Survey Procedure
Revision 5

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Change from Revision 4: Improved clarity of the Download and Analysis Section.

Calibrating the Vulcan is not necessary for every survey, in fact it is best if all the surveys are taken from the one good calibration. The Vulcan will remain calibrated unless one or both of the transmitters are knocked, or, more drastically, the survey pole is bent or damaged. Therefore, be extremely careful when turning the transmitters on and off.

1) Turn on the two transmitters. They take approximately 5 minutes to warm up.
2) Whilst the transmitters are warming up, begin filling out the plane survey checksheet. The checksheet should be filled out during the survey procedure insofar as it is practical to do so.
3) Put on the belt and insert all three color-coded cables into the receiver hub.
4) Attach the one foot pole to the 1.5-inch ball and the technical section. When attaching the pole, be sure to twist the pole onto the technical section; **never twist the technical section onto the pole**. Avoid bumping or otherwise putting stress on the technical section, as this can cause a misalignment of the sensors. Once the pole is attached, the technical section is connected to the receiver hub with the green cable.
5) Press button C then Bottom Detector- Tip and ensure that the short pole and 1.5-inch tip are selected. The pole selection is also displayed on the status bar at the bottom of the screen. The pole(s) highlighted in yellow are selected.
6) Once all connections are made, including the detector pole, turn on the power at the receiver hub. The switch light should be a steady green. If it is flashing green, cycle the power again. Check that the handheld computer has a yellow light, either flashing or steady, which indicates that the computer is receiving power. Press the power button on the handheld computer. Start the survey program with button A.
7) The first step is to check the calibration of the Vulcan. Select a control point on the floor with a line of sight to both transmitters. Remove the rubber stop and place the nest in the Dijak bolt.
8) Select Measure then XYZ. Position the tooling ball in the nest.
9) When all 4 spheres on the status bar are green, coordinates should appear in the X, Y and Z boxes. If any are red, check for line-of-sight blockage. If they still don't show up, or if the coordinates of the control point differ from the tabulated value (see Table 1) by more than .003 meter, go to Calibration Procedure. If the calibration is OK, then replace the 1.5 inch sphere with the 0.75 inch sphere and proceed with the survey.

10) Press button C then Bottom Detector- Tip and ensure that the short pole and 0.75-inch tip are selected. The total distance should then read 0.45403.
11) Make sure that the system is in "automatic" range-finding mode. It is toggled between automatic and manual using the status bar tool to the right of the four spheres. Manual mode is used only for calibration.
12) Go back to Measure and then the Data menu.
13) Press New to open a new file and then name to title it.
14) Files are called SM1-<plane#> e.g. SM1-17
15) Press OK and Save. Return to the XYZ screen and the name of the data file just entered will appear at the bottom of the screen. The survey can now be taken.
16) Diagrams are available indicating which points must be surveyed and how they are labeled for V (odd numbered) and U (even numbered) planes [This is valid for supermodule one; the numbering scheme changes with supermodule 2]. 19 alignment holes, the 8 axial bolts, 8 points on the collar are surveyed, and two points on the ears just above the rails; a total of **37** points for most planes. Every fifth plane includes 8 edge lugs, which are also surveyed. Planes with edge lugs have **45** total points.
    - The axial bolts are labeled A1 through A8 with A1 being at the 1 o'clock position continuing clockwise to A8.
    - The collar points are C1 to C8, following the same pattern as the axial bolts.
    - The ear tab measurements are taken only for z information, so the x-y is just approximately the middle of the ear above the rail. These are Z-EAR-E (east side) and Z-EAR-W (west side).
    - The alignment holes have a three character label. The first character is corresponds to the module number, 1 to 8, with module 1 being at the bottom of the detector. The second is either B or T, referring to the bottom or top of the module respectively. The final character refers to the alignment hole, 1 to 3, with 1 always being closest to the centerline of the plane.
    - The edge lugs are labeled S1 through S8 and follow the same pattern as the axial bolt and collar points. **These should be surveyed using the nest and the 1.5 inch sphere.** See step 24.
17) To survey a point, determine its label and select it from the list available by pressing the small triangle at the end of the Label box.
18) The labels are listed in the approximate order the points have been taken in previous surveys, however this order is NOT important.
19) After the label has been selected, rest the 0.75-inch ball on the alignment hole or in the bolt (Axial bolts and collar) .
20) Hold the pole as vertically as possible whilst ensuring the ball does not slip from the point. Holding the pole horizontally gives the worst performance of the system. For points on the bottom of the plane, remove the pole and attach the tooling ball directly onto the technical section. This allows the technical section to be held more vertically without hitting the floor. When measuring points in this way, be sure to de-select the pole on the status bar and to re-select it when the

pole is put back on. Most points should be measured using the pole in order to minimize handling the technical section directly.

