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WSI Field Calibration System Operations Manual

DAY/NIGHT WHOLE SKY IMAGER
(E/O CAMERA SYSTEM 6A)

UNIVERSITY OF CALIFORNIA SAN DIEGO

SCRIPPS INSTITUTION OF OCEANOGRAPHY

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1. Principles of Operation

Due to the remote siting of several of the WSI instruments, it is often not practical to return them to MPL for radiometric calibration. For this reason, a field calibration device had been developed to enable full calibration in the field.

1.1. The Field Calibration Device Hardware

There are several physical components included in the Field Calibration kit, for a variety of purposes. The primary components are discussed here.

The Absolute Radiance device is shown in Fig. 1-1. The top piece is a Labsphere URS 600 Uniform Radiance Standard, calibrated for absolute spectral radiance. It includes a 6" integrating sphere, and an adjustable slide attenuator, which allows one to adjust the flux entering the sphere (without affecting the color temperature of the lamp). The lamp is controlled with a DC constant current regulated power supply. The output of the sphere is monitored by a solid state photopic photodetector, so that changes due to the aperture setting, as well as changes due to the temperature, lamp age, or other environmental factors, may be adjusted for. The lower piece in the illustration is the mating device that attaches the URS to the WSI. It includes a 3 log neutral density filter which is positioned with a filter holder and may be manually brought in and out of the optical path by the user. The absolute radiance device is used for measuring the linearity, shutter effective opening time, absolute radiance response, and optical dome calibration.

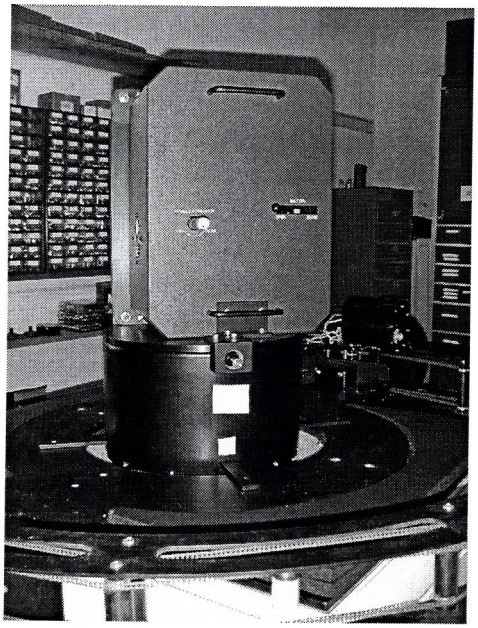

Fig. 1-1. URS Device

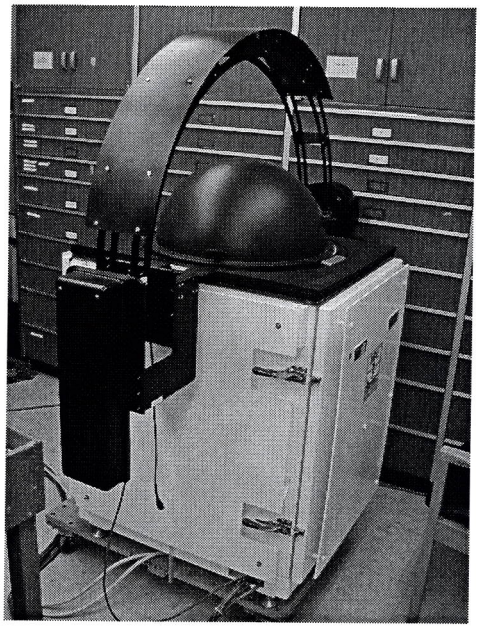

Fig. 1-2. Uniformity Device

The Uniformity Device (Fig. 1-2) is a white hemisphere coated with Spectraflect, with a lamp and baffle. It is mounted on the WSI and images are acquired over a set of rotational angles. The inside of the hemisphere has been mapped for relative radiance.

The half of each image which does not include the lamp and baffle may be corrected for the device relative radiance, and then these half images are combined to yield an image of the system non-uniformity. This non-uniformity includes the lens rolloff (the decrease in sensitivity as a function of zenith angle caused by the changing solid angle per pixel and by vignetting) as well as pixel-to-pixel effects such as the non-uniformity of the fiber optic taper in the camera.

The third large component in the field kit is the near-horizon calibration device, to enable determination of the image geometry near the horizon. This is shown in Fig. 1.3.

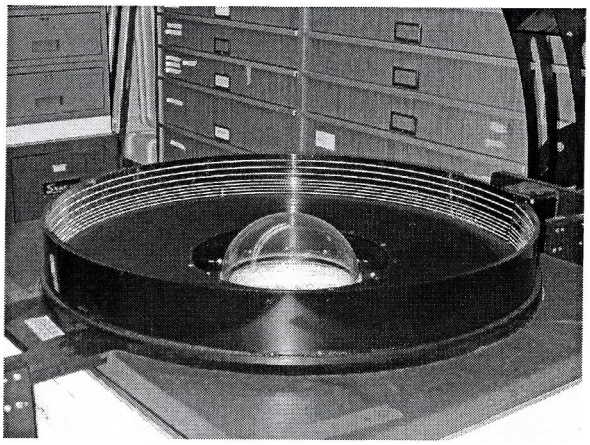

Fig. 1-3. Near-horizon geometric device

Additional components include a small siting device and transit for aligning the instrument, and related power supplies and other components. A full list of all of the components in the kit is included in the WSI Field Cal Kit Contents in Section 3.

