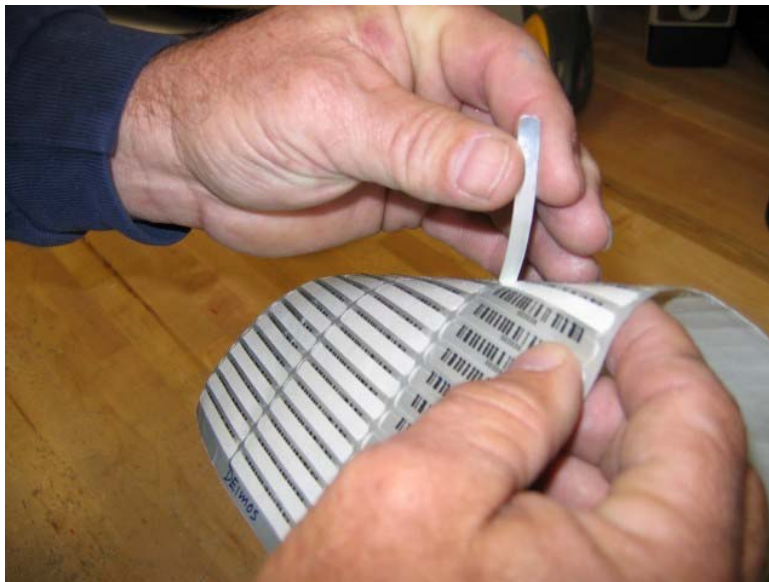
Figure 30 - Peeling off a barcode label

Figure 31 - Applying barcode label

- o Verify the serial switch is selecting the appropriate pc for the bar-gun. If it is not selected properly the software will need to be restarted after selecting the correct pc.
- o In the Mask Mill GUI, locate the line for this mask and click to select it. The GUI should now show the mask name and the 2-letter ``mill code'' in large black letters in the center of the GUI.
- o Verify that the mask name and mill code match exactly what is displayed on the mask you are about to scan!
- o Point the handheld barcode scanner at the barcode label on the mask and press the trigger to scan the mask *twice*.

Figure 32 - Scanning barcode label

- o The GUI should now display the barcode number in the center of the GUI; verify that this matches the barcode label you just scanned. *NOTE: occasionally the scanner will fail to read a barcode label. In this case, remove the bad barcode label and apply a new one.*
- o In the GUI, The mask line should change from red to green and the status from FLOPPY to DONE.
- o Write the barcode number below the barcode label using the sharpie pen so that staff can read the barcode more easily.

Figure 33 - Barcode number written on mask

13. **Apply rivet and sleeve (DEIMOS only).** For DEIMOS masks, the rivet and sleeve are required to keep the mask in place as it moves along its track in the instrument. Install them as follows:
    o Select one rivet and sleeve from the supply drawer on the desktop.
    o Insert the sleeve into the round metal disk inlaid into the wooden tabletop.

Figure 34 - Sleeve in metal disk

    o Position the mask within the outlined area on the tabletop so that the sleeve puka is aligned directly over the sleeve.
    o Insert rivet into the sleeve hole and pound firmly with mallet to set the rivet.

Figure 35 - Striking rivet with mallet

- o Flip the mask over, insert punch tool into rivet collar and strike firmly. This secures the brass rivet to the collar by deforming the tip of the brass. When doing this, be sure to position the rivet over the metal disk so that you don't mar the wooden tabletop.

Figure 36 - Striking sleeve side with mallet

14. **File the mask.**
    - o Pick up the mask and thoroughly blow it off using the air hose.
    - o File the mask in the appropriate drawer (top one for LRIS, bottom for DEIMOS) putting higher numbered barcodes at the back.

Daily Shutdown Procedure

1. Press ESC button on Milltronics control panel as needed to return to the main menu.
2. Press F1=HOME button to select the Home function.
3. Press CYCLE START button to send the mill to home position. Wait for the mill to halt.
4. Press the square red STOP button on the front panel of the mill to halt the mill.
5. Press the red ESTOP button to really halt the mill.

Figure 37 - STOP button at left; ESTOP button at right

6. Listen for the ``thump'' which indicates that the mill is now off.
7. At the back of the mill, rotate the power switch to the OFF position to power down the mill.

Z-axis Adjustment Procedure

To ensure the mill cuts slits at the correct depth. The mill requires the Z-axis to be calibrated to a specific height from the surface of the table. This is done through the process of "ZTOOLING" the machine. The ZTOOL process should be done when ever a new bit is installed.

Tools

1. **Z-tool block**
2. **Flashlight**

Procedure

1. Park the table. **Use** 'PARK' file saved on the mill.
    o Run the "park" file saved on the mill.
        ▪ From the home menu press F10 to select Util.
        ▪ Press F6 to select DNC.
        ▪ Press F4 to select RUN.
        ▪ Press F2 to select FILE.
        ▪ Use F7/F8 (Up/Down arrows) to highlight the ENGR directory.
        ▪ Press F5 to select ENTER.
        ▪ Use F7/F8 (Up/Down arrows) to highlight the PARK file.
        ▪ Press F5 to select ENTER.
        ▪ Press F1 to select START.
        ▪ Press CYCLE START button.
2. Remove all mask and spacer mask material to expose bare vacuum chuck and clean top.