21) The number 3.0 should be displayed on the status bar. This is the time, in seconds, that it takes the Vulcan to calculate a position. When the XYZ numbers have settled, press save. A chime should be sound and the screen will display "Point X Collected" where X is the number of points surveyed so far.
22) 18 points can be surveyed from the ground or 1st and 2nd levels (6 axial bolts and 12 alignment holes.) The remaining 17 points must be reached from the Sky Jack or the bridge.
23) If the plane has edge lugs (S1-S8), follow steps 25-28; otherwise go to step 29.
24) Remove the 0.75-inch sphere and replace it with the 1.5-inch sphere.
25) Place the nest in the 0.25-inch hole at the end of the edge lug.
26) Take all 8 lug coordinates with the 1.5 inch sphere resting in the nest.
27) Sometimes, whilst surveying points at the top of the plane, reception may be lost because of angle or distance, even if there is no blockage. A possible remedy is to detach the pole and survey the point without it. This may lower the sensors enough to get a good signal, but it also means more direct handling of the technical section. Use this technique only if it is impossible to get a signal otherwise. Remember to de-select and re-select the pole.
28) To check what points have been saved, press back, and then Data and then View. This will display the labels of the points already taken in this data file. This can be used to determine what points have been missed.
29) A bad point can also be removed here, by pressing Delete and Yes.
30) Back out and quit the program when all 37 (45) points have been saved. Caution: Version 3.0 has records a point number with every measurement. If a bad point is deleted and re-measured, the point number is not replaced but increased. This means that **the point number does not necessarily indicate the number of points in the data set.** If the number is greater than 37 (45), check to see if numbers are missing before assuming that there are really that many points in the data set.
31) Turn off the receiver hub switch and then the hand-held computer.
32) Unplug the cables and unscrew the pole. Pack the Vulcan away.
33) Turn off the Vulcan transmitters.
34) Make sure that the plane survey checksheet is complete and file it in the documentation folder for the plane.

Download and Analysis of the Data

1) The handheld computer (HHC) is not packed away, it is returned to the survey desk on the east side of the MINOS hall at floor level.
2) Remove the HHC from its protective casing. Ensure it and the desktop PC are on.
3) Plug the serial cable into the rectangular connector at the base of the HHC. This cable is permanently attached at the other end to the PC's com port.
4) The ActiveSync window will automatically appear on the PC. When it says it is synchronized, click on the Explore button of this window.
5) Click on:
   MyPocketPC->ProgramFiles->Survey3DI->Data.
6) Drag the current SM#-<plane#> file into the Survey folder on the PC's desktop (in the top right corner.)
7) Close the Explore and ActiveSync window.
8) Unplug and turn off the HHC. Remove it from its case and plug it into the charger.
9) Open Excel. There is an icon for it at the toolbar at the bottom of the screen.
10) Open the SM# text file in Excel by clicking:
    File->Open->Desktop->Survey->SM#-<plane#>.
    It is necessary to tell Excel to look for "All Files". It may be easier to find the Desktop folder in the left side column of the "Open" dialog box.
11) A window will appear, click next then check comma delimited and click next, then select the last column, and select text. Finally click finish. The data will now appear in spreadsheet format.
12) Highlight all the points and labels. In the Data menu, choose Sort, then select column E and ascending. This sorts the points into the order expected by the spreadsheet, no matter what order the points were surveyed in. Check that there are no double or extra points. Delete those that are bad or unnecessary.
13) Highlight and copy (ctrl-c) the 19 alignment point coordinates and labels. Do not copy the point numbers. At this point, you can minimize the data sheet by clicking the first button in the upper left corner of the spreadsheet.
14) Open the workbook todbase rev 2. There are five worksheets in this file, but generally the surveyors will use only two: sm#-xxx, which will contain the data for the plane just surveyed; and Check sheet, which will contain the data from the last plane of the same type. The other three worksheets calculate the positions of the B module alignment holes and perform QA checks. These sheets are write-protected.
15) The tab at the bottom of the spreadsheet indicates which worksheet is open. Click on the tab to open the sm#-xxx worksheet if it is not already open. Paste the data into the spreadsheet by clicking on cell A1 and then pressing ctrl-v. Double-click on the tab to edit the name of the worksheet. Replace "xxx" with the plane number.
16) Enter the plane number in the light blue cell as indicated on the spreadsheet.
17) Double check that the labels of the points match with the expected labels in column E.