1.2. An Overview of the Calibration Measurements

The calibration is intended to provide the information needed to process raw field data and yield distributions of absolute radiance. That is, an absolute radiance value is provided at each pixel, in each wave band acquired by the instrument. In association with this, geometric calibrations provide an assessment of the zenith and azimuth look angle for each pixel. For the application of determining cloud cover, the calibration stability is less critical, because the system uses image ratios, and only relative calibration must be stable or corrected for. The most critical calibration, the dark calibration, is measured in the field as part of the automated data acquisition procedure.

The following sections give a brief overview of the calibrations which are acquired during the WSI field calibration. In the past, most of these calibrations were acquired in a calibration facility at MPL with a 2-meter precision calibration bar. At the MPL facility, the source is a 1000W FEL lamp traceable to NIST. A lambertian reflectance plaque is placed at the 0 point on the bar, and the imager views this plaque. A high accuracy resistance shunt is used to monitor the lamp current, and the power supply automatically

adjusts the voltage to maintain fixed current through the lamp. With the field calibration device, this source has been replaced by a Labsphere device as discussed in Section 1.1. Although this device is also traceable to NIST, tests at MPL revealed that the Labsphere calibration accuracy was not as accurate as desired, and it was adjusted by comparison with FEL lamps.

1.2.1. Initial Images

The program first acquires images with the WSI in standard mode, ie without the calibration device mounted, so that the pre-calibration condition can be documented. The program also saves diagnostic files from the previous run of RunWSI, the normal data acquisition program.

1.2.2. Dark Level vs Exposure

A dark image is an image acquired with the shutter closed, and provides a measure of the dark current, electronic bias, and readout noise. The dark current is pixel-dependent, and is normally subtracted from the measured images in the field. In the field calibration, the dark image is acquired as a function of shutter exposure in order to characterize camera performance. When normal field data are acquired, a dark image is acquired whenever the exposure changes, so that a current dark image may be subtracted in the near-real-time processing in the field.

1.2.3. Shutter Calibration

Images of the uniform URS source are acquired at short exposure times ranging from 25 msec to 200 msec, in order to measure the effective shutter opening time.

1.2.4. Linearity Calibration vs Exposure

Images are acquired at signals ranging from 100 counts to approximately 50,000 counts, in order to verify system linearity. The signal is changed by changing the exposure as necessary. Although CCD cameras can often have very significant non-linearities, even if they are advertised to have good linearity, the 16-bit Photometrics cameras used in the Day/Night WSI are typically linear to within a percent over most of the range, with non-linearities of about 2% at either extreme end of the sensitivity range.

1.2.5. Absolute Radiance Calibrations

Absolute calibrations are acquired for each combination of spectral filter and neutral density filter used in the system. In each filter setting, measurements are acquired at each of four exposures. The 4 exposures yield four signals for four different radiances. If the calibration is stable, these four measurements should yield the same calibration constant, in the absence of measurement error. The redundancy in this procedure yields a more accurate determination of the calibration constant, and also enables an evaluation of

calibration uncertainty. Test results to date show self-consistencies of better than a percent, with a typical value of about 0.25% standard deviations.

1.2.6. Dome Calibrations

The WSI uses either an optical or an acrylic dome to protect the lens and other optics. The absolute calibrations are normally acquired without the dome in place. However, a dome calibration is acquired first, with the existing dome which is on the WSI; this occurs prior to the shutter calibrations. Then, if a new dome will be placed on the WSI, a second dome calibration is acquired after the absolute calibrations are completed. The intent of the dome calibration is to determine the attenuation due to the dome, so that all of the absolute data results may be adjusted accordingly.

1.2.7. Uniformity Calibration

The uniformity calibration characterizes the variance in overall sensitivity of the system as a function of pixel. Part of the variance is due to the optical system, and consists primarily of a variance as a function of zenith angle in the field of view. This was previously referred to as the rolloff. In addition, this uniformity variance includes what is normally referred to as the flat field, which is the variation in pixel sensitivity due to fiber optic taper and the CCD chip characteristics. Together, the dark image and the uniformity image may be used to adjust the pixel-to-pixel variations in bias and gain. The uniformity images are acquired with the Uniformity device.

1.2.8. Near-Horizon Geometric Calibration

Following careful leveling of the instrument and careful alignment with respect to True North, the Near-horizon Geometric calibration device is mounted on the instrument. This device is checked for level, and images of it are acquired. It has marking rings at zenith angles 80°, 82°, 84°, 86°, 87°, 88°, 89°, and 90°. The analyst normally determines most of the geometric calibration using star positions; this device enables determination of the geometric calibration for near-horizon angles.