Figure 38 - Clean/Bare table

3. Utilize the ZTOOL file to move the table and spindle to the proper position.
    o Run the "ZTOOL" file saved on the mill.
        ▪ From the home menu press F10 to select Util.
        ▪ Press F6 to select DNC.
        ▪ Press F4 to select RUN.
        ▪ Press F2 to select FILE.
        ▪ Use F7/F8 (Up/Down arrows) to highlight the ZTOOL file.
        ▪ Press F5 to select ENTER.
        ▪ Press F1 to select START.
        ▪ Press CYCLE START button. Table and spindle will now move to the proper position for Z-axis adjustment. The z-axis will stop 30mm from the top surface. The z-tool block is 25 mm thick.
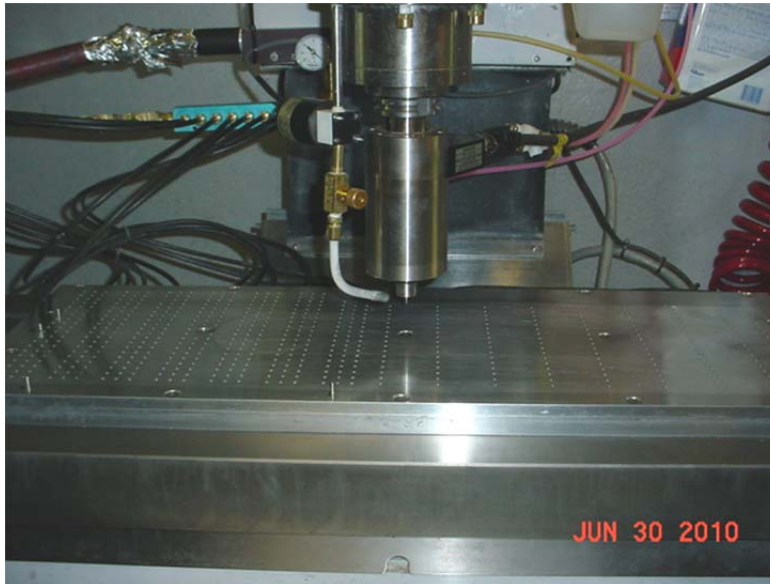
Figure 39 - ZTOOL position

4. Place Z-tool block on to the mill table under the endmill.

Figure 40 - ZTOOL block in case
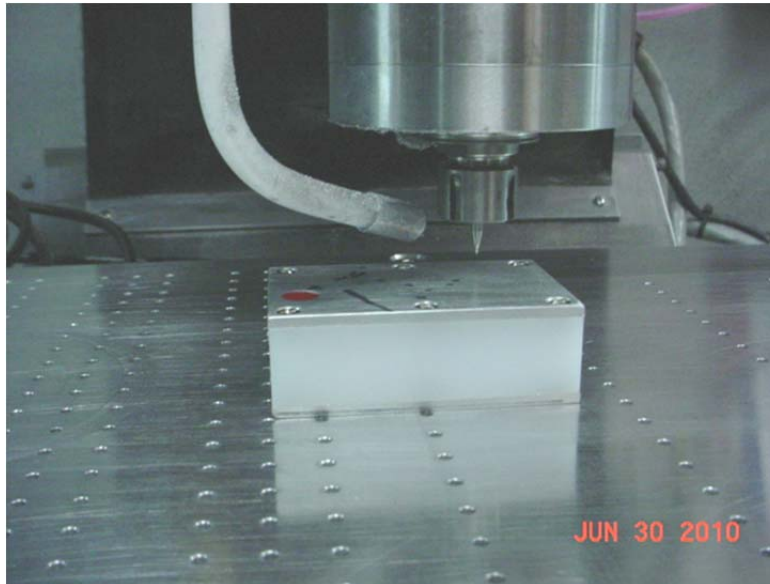
Figure 41 - ZTOOL block located under endmill

5. Use a conductive tool to create a connection between the top of the Z-tool block and the endmill shaft. The block should light-up verifying proper operation.
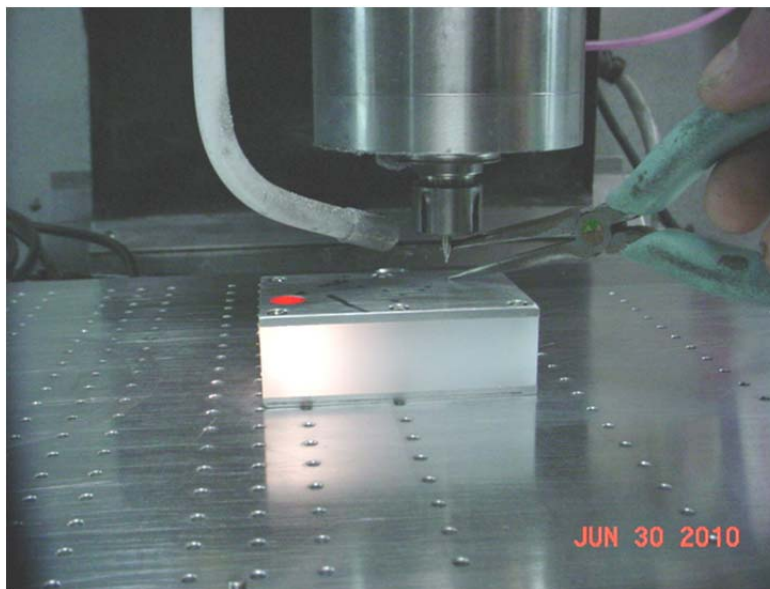
Figure 42 - Testing ZTOOL block

6. Prepare the mill to move the endmill to the block for Z-tooling. To do so:
    o   From the main menu press F3 to select HDW.
    o   Press F3 to select the Z-axis
    o   Set the speed of the mill to 20 by turning the feed-rate dial.