18) All the number one alignment hole coordinates are displayed at the bottom.
19) The spreadsheet automatically projects to determine the position of the number 1 alignment holes at both ends of modules 2 and 7 (the B modules). Check the 4 red lettered cells next to each B alignment hole position. The status of the QA check is indicated by a "passed" or "FAILED" flag. If any fail the QA check, look at the point labels again to make sure that all of the B module points were properly entered.
20) These coordinates must be compared with those of the previous U or V plane.
    The number "xxx" of the previous U or V plane can be found from the Check sheet tab in the todbase spreadsheet in the blue box next to the words "Enter Data for Plane".
    The data corresponding to this plane is stored in:
    Desktop\Survey\Results\final-sm#\final sm#-xxx
    Open the file and make sure the correct worksheet is open by clicking on the sm#-xxx tab. There should be a blue box with the words "Use these data as checksheet for plane:" and the number should be that of the plane just measured. Select the data from cell A1 to cell D19 by highlighting with the mouse and pressing ctrl-c. Now, close the current spreadsheet and go back to todbase, click on the Check sheet tab, click on cell A3 and press ctrl-v. This will paste the contents of the final-sm#-xxx file into the check sheet.
21) The check sheet makes a direct comparison between the two data sets. Columns F, G, and H, starting at row 23, show the differences in the x, y, and z coordinates for each point. The x and y values should agree to within 0.025 m and the z value should be greater by 0.10 to 0.15 meters (the coordinates are in meters).
22) The columns to the right of the differences will flag either "OK" or "DEVIATION."
23) There are several reasons why a coordinate might be flagged as a deviation.
    - If the deviation is for a B module point, check the QA flag for the checksheet data. If the B module position for the checksheet failed the QA test, then the deviation may simply indicate that the comparison data is faulty. There's nothing to be done about it at this point.
    - If there is just a single deviation it is probably due to a point being mislabeled. Check to see if the coordinates actually match a different point. If the point is properly labeled and still in deviation, it should be re-measured if possible. If it is not possible to re-measure the point, make a note of the deviation on the survey QC sheet.
    - If all of the points are in deviation, it is probable that data from the wrong plane have been loaded into the check sheet. Clear the Check Sheet data by selecting cells A1 to D19 and pressing the delete key. Then go back to step 18, making sure to use the data from plane "xxx – 2," i.e., for plane 132 check against 130; for plane 133 check against plane 131, etc.
24) Once the data agree, click the sm#-xxx tab to return to that worksheet.
25) At this point, one needs to rename and store the todbase spreadsheet. From the File menu, "save as" the file as
    Desktop\Survey\Results\final-sm#/final-sm#-<plane#> .

26) Since all the necessary operations with Excel are completed at this point, close the program by clicking:

File->Exit.

Answer "no" to any prompts for saving files that may appear.

27) Open the Survey folder by double clicking the icon located on the top right corner of the screen. Drag and drop the text SM#-xxx file in the Raw Data folder. Do not close this window yet.

28) Post the data files on the world-wide web by double-clicking the WS-FTP95 icon on the computer screen followed by "ok".

a) In the "Remote System" window within the FTP session, double click the "raw data" folder. Now, Select the raw data file and drag it with the mouse into the "Remote System" window. After a few seconds required to transfer the file, click the arrow "▼" on the upper right corner of the "Remote System" window and from the drop-down menu select:

/home/survey

b) In the Survey folder click the "back" (⇦) button and go into:

Results->final-SM#

Now, drag the "final-sm#-xxx" file into the "Remote System" FTP window. After the file completes transferring, close the FTP session by clicking the × in the upper right corner of the window.