1.2.9. Filter Passband Calibrations

In order to provide absolute radiance, it is necessary to know the effective lamp irradiance over the passband of the instrument. The passbands for the D/N WSI are shown in Fig. 1.4. In order to determine this, it is necessary to know the lamp spectral irradiance as a function of wavelength, the CCD sensitivity as a function of wavelength, and the transmittance of each filter as a function of wavelength. Lamp and CCD calibrations are provided by the vendors, and the filter passband calibrations are measured separately. These values are not measured during the field calibration, but are determined prior to fielding the system. They are mentioned here, because the results of these calibrations are used in the processing of the field calibration.

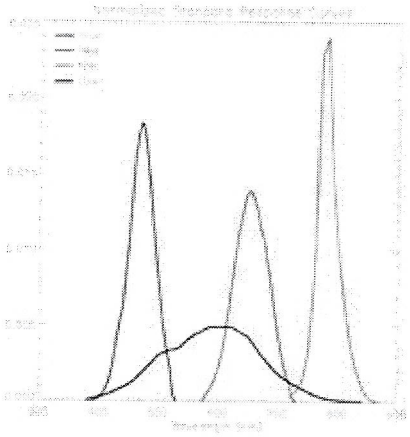

Fig. 1-4. Spectral Passbands of the Day/Night WSI

2. Field Procedures

Most of the field procedures are documented in the User Log, discussed below. In addition, there are a variety of documents such as the calibration logs and lamp logs which are used in the field. These are further discussed in Section 5.

The User Log serves two functions. It serves as a checklist for the user, and it also serves as detailed documentation for the steps involved in the calibration. It also documents when to use the calibration logs and lamp logs. The sections of the user log include the following:

I. Steps Prior to Starting
II. Initial System Check with system running
III. Get the Devices Ready to Set Up
IV. Initial Setup of the Software and Initial Calibration Checks and Inputs
V. Set up the URS Abs Cal Device
VI. Dark Image Calibration (Approx. 6 min)
VII. Dome Calibrations for Existing Dome (Approx. 50 min)
VIII. Acquire Shutter Calibrations (Approx. 7 min)
IX. Acquire Linearity Calibrations (Approx. 6 min)
X. Acquire Absolute Calibrations (Approx. 50 min)
XI. Dome calib for new dome, if the dome is changed
XII. Turn off the URS-600 and Set up the Uniformity Device
XIII. Acquire Uniformity Calibrations (Approx. 30 min)
XIV. Turn off and remove Uniformity Device
XV. Level and Align WSI
XVI. Acquire Near-horizon Geometric Images (Approx 2 min)
XVII. Save the Output Files and Images and Pack the System
XVIII. Return WSI to normal operation
XIX. Final System Check with system running

A1. Installing the lamp in the URS
A2. Set up the URS Abs Cal Device
A3. Program Details
A4. Remove the URS and Set Up the Uniformity Device
A5. Turn off the Uniformity Device
A6. Install a new lamp in the Uniformity Device

This user log may evolve with time, especially as a result of the first system tests with ARM personnel. If the user log changes significantly, it will be re-issued as a technical memoranda. The user log follows on the next pages.

WSI Field Calibration
User Log

File ArmFldCalAcqUserLog1.doc Version Date 24 Jan 03

Instrument Location _____
Unit Number (if known)_____
Calibration Date _____

For details on many of these procedures, see the Appendix sections. In many places in this log, have indicated things to check, such as current levels or program performance. They are intended as alerts that something could be wrong, in which case the user should inspect the calibration device and the WSI to try to determine the problem, or consult with MPL.

I. Steps Prior to Starting

1. _____ You will need a clean copy of this log for each instrument you plan to calibrate.
2. _____ Check the field cal kit with the WSI Field Cal Kit Contents list, and make sure everything is in place. Make sure the calibration logs and lamp use logs in the kit are up to date.
3. _____ Before going out into the field know the magnetic declination of the site and how to adjust your compass to accommodate for this. The declination can be obtained at the www.ngdc.noaa.gov site, by clicking on geomagnetism, then magnetic declination on-line. Enter the site latitude and longitude and submit it. The declination is the D value. Be sure to note the sign; + is East, - is West.
   Note Latitude _____ N or S
   Note Longitude _____ E or W
   Note Declination _____ E or W of True North
4. _____ A method needs to be worked out in advance or at the site for saving the calibration files to the ARM personnel laptop computer.
5. _____ We recommend occasionally checking the inclinometer alignment with respect to the bracket by using separate digital level. Verify that the 9V battery is good, and you have a spare.
6. _____ Verify that the batteries on the "walkabout" are good, and that you have spares. They each require three AA batteries.