Figure 43 - Feedrate dial

7. Turn the crank CW, for downward motion, 1 unit at a time until the Z-tool block lights up. Use *extreme caution* not to break the endmill or damage the Z-tool block.

Figure 44 - Endmill position crank

8. Press F6 to select ZTOOL.

Figure 45 - Endmill at correct Z-position

9. Press ENTER twice verifying the tool is 0.015 and the Z position is 0.000. Enter button is on the keypad to the right.

Figure 46 - Popup screens for ZTOOL

10. Return the feed-rate back to 100 and run the 'PARK' file.
11. Z-axis adjustment is now complete and the table is ready for spacer and mask material.

Milling A Spacer Mask Procedure

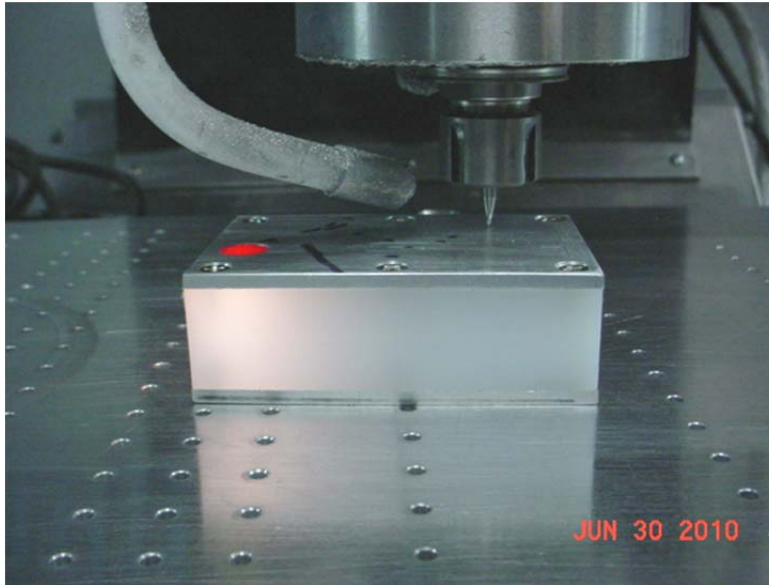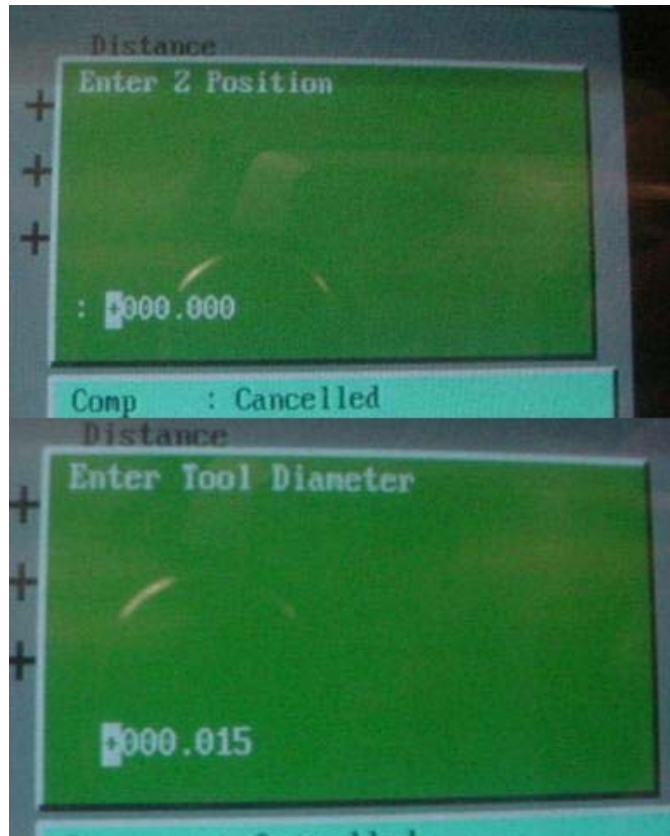To mill an instrument mask properly a spacer mask is required to be placed between the mill table and the blank slitmask material before milling. When milled, the slits in the instrument mask plunge though the blank and mill parts of the spacer plate. Because of this the spacer is required to be changed occasionally.