Calibration Procedure

1) This procedure assumes starting from step 6 of the Survey Procedures, where no numbers appeared in the XYZ screen.
2) Change to the 3 foot pole and the 1.5-inch ball.
3) Press button C and then Bottom Detector-Tip and change to the long pole, deselect the short pole if necessary, and choose the 1.5-inch ball from the Custom list. The total length should be 1.06269.
4) Attach the bipod to the pole. The bubble should indicate that the setup is approximately level, but the most important thing is that it be stable. Do not attempt to calibrate the system without using the bipod.
5) Go to Setup->Calibration->Quick.
6) Setup the ball and bipod above point 1 (review the diagram on the column below the east transmitter showing the approximate position of the calibration points, to help find them.)
7) Level the pole, ensure that all 4 spheres are green, then collect the point. The system will chime 4 times for each point collected.
8) Collect all 6 points marked. 4 are in a rectangle between the two transmitters, the fifth is along the centerline towards the detector, the sixth is a few feet west of the 5th.
9) Now press "Calibrate". If the calibration is unsuccessful, repeat the procedure. Otherwise proceed to the Scale Setup.
10) Select two control points to be used for the scale. The exact distance between them may be determined by using the distance calculator in the spreadsheet MINOS Survey Points. This spreadsheet is on both the hand-held and desktop computers.
11) Follow the instructions on the Set Scale screen. Select square 1 at the top of the screen. Then press the "Enter" button and enter the distance between the control points. Select the check box in the second column and then de-select the check box in the first column.
12) Select measure and set up to measure the first endpoint of the scale, using the nest and the 1.5" sphere.
13) The Vulcan should be in precision measurement mode, indicated by a check mark in the far right box on the status bar. This mode requires two sets of 3 measurements for each endpoint. Take the first three measurements by pressing the save button, then loosen the bipod just enough to rotate the pole 180°, re-tighten it, and take three more measurements.
14) A set of standard deviations will now be displayed. They should all be less than 8 8 mm (0.008 m). If any of the standard deviations are 8 mm or greater, take the measurements over again, taking care to keep the pole steady.
15) Repeat this process for the second end point.
16) If the measured distance is not the exactly the same as the scale bar value entered, select the first checkbox, deselect the second box, then re-select the second box and de-select the first. Yes, it's complicated, but this forces the system to use the

entered value as the scale. This can be verified by checking that the value of delta in the second column is 0.000.

17) The Vulcan is now calibrated with Transmitter 1 (1163) as the origin. It must now be transformed to the detector origin, the center of the coil in plane zero.
18) Go to Setup->Transform->Snap point.
19) Select the file "MINOS_Survey_Points" from the list.
20) 4 floor points and two column points will be used in the transformation. Select points that are in the vicinity of the transmitters.
21) Measure each of these points with the 1.5" sphere and nest in the precision measurement mode (check mark in the far right box on the status bar).
22) The Fermilab coordinates for this point will be shown, double check that the z, horizontal distance from the plane, is sensible (i.e. that a wrong point has not been selected), and then press Yes to accept the point.
23) The Vulcan will then determine its coordinates for this point. Press save and then next.
24) Repeat these steps for each of the four floor points, each time using the nest and leveling the pole.
25) Remove the bipod and change to the one-foot pole.
26) Go upstairs to the column points closest to the detector.
27) Insert the nest into the central hole of the construction block that has been welded to the column. The nest will only fit into this hole.
28) Again select the point from the list and check its coordinates are sensible.
29) When trying to record the column points it is general necessary to keep the pole as nearly vertical as possible. When all four balls are green and the numbers have settled save the point and press next.
30) Take the opposite column point.
31) Press the Trans button instead of Next, when all 6 points have been saved.
32) Hopefully "Result Success" will be shown. If not, repeat the procedure more carefully. Note though, that the transformation points can be taken in any order, i.e. the column points can be taken, then the floor points.
33) The system is now ready to take measurements. Cover all the survey monuments with their rubber stoppers and pack away the bipod and nest.