II. Initial System Check with system running

A) Inspection of "Blue Box" Controller (check off each section when completed)

1. _____ Verify the WSI system is running.
   _____ Does the monitor display the correct date and time?
   _____ Is the monitor display free of flags?
   _____ Does the monitor display an image of the sky?
   _____ Does the monitor display show the sun within the occultor boundary?
   _____ Does the image on the monitor change as the program acquires new images?
   _____ Does the monitor display an "FTP IN PROGRESS" message in the status column (this happens only when the WSI is hooked to ADaM).
   _____ On the Sensor ACP; do the "spectral" lights change as the program acquires new images?
   _____ On the Occultor ACP; did the "ARC POSITION (DEG)" change as the program updates the occultor position?
2. _____ Check ACPs
   _____ For occultor systems without encoders, note occultor arc position, does it appear Ok (0 = E 180 = W)
   _____ For occultor systems without encoders, note occultor trolley position, if trolley is present, does it appear Ok (0 = N, 180 = S)
   _____ Record Camera Housing Temp (normal range < 32 C) _____
   _____ Record CCD Temp (normal range < -30 C) _____
   _____ Record Environmental Housing Temp (normal range < 32 C) _____
   _____ Record Flow Rate (normal range > .125 gpm) _____
   _____ Record N2 Pressure (normal range 2-6 psi) _____
3. _____ Checks during Grab Sequence
   _____ Watch ACP filter lights to verify filter wheel changes position smoothly, ie without skips
   _____ Verify ACP filter lights do not blink excessively
   _____ Verify an image is grabbed for each filter position
   _____ Verify the program moves the occultor to the new position
4. _____ Inspect the diagnostic files:
   _____ Press S for status, and then inspect the resulting diagnostic file for abnormalities (Ref Memo AV01-083t).
   _____ If feasible, have a system administrator let you look at one of the files such as 21131200.dgn and check for abnormalities (Ref Memo AV01-083t).

B) Inspection of "White Box" Environmental Housing

1. _____ Occultor Inspection
   _____ Verify brake releases before arc is moved and sets on completion
   _____ Verify arc is in correct position to shade dome
   _____ Verify trolley is in correct position to shade dome
2. _____ Other Outside Inspection
   _____ Inspect the dome, indicate whether it is clear, somewhat cloudy, or very cloudy
3. _____Inspect Inside of housing
   _____ Record flow rate, should be close to the value read from ACP

_____ Record env hsg temp, should be close to the value read from ACP
_____ Record CCD temp, should be close to the value read from ACP
_____ Check for standing water or other signs of problem

III. Get the Devices Ready to Set Up

1. _____ Set up the field cal cases near the WSI sensor (or put them in a convenient location and plan to carry the components out as needed).
2. _____ Bring the calibration log notebook for the site in to the WSI controller.
3. _____ Install a Lamp in the URS Abs Cal Device as described in Appendix Secn A1. Be very careful not to break the lamp or touch the glass.

IV. Initial Setup of the Software and Initial Calibration Checks and Inputs

1. _____ Turn off the data acquisition program by pressing the X key and waiting for the system to respond.
2. _____ Note the directory you are in. This will be used in step 5.
3. _____ You will need approximately 170 MB space on the C: drive of the Dos system. If you do not have this much space, speak with the system manager and see if additional space can be generated.
4. _____ If the field calibration program is not already installed, install it by inserting the diskette labeled "WSI Field Cal installation disk (Version X)" in the WSI drive (not the NT drive). Then type a:install<CR>. It will self-install, creating a directory C:\Fieldcal, and copying the necessary files there. Do not change the input files. At the end, you should be in directory C:\Fieldcal.
5. _____ Start the field cal program by typing Fieldcal.
6. _____ The program will ask you what your site is, and what calibration number is to be assigned. Use the calibration log for the site to determine what the next calibration number should be, and enter it in the log. The program will also ask what directory contains the diagnostic files - this is the directory you were in at step 2. It will automatically save diagnostic files and images. (You can see the SP filters changing.) It also does self-checks of CCD temp etc, but this is transparent to the user.
7. _____ When the above has been completed by the program, it will show, in yellow, "The first calibration test is the Dark image test". Before responding to the program, proceed with Section V of these instructions, to set up the URS.

V. Set up the URS Abs Cal Device

1. _____ Before you turn on the lamp, note that it is best to leave on the lamp for as short a time as possible – the best time for lunch breaks is after the dome calibrations in Section XI, but you may break between any calibration section, as long as you turn off the URS or uniformity device, and then turn it back on after your return.
2. _____ Follow the detailed instructions in Appendix Secn A2, remembering in particular to do the following:
3. _____ Using the Occultor ACP, move the occultor to approximately 135°. In systems with occultors that use encoders, this should be done with the utility program

EncUtil. Remove the top plate from the WSI, and remove the outer ring of dome plate screws.