Tools

1. **0.030" Endmill bit**
2. **Appropriate slitmask blank material (LRIS or DEIMOS)**

Procedure

1. Park the table. **Use** 'PARK' file saved on the mill.
   - o Run the "park" file saved on the mill.
     - From the home menu press F10 to select Util.
     - Press F6 to select DNC.
     - Press F4 to select RUN.
     - Press F2 to select FILE.
     - Use F7/F8 (Up/Down arrows) to highlight the ENGR directory.
     - Press F5 to select ENTER.
     - Use F7/F8 (Up/Down arrows) to highlight the PARK file.
     - Press F5 to select ENTER.
     - Press F1 to select START.
     - Press CYCLE START button.
2. Place new slitmask blank on old spacer.
3. Replace the normally used 0.015" bit with the 0.030" endmill using the 'Endmill Changeout Procedure'.
4. Use the 'Z-axis Adjustment Procedure" to set the correct Z-axis height for the new bit.
5. Utilize the appropriate spacer file to mill the spacer.
   - o Run the "DMOSpace" or the "Irispace" file saved on the mill.
     - From the home menu press F10 to select Util.
     - Press F6 to select DNC.
     - Press F4 to select RUN.
     - Press F2 to select FILE.
     - Use F7/F8 (Up/Down arrows) to highlight "DMOSpace" or "Irispace" file.
     - Press F5 to select ENTER.
     - Press F1 to select START.
     - Press CYCLE START button.

Figure 47 - Used spacer plate
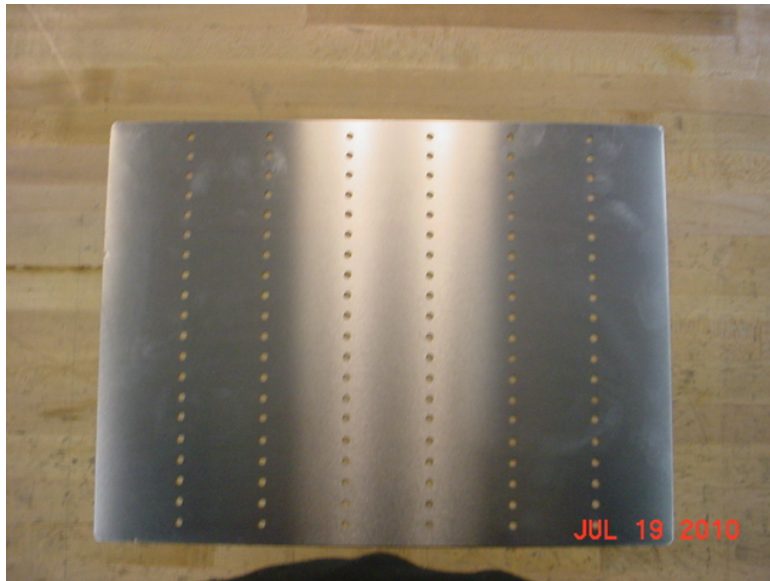
Figure 48 - New LRIS spacer
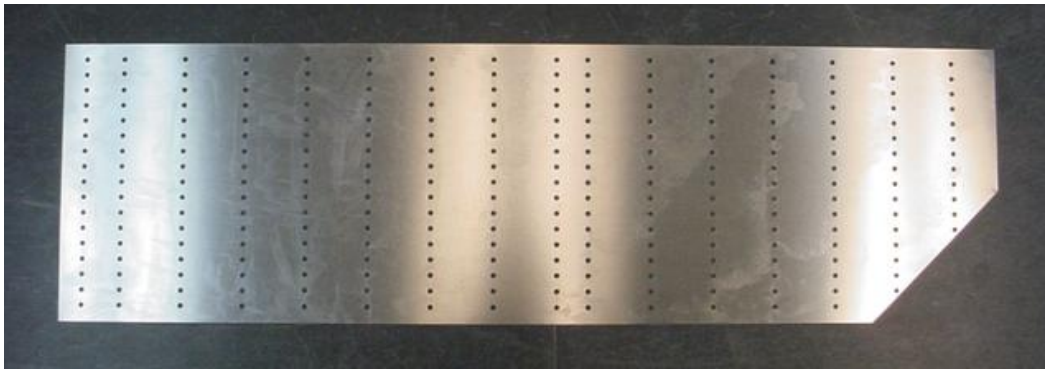
Figure 49 - New DEIMOS spacer

6. After the spacer plates have been milled, return the mill back to its normal configuration.
   o Replace 0.030" bit with 0.015" bit using the 'Endmill Changeout Procedure".
   o Use the 'Z-axis Adjustment Procedure" to set the correct Z-axis height for the new bit.

Endmill Changeout Procedure

Tools required

Obtain the following tools from the spindle tools drawer in the desk:

- Spanner wrench
- Open-end wrench
- Needle-nose pliers to grab endmill

Figure 50 - Spindle wrenches

Procedure

Follow these steps to change out the endmill when it breaks in the middle of a mask:

1. **Position the spindle for change out.**
    o Press the square red STOP button on the Milltronics control panel to halt the mill.
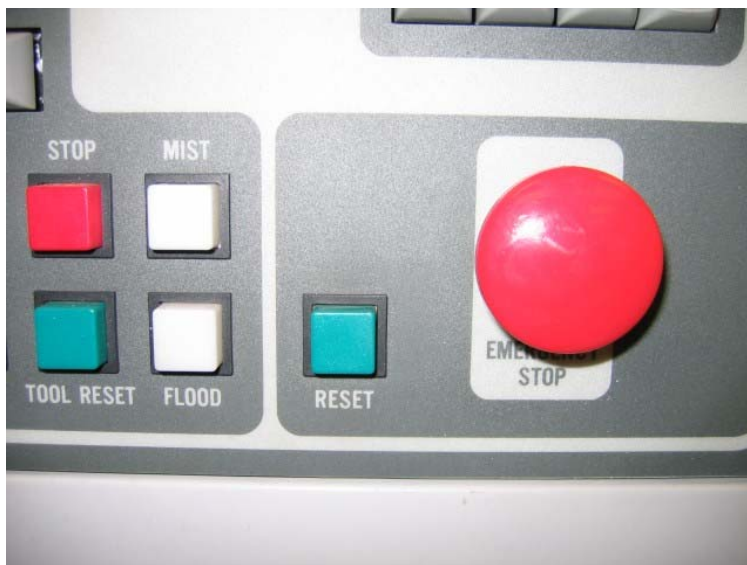
Figure 51 - STOP button at left

  o Press the F9=HALT button on the control panel to cancel the program.

- Park the table. **Use** 'PARK' file saved on the mill.
  1. From the home menu press F10 to select Util.
  2. Press F6 to select DNC.
  3. Press F4 to select RUN.
  4. Press F2 to select FILE.
  5. Use F7/F8 (Up/Down arrows) to highlight the ENGR directory.
  6. Press F5 to select ENTER.
  7. Use F7/F8 (Up/Down arrows) to highlight the PARK file.
  8. Press F5 to select ENTER.
  9. Press F1 to select START.
  10. Press CYCLE START button.

2. **Change endmill.**
   - While using the open-end wrench above the chuck to secure the spindle, place the spanner wrench on the chuck and turn clockwise (as seen from above) to loosen the endmill.

Figure 52 - Loosen chuck

- Remove the bit using pliers to pull the spent endmill down. Discard old endmill.

Figure 53 - Remove endmill

- o Insert new endmill into spindle using your fingers, being careful to avoid touching tip of bit (*milling tip is fragile!)*. Be sure to push the endmill all the way up into the spindle so that it is seated securely.
- o While using the open-end wrench above the chuck to secure the spindle, hand-tighten the chuck counter-clockwise (as seen from above) until snug. Apply 10-15 lb of torque.
3. ZTOOL the mill. Use the Z-axis adjustment procedure to re-ztool the mill.
4. **Prepare mill.**
   - o Press the ESC button on the Milltronics control panel as needed to return to the main menu.
   - o Remove and discard the partially-milled mask.
   - o Place a fresh blank on the mill table and begin the program again.
   - o Label spindle housing, indicating the size of the bit and date with your initials.

Hardstop Recovery Procedure

If the mill table is driven to the end of travel in either the X or Y axis, it may hit the hard stop and refuse to move under computer control. Follow these steps to re-enable computer control of the stage:

1. Hold down the RESET button on the Milltronics control panel.
2. Press F1=HOME to send the mill table to its home position.
3. Resume computer control of mill.

Slitmask Milling Procedure Check-list

This checklist describes the steps involved in milling slitmasks for DEIMOS and LRIS.

Start-up procedure

1. **Start up computer and put new files on disk/directory.**
   - If needed, power on and log into slitmaskpc. (Normally this computer is always on and logged in, so this should not be necessary)
   - On the Slit Mask Milling window, click on the red QUIT button to kill the current window.
   - On the desktop, click the Mask Mill (Swiss army knife) icon to launch a new window and re-read the slitmask status list to get new mask data.
   - Check for un-milled masks, which are listed in black at the top of the list. If none are present, no milling is needed.
   - Select mask to mill and click on "Send Files to Mill" or "Make Floppy" button.
2. **Start up the mill.**
   - Locate the ON/OFF throw switch on the back of the mill and turn it clockwise to the ON position. The system will power up.
   - Very proper air pressure on the gauges at the back of the mill:
     - White gauge (supply) should read about 7.0 = 70 PSI
     - Black gauge (spindle) should read about 50 PSI
   - At the front of the mill, check the video screen for errors. It is normal to see ERROR 450 on startup, but other errors should be investigated.
   - Press the green RESET button on the mill control panel to bring up the main menu on the video screen.
   - Press the F1 key to select HOME. The CYCLE START light will flash. Press CYCLE START to home the mill.
   - A green popup window on the mill video screen says Homing... The mill platform will slew horizontally to the home position (unless it was already at home).
3. **Park the table. Use** 'PARK' file saved on the mill.
   - Run the "park" file saved on the mill.
     - From the home menu press F10 to select Util.
     - Press F6 to select DNC.
     - Press F4 to select RUN.
     - Press F2 to select FILE.
     - Use F7/F8 (Up/Down arrows) to highlight the ENGR directory.
     - Press F5 to select ENTER.
     - Use F7/F8 (Up/Down arrows) to highlight the PARK file.
     - Press F5 to select ENTER.
     - Press F1 to select START.
     - Press CYCLE START button.
4. **Warm up the spindle.**
   - Press the CW button to power on the Precise spindle control unit atop the mill.
   - Turn the red dial on the Precise unit to 1.0 to set the speed to the warm-up velocity.
   - Press the green START button on the Precise unit to start the spindle rotating. Slowly turn the red dial to 2.5 (10,500 RPM)
   - Visually verify that the spindle is rotating. *Note: do not touch!*
   - Allow the spindle to run following these guidelines:
     - Daily use
       1. 10 minutes at 25% (10,500 RPM) or 2.5 on the red dial.
       2. 10 minutes at 50% (24,500 RPM) or 5.0 on the red dial.
     - Idle for > 1 week
       1. 30 minutes at 25% (10,500 RPM) or 2.5 on the red dial.
       2. 60 minutes at 50% (24,500 RPM) or 5.0 on the red dial.