4. _____ Mount the absolute device on the WSI, with the bottom mounting plate facing West.
5. _____ When turning on the power supply, verify that the window says "5.940 I-Set"
6. _____ **Note the start time in the lamp log, along with date and other entries.**
7. _____ Open the aperture all the way by turning the micrometer handle as indicated.
8. _____ Pull out the Offset filter by unscrewing the gray handle on the mounting device, and pulling the small rod to its fully extended position.
9. _____When 20 minutes have passed, verify that the lamp current on the power supply, I-Out is 5.940. (If it is not, check the URS system and system documentation.)
10. _____ Read the photodiode current on the System Controller, and note it on the lamp log. It should be similar to previous values. Note the photodiode current: _____ (If it's not, check the lamp, the offset filter, and the aperture.)
11. _____ Verify that the Sensor ACP is On, with the switch set in Computer. (The other switch settings do not matter for this procedure.)

VI. Dark Image Calibration (Approx. 6 min)

1. _____ The program will ask if you would like to proceed with the dark calibration. Respond Y, and then follow the instructions on the monitor. (See Appendix Secn A3 for more program details.) (Responding N will skip this step. This is true throughout the program.)
2. _____ On completion of the dark calibration, the program will return some diagnostics. This is also true of most of the calibration sequences.
3. _____ Was the signal at 100 msec in normal range (less than 1500)?
4. _____ Was the difference between the signal at 60000 msec and 100 msec in normal range (less than 500)?

VII. Dome Calibrations for Existing Dome (Approx. 50 min)

1. _____ The program will ask if you would like to proceed with the dome calibration. Respond Y, and then follow the instructions on the monitor.
2. _____ The first dome calibration is done with the existing dome. The program will also ask you the lamp number, which is the same as the lamp number on the lamp log.
3. _____ The program may ask you to adjust the variable attenuator. If you are doing this calibration with a partner, we suggest using the radio transmitters provided with the kit to make this step easier.
4. _____ On completion of the portion with the dome, was the photodiode reading stable?
5. _____ The computer will tell you to remove the dome. You will need to temporarily remove the URS 600 to do this.
6. _____ On completion of the portion without the dome, was the photodiode reading stable?

VIII. Acquire Shutter Calibrations (Approx. 7 min)

1. _____ The program will ask if you would like to proceed with the shutter calibration. Respond Y, and then follow the instructions on the monitor.
2. _____ On completion, the program will report the effective shutter time. Was the effective shutter time normal (offset between +-5 msec)? Enter offset time in msec _____
3. _____ Was the photodiode reading stable?

IX. Acquire Linearity Calibrations (Approx. 6 min)

1. _____ The program will ask if you would like to proceed with the linearity calibration. Respond Y, and then follow the instructions on the monitor.
2. _____ Was the photodiode reading stable?
3. _____ Did the linearity pass its two self-check in SP4?
4. _____ Did the linearity pass its two self-check in SP3?

X. Acquire Absolute Calibrations (Approx. 50 min)

1. _____ The absolute calibration is normally done without any dome in place. If this is not the case, and you have a dome on, please note which dome (glass, acrylic, old dome calibrated in Secn VII or new dome calibrated later) here: _____
2. _____ The program will ask if you would like to proceed with the absolute calibration in ND3 (neutral density 3). Respond Y, and then follow the instructions on the monitor.
3. _____ Was the photodiode reading stable during the ND3 calibration?
4. _____ The program will ask if you would like to proceed with the absolute calibration in ND2 (neutral density 1). Respond Y, and then follow the instructions on the monitor.
5. _____ Was the photodiode reading stable during the ND2 calibration?
6. _____ The program will ask if you would like to proceed with the absolute calibration in ND1 (neutral density 1). Respond Y, and then follow the instructions on the monitor.
7. _____ Was the photodiode reading stable during the ND1 calibration?
8. _____ Did the absolutes pass the self check for red/blue?
9. _____ Did the absolutes pass the self-check for ND3/ND1?
10. _____ Did the absolutes pass the self-check for ND2/ND1?

XI. Dome calib for new dome, if the dome is changed

1. _____ Install the new dome, if you are planning to install the dome. If no new dome is being installed, reinstall the old dome, and skip this step in the calibration.
2. _____ The program will ask if you would like to proceed with the dome calibration. Respond Y, and then follow the instructions on the monitor.
3. _____ Was the photodiode reading stable?

4. _____ No "without dome" calibration needs to be acquired with this second dome calibration.

XII. Turn off the URS-600 and Set up the Uniformity Device

1. _____ **Push STOP on the Power Supply before you turn off the power. Verify that I-Out goes to 0.**
2. _____ **Enter the lamp stop time in the log.**
3. _____ Disconnect and remove the URS. Detailed instructions are given in Appendix Secn A4.
4. _____ Install the Uniformity Device onto the WSI, with the 0 point to the West. Detailed instructions are given in Appendix Secn A4.
5. _____ When turning on the power supply, if the window does not say "4.167 I-Set", touch the "Options" button, then push the button with the up triangle until the window displays "HLS-100-50 50 Watts", then push "Stop". Now it should say "4.167 I-Set". **Do not run the uniformity lamp at the URS lamp current; always run it at 4.167.**
6. _____ Push "Start". This should start the lamp ramping up to a current of 4.167 A.
7. _____ **Note the start time in the Uniformity lamp log, along with date and other entries.**
8. _____ You do not need to turn on the System Controller for this calibration.
9. _____ If the light does not come on or the current does not start to ramp up, there may be no lamp in the uniformity device, or it may have broken in shipment. Instructions for changing the lamp are given in the Appendix Secn A6.
10. _____When 20 minutes have passed, verify that the lamp current on the power supply, I-Out is 4.167. (If it is not, check the power supply system documentation.)

XIII. Acquire Uniformity Calibrations (Approx. 30 min)

1. _____ The program will ask if you would like to proceed with the Uniformity calibration. Respond Y, and then follow the instructions on the monitor.
2. _____ Note, this calibration is normally done with the final dome in place, but it can be done either way. Please note whether the dome was used: _____
3. _____ During this calibration, you will need to turn the device clockwise about 30 degrees when requested. The marks 30, 60, etc should be facing west when the program asks you to take measurements in the 30, 60, etc position.
4. _____ Did the uniformity calibration reach completion?
5. _____ Did the self check comparing the images with the image at position 0 all pass?

XIV. Turn off and remove Uniformity Device

1. _____ **Push STOP on the Power Supply before you turn off the power.**
2. _____ **Enter the lamp stop time in the log.**
3. _____ Turn off, disconnect, and remove the uniformity device as described in the Appendix Section V.

XV. Level and Align WSI

1. _____ The program will instruct you to proceed with the north alignment, and press return when you are finished at the end of this section.
2. _____ Install the 9V battery in the Electronic Clinometer controller, and turn the power on the display.
3. _____ Measure the level along a N-S line and an E-W line, and determine whether the WSI is level to within about half a degree. If it is level in both directions, skip to step 8. If, with experience, we find that a closer tolerance is realistic, then closer is better.
   On a N-S line, the device is _____ deg low on the _____ side.
   On a E-W line, the device is _____ deg low on the _____ side.

4. _____ Determine which side of the WSI has 3 legs. These instructions are written for the case where the 3 legs are on the North side; if they are elsewhere, adjust the procedures accordingly.
5. _____ On the side with 3 legs, raise the two outer legs so that the WSI is resting on the central leg. The leveling legs are adjusted by lowering the top nut (the jam nut), and lowering or raising the leg. Always be careful not to raise the leg so high that it is disengaged from the WSI housing; there is no stop on the upper end of the legs.
6. _____ Place the digital level on the South side of the Occultor Base Plate (away from the 3 legs), pointing East-West[1]. Adjust the E-W level as necessary by adjusting the leveling legs in the SE and SW corners of the White Box. (This step levels the side opposite the 3 legs.)
7. _____ Place the digital level on the East side of the Occultor Base Plate, pointing North-South. Adjust the N-S level by adjusting the leveling leg in the center of the North side of the housing. (This step levels the previous plane with respect to the third leg.)
8. _____ Attach the MPL fabricated True North Alignment device on the WSI. The alignment device should be placed on either the East or West side of the Occultor Base Plate. It will mate with the two ¼-20 holes in the Occultor Base Plate on that side using two 1/4-20 x 1 ½" bolts.
9. _____Using the alignment sight align the N-S axis of the WSI with True North. If the site does not provide an indication for True North, or other directional alignment, refer to the next steps for directions on how to use the magnetic compass provided.
10. _____ Open the Brunton pocket transit compass (it opens at the end with the black pieces by just pulling it open) and place the assembly on the tripod. Place the compass/tripod a few feet to the North of the WSI. Make sure there are no motors or large metal masses in the close vicinity that could affect the magnetic readout of the compass. The compass should be placed so that it is on a North line with the WSI. In this way the distant object will also be at True North with respect to the WSI. [If the target is 100' away, the compass may be up to 1' away from the line connecting the WSI dome and the target.]

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[1] This section is written for the case in which three leveling legs are on the North side of the White Box. If they are on another side, adjust the instructions accordingly.

11. _____ Using the round bubble level next to the compass spinner, make sure the compass is perfectly level.
12. _____ Correct the compass alignment for the magnetic variation as determined in the first step. Make sure the sights on the compass are pointed to True North. If the variation is East, then magnetic North is east of True North
13. _____ Looking through the sights on the compass, locate a distant object at True North.
14. _____ Rotate the White Box until the distant object at True North can be seen through both channels of the WSI alignment device dove tail sight at the same time.
15. _____ Once the White Box has been aligned, readjust the three leveling legs as necessary.
16. _____ When the system is fully level, snug down the leveling legs in the NE and NW corners to fully support the system. Be careful not to change the level of the White Box during this step.
17. _____ Tighten the jam nuts on all five legs up against the bottom of the White Box to secure the leveling leg position.
18. _____ If the sun is present, True North can be verified. Run Program OCCINFO, if it is on the hard disk, and determining the time for local apparent noon at the site. Then, using a straight vertical rod, cast a shadow at the time given for local apparent noon. The shadow cast by the straight vertical rod should align with True North. This is not a precise check, but it will let you know if you made the declination correction in the wrong direction.
19. _____ Remove the WSI alignment device from the top of the occultor base plate.
20. _____ Remove the 9V battery from the Clinometer controller for shipping.