Milling masks

1. **Generate slitmask files to /OBSR directory. (Option #1)**
   - Select masks to mill by clicking on the corresponding lines in the mask list and then click the "Send Files to Mill" button to generate the data. In the top of the Slit Mask Milling window, the masks being written to disk turn blue. (NOTE: Technically the files reside on the pc. They do

not get transferred to the mill. So if you create the files on one pc they will not be available on the other pc until your re-create the files.)
- o Wait for the files to save to the hard drive. When the files are written, a list of the contents of the disk is printed in the dialog area at the bottom of the Slit Mask Milling window, the lines for the masks written to disk will turn red, and their status will be indicated as FLOPPY.
- o The files will now be available on the mill. You can select the appropriate drive on the mill menu. The files should be located in the /OBSR directory.

2. **Generate a new floppy. (Option #2)**
   - o Insert a floppy disk into the disk drive on the slitmaskpc. Floppies are stored in the beige plastic box on the desk.
   - o Select up to 10 masks to mill by clicking on the corresponding lines in the mask list, then click the Make the Floppy button to generate the data. In the top of the Slit Mask Milling window, the masks being written to disk turn blue.
   - o Wait for the disk to be written (*NOTE: can take 5-10 minutes depending on the number of slits to be milled*). When the disk is written, a list of the contents of the disk is printed in the dialog area at the bottom of the Slit Mask Milling window, and the lines for the masks written to disk will turn red.
   - o Remove the floppy disk from the drive on slitmaskpc.
   - o Insert the floppy disk into the drive at the back of the Milltronics unit.

3. **Prepare the table for a new mask blank.**
   - o Remove the spacer from the mill platform.
   - o Use brush and air hose to clean the table and spacer.
   - o Select the appropriate spacer (DEIMOS or LRIS) and apply spacer securely against the defining points.

4. **Insert** new blank.

5. **Verify alcohol flood level**

6. **Run up the spindle**
   - o On the Precise unit, rotate the red speed knob in *small increments* until reaching 40.0 ± 0.1.
   - o Monitor the acceleration graph closely and do keep the acceleration at or below 3 at all times to ensure that the high-speed spindle unit is not damaged by accelerating too quickly.

7. **Slitmask files from network. (Option #1).**
   - o Selecting the file from the network drive (L:, M:)

     - From the home menu press F10 to Util.
     - Press F6 to select DNC.
     - Press F4 to select RUN.
     - Press F2 to select FILE.
     - Note: If not in the M: directory
     - Press HELP to select DRIVE
     - Press F5 to select M: drive (slitmaskpc2)
     - If not in the parent directory select '..' to move up one directory
     - Use F7/F8 (Up/Down arrows) to highlight the mask file.
     - Press F5 to select ENTER.
     - Press F1 to select START.

8. **Load file from floppy (Option #2).**

   - o On the Milltronics control panel, press ESC 1-3 times to bring up the menu.
   - o Access the listing of contents on the floppy disk by pressing:

     - F10 = UTIL
     - F6 = DNC
     - F4 = RUN
     - F3 = DISK
     - Press the F7=Up Arrow and/or F8=Down Arrow keys as needed to select the next mask file to mill.
     - Press F5=ENTER to load the mill program. On the display, a green window flashes the message

       OPENING FILE

- Press F1=START to enable the mill. The green window now displays.

9. **Mill mask**
   - Press Cycle start button to start milling of masks
   - Wet surface of blank with squirt bottle full of alcohol
10. **Monitor milling**
    - Periodically check to ensure endmill has not broken.
11. **Inspect and clean mask**
    - Verify label, puka, and cutout were milled.
    - Brush and blow off slitmask
    - Wipe mask
    - Inspect slits
12. **Inventory mask**
    - Barcode mask/write barcode on mask
    - Scan barcode
    - DEIMOS only

      - Apply rivet and sleeve

13. **File mask**

Parameter Recovery Procedure

On occasion, the memory card in the Milltronics system may become corrupted and lose the stored parameters from its memory. This may cause the mill to drive the table into a limit or to refuse to mill a mask because the coordinates are illegal. The symptom of bad coordinates in memory is that the Milltronics control panel display does not display the correct numbers for the plane:

- For DEIMOS, the display should read XY (G55) 0
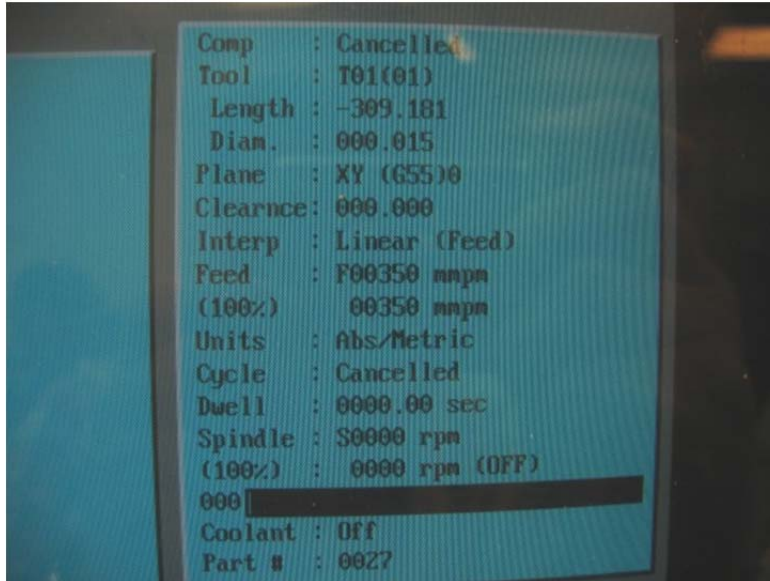- For LRIS, the display should read XY (G54) 0

Figure 54 - Milltronics display correctly showing (G55) under "Plane"

Follow these steps to restore the parameters from the backup directory:

The files are located on the corresponding slitmaskpc you are using. They are in the \slitmasks\ENGR\PARAMS directory.

1. Press the ESC button on the Milltronics control panel as required to return to the main menu.
2. Press F7=PARAMS to access the parameters menu.
3. Press F7=LOAD to load new parameters. A green popup window on the screen will display a warning:

   Current params will be overwritten

4. Press F1=OK to accept the parameters from disk. A red popup window should display the warning:

   File access denied

   This is normal; ignore the warning.

5. Press ESC to ignore the warning.
6. Press ESC to return to main menu.
7. Press F7=PARAMS to access the parameters menu.
8. Press F2=COORDS to access the coordinates menu.
9. Press F8 (scroll down) as needed to select either G54 or G55.
10. Verify that the mill has accepted the new coordinates by verifying that the display shows G54 or G55.

Milling Supplies & Reordering

This document describes the tools and materials required to complete the mask milling procedures.

Tools and Permanent Supplies

These items should always be on hand.

Item	Location	Purpose
Mallet	Desktop	Setting rivets in masks
Spanner wrench	Spindle tools drawer	Servicing spindle
Open-end wrench	Spindle tools drawer	Servicing spindle
Needle-nose pliers	Desktop	Servicing spindle
Hand File	Desktop	Smoothing sharp mask edges
LRIS mask frames	Shelf adjacent to desk	Hold masks in instrument
LRIS pickoff mirrors	Pickoff mirror drawer	Reflect starlight into guider camera
Floppy disks	Plastic box on desk	Transferring mask files from PC to mill
Plastic tape	Dispenser on tabletop	Taping slitmasks onto mill table
Sharpie pen	Pen supply	Writing barcode numbers on masks
ZTool calibrated block	Desktop	Z-axis adjustment

Consumable Supplies

The following items must be re-ordered periodically from the vendor indicated below when the supply reaches the specified re-order point:

| Item	Inst	Location	Vendor	Order Qty	Re-order Point	Part#	Keck PO #	Notes
Mask blanks	LRIS	On shelf	Cygnet Stamping	1000	200	KECK-452	Req. 16086 P.O. 29835	Long lead times
Mask blanks	DEIMOS	On shelf	Cygnet Stamping	1000	200	KECK-460	Req. 16086 P.O. 29835	Long lead times
Rivets	DEIMOS	Blue drawer	Jay-Cee Sales	1000	200	T125B001250	Req. 18833 P.O. 2988	
Sleeves	DEIMOS	Blue drawer	McMaster-Carr	1000	200	92510A688 4N12R18AP	Req. 18832 P.O. 2988	
Barcode labels	Both	Blue drawer or top mask drawer below work top	Express Inc.	2000	400	See P.O.	Req. 17351 P.O. 2880	• Continue numbering from last order • Order 6 digits with leading zeros.