XVI. Acquire Near-horizon Geometric Images (Approx 2 min)

1. _____ Install the near-horizon calibration device on the WSI with the cut in the Lexan piece to the South.
2. _____ Check the level of the device and note the results below, then remove the Inclinometer.
   On a N-S line, the device is _____ deg low on the _____ side.
   On a E-W line, the device is _____ deg low on the _____ side.
3. _____ Using the occultor ACP, move the occultor until it shades the dome.
4. _____ The program will ask if you would like to proceed with the Near-horizon Geometric calibration. Respond Y, and then follow the instructions on the monitor.
5. _____ Did the geometric calibration reach completion?
6. _____ The program will automatically end at this time. If you need to rerun any calibrations, this may be done by starting the program over, and saying N (no) to all those options you wish to skip.

XVII. Save the Output Files and Images and Pack the System

1. _____ If you were calibrating unit UU, and used calibration number NN, type ?UUNNSUM.log. You should see the following list of output files:

BUUNNSUM.log, the Dark calibration
CUUNNSUM.log, the Dome calibration acquired with the old dome
DUUNNSUM.log, the Dome calibration acquired with no dome
EUUNNSUM.log, the Shutter calibration
FUUNNSUM.log, the Linearity calibration
GUUNNSUM.log, the Absolute calibration taken in ND=3
HUUNNSUM.log, the Absolute calibration taken in ND=2
IUUNNSUM.log, the Absolute calibration taken in ND=1
JUUNNSUM.log, the Dome calibration acquired with the new dome
KUUNNSUM.log, the Uniformity calibration
LUUNNSUM.log, the Geo calibration
In addition, there should be data files for all of these calibrations, as well as data files beginning with A, which represent the Initial Conditions images.

3. _____ If you need to view any of the image files, the program ImgViewM in the \Calib directory may be used. Also, you may wish to review the log files.
4. _____ Move all of these log files (*.log) and their accompanying image files (*.dat) to the laptop (method to be determined by ARM site personnel). All of the .log and .dat files should be saved. This will require approximately 170 MB.
5. _____ Remove the Geo device from the WSI.
6. _____ Assuming the URS has been off at least a half hour, remove the lamp from the URS being very careful not to touch the glass, and store it in its storage case.
7. _____ Take apart the URS into its shipping configuration, and replace the cover over the integrating sphere.
8. _____ Pack up the field calibration device, being sure to remove batteries from the Walkabout and the Inclinometer.
9. _____ Put the software disk with the field calibration device.
10. _____ Store the lamp logs and calibration logs with the calibration device. The user log should be copied and sent to the prearranged location (probably Dr. Tooman or MPL), along with the data files.
11. _____ Check the Field Kit contents list, and verify that you've got everything packed.

XVIII. Return WSI to normal operation

1. _____ Be sure that the dome you want is on the WSI, and that it has been calibrated.
2. _____ Complete any necessary repairs, and do any work like cleaning lenses and changing desiccant packets as required, and seal the dome.
3. _____ Reattach the sun shade and its bolts, sealing the bolts if appropriate.
4. _____ Repressurize the camera housing to approximately 5 psi using the normal site procedures.
5. _____ At the controller, return to the normal RunWSI directory noted in step IV 2.
6. _____ Start the program by typing RunWSI6M.

XIX. Final System Check with system running

A) Inspection of "Blue Box" Controller (check off each section when completed)

1. _____ Verify system is running.
   _____ Does the monitor display the correct date and time?
   _____ Is the monitor display free of flags?
   _____ Does the monitor display an image of the sky?
   _____ Does the monitor display show the sun within the occultor boundary?
   _____ Does the image on the monitor change?
   _____ Does the monitor display an "FTP IN PROGRESS" message in the status column (this happens only when the WSI is hooked to ADaM).
   _____ On the Sensor ACP; do the "spectral" lights change?
   _____ On the Occultor ACP; did the "ARC POSITION (DEG)" change?
2. _____ Check ACPs
   _____ For occultor systems without encoders, note occultor arc position, does it appear Ok (0 = E 180 = W)
   _____ For occultor systems without encoders, note occultor trolley position, if trolley is present, does it appear Ok (0 = N, 180 = S)
   _____ Record Camera Housing Temp (normal range < 32 C) _____
   _____ Record CCD Temp (normal range < -30 C) _____
   _____ Record Environmental Housing Temp (normal range < 32 C) _____
   _____ Record Flow Rate (normal range > .125 gpm) _____
   _____ Record N2 Pressure (normal range 2-6 psi) _____
3. _____ Checks during Grab Sequence
   _____ Watch ACP filter lights to verify filter wheel changes position smoothly, ie without skips
   _____ Verify ACP filter lights do not blink excessively
   _____ Verify an image is grabbed for each filter position
   _____ Verify the program moves the occultor to the new position
4. _____ Inspect the diagnostic files:
   _____ Press S for status, and then inspect the resulting diagnostic file for abnormalities (Ref Memo AV01-083t).
   _____ If feasible, have a system administrator let you look at one of the files such as 21131200.dgn and check for abnormalities (Ref Memo AV01-083t).