Mill Interface
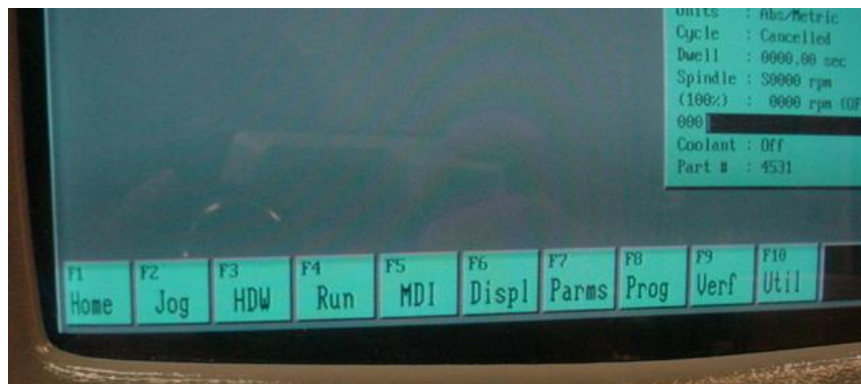
Quick Reference (Pictures)
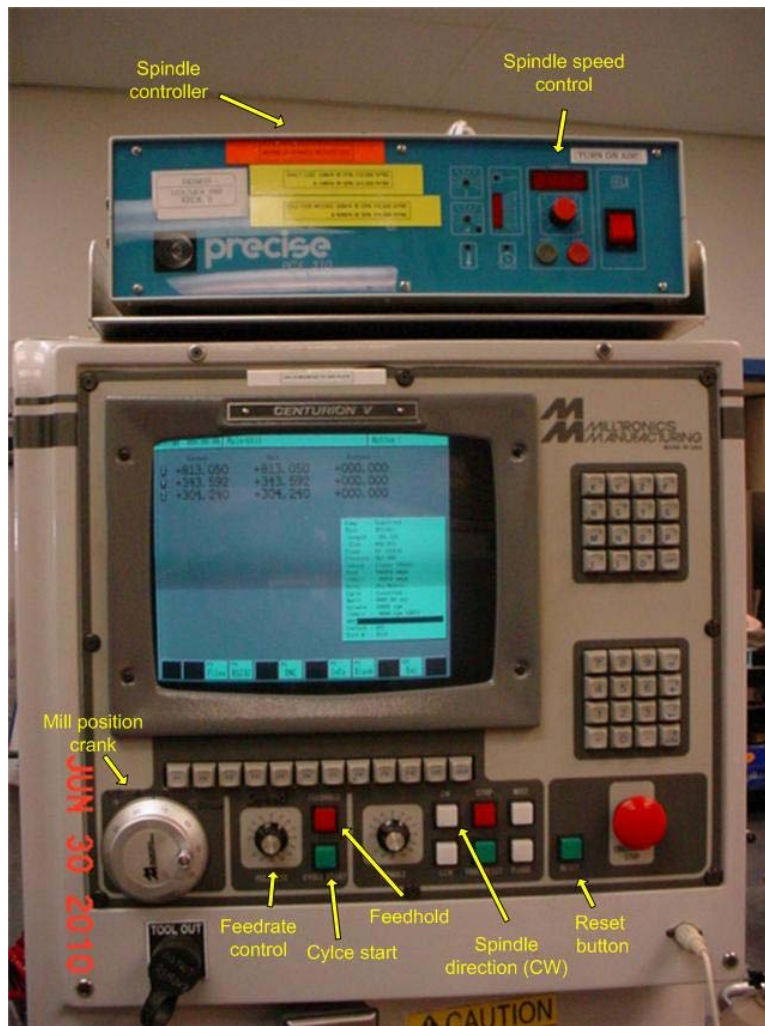
Figure 55 - Controller

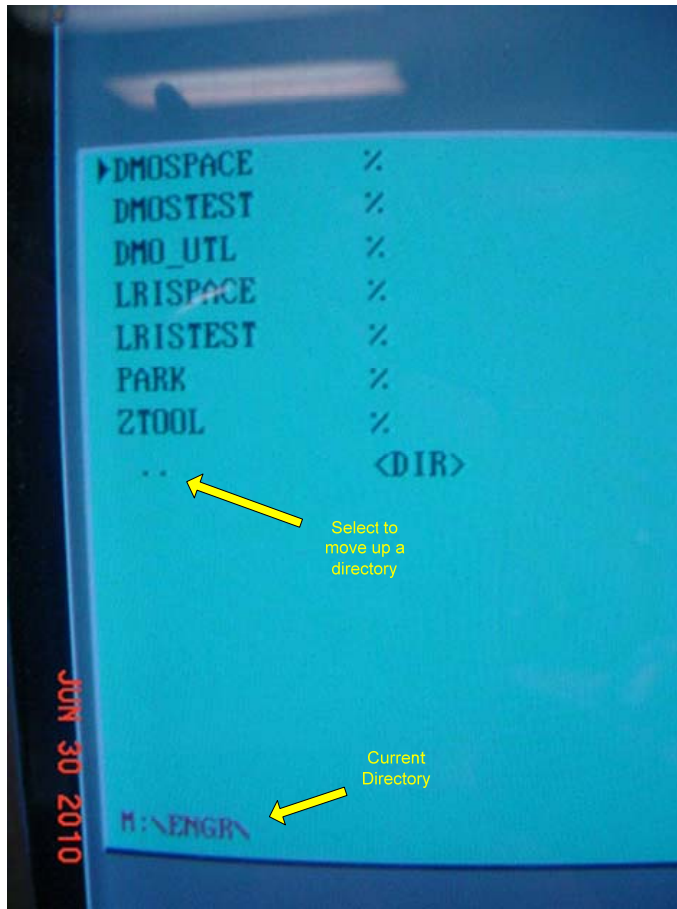
Figure 56 - Home menu

Figure 57 - File selection

Figure 58 - Position crank

Figure 59 - Feedrate knob

Figure 60 - Feedhold/Cycle start

Figure 61 - ESTOP/Reset

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Rev	Date	Author	Reason
--	--	G. Wirth	Original Web based document
--	2010 Jul 19	D. Chan	Initial Release – Added to controlled documentation. 114 series.
A	2011 Dec 07	D. Chan	Added notes.
B	2012 Jun 06	D. Chan, dlynn	Added bar-gun serial switch note, demios rivet punch.