B) Inspection of "White Box" Environmental Housing

1. _____ Occultor Inspection
   _____ Verify brake releases before arc is moved and sets on completion
   _____ Verify arc is in correct position to shade dome
   _____ Verify trolley is in correct position to shade dome
2. _____ Other Outside Inspection
   _____ Inspect the dome, indicate whether it is clear, somewhat cloudy, or very cloudy
3. _____ Inspect Inside of housing
   _____ Record flow rate, should be close to the value read from ACP _____
   _____ Record env hsg temp, should be close to the value read from ACP _____
   _____ Record CCD temp, should be close to the value read from ACP _____

_____ Check for standing water or other signs of problems _____

Appendix [to User Log]

A1. Installing the lamp in the URS

1. _____ If the URS is on the WSI, remove it (Secn A4 steps 1 – 11), and be sure the lamp is cool –without touching it – before proceeding.
2. _____ Using a 5/32" hex wrench, remove the URS from the mounting device by removing the three ¼-20 hex-head screws that attach the URS mounting plate to the cylindrical mounting device.
3. _____ Remove the 4 hex-head screws from the corners of the blue URS, then put the shutter lever in an intermediate position between open and closed, and lift the cover off the device. (These instructions are also given, with illustrations, in the URS-600 manual.)
4. _____ Use a 3/16" hex wrench to remove the fan mounting bracket screw and flat washer.
5. _____ Gently pull the fan shroud assembly straight back to remove it, noting how the wire cable is routed in a small cutout on the left side of the assembly.
6. _____ Support the ceramic lamp socket with one hand. Use a Phillips screwdriver to remove the two small screws from the rear of the ceramic lamp socket.
7. _____ Being very careful not to touch the glass of the lamp, remove the ceramic lamp socket by pulling it straight back to reveal the lamp.
8. _____ Carefully grasp the ceramic lamp base and pull it straight out from the ceramic lamp socket to remove the lamp.
9. _____ Carefully unpackage the new lamp and observe the polarity of its pins. Carefully grasp the lamp's ceramic base and insert its pins into the ceramic lamp socket.
10. _____ Carefully insert the lamp's glass envelope into the rear of the reflector. Line up the screw holes in the ceramic socket with the standoffs for mounting. Secure the socket in place with the two small Phillips screws.
11. _____ Place the lamp wire cable into the cutout on the left side of the ring during the next step. Hold the cable in place so that the wires do not get crushed.
12. _____ Slide the fan shroud assembly over the ring and secure in place with the screw and flat washer. Use a 3/16" hex wrench to tighten.
13. _____ Position the shutter lever in the straight up position.
14. _____ Carefully lower the cover onto the base plate. Be careful not to crush the gasket. Secure the cover in place with the four cover mounting screws. Use a 5/32 hex wrench to tighten these four screws securely. Return the shutter to "Open".
15. _____ Reattach the URS to the mounting device using the three screws.

A2. Set up the URS Abs Cal Device

1. _____ Before setting up the URS, make sure a plastic sheet is available in case of rain or snow. There should be one in the kit.

2. _____ Initial assembly of the URS requires the user to locate the Offset Filter Pushrod assembly, the URS Mounting Legs, and the URS Front Restraint. The mounting legs and front restraint are found in plastic baggies within the storage compartment of the Power Supply and Parts Case.
3. _____ Lift off the top of the URS Mounting Canister by removing the eight 6-32 pan head phillips screws found around the base of the Canister. (Note: Canister will drop about ¼" when last screw is removed.)
4. _____ Attach the four URS Mounting Legs to the base ring of the URS Mounting Canister in the four slots provided, using two 8-32 flat head phillips screws for each leg. The legs should protrude outward, with the counter-sink holes facing up.
5. _____ Replace the top of the URS Mounting Canister and reattach the eight 6-32 pan head phillips screws removed in step 2.
6. _____ Take out the Offset Filter Pushrod assembly and unscrew the PVC rod cover from the metal bracket. Slide out the stainless steel rod and place it and the PVC cover to the side. Attach the remaining black anodized bracket to the top plate of the URS Mounting Canister using the two 8-32 socket head screws provided near the East rim of the canister. (The hole for the rod goes below the top of the canister.)
7. _____ Take the stainless steel rod out of the cover, and slide it into the hole in the bracket until it encounters resistance with the filter plate located inside the top plate of the canister. Screw the rod into the mating hole in the filter plate. Confirm that you can use the rod to slide the filter into and out of position.
8. _____ Reattach the PCV cover to the device until ready to use.
9. _____ Clean the sliding filter if it appears dirty.
10. _____ Remove the plastic cover that goes over the hole in the URS integrating sphere.
11. _____ The blue URS Device is normally left attached to the URS Base Plate. Attach the assembly via the Base Plate to the URS Mounting Canister using the three ¼-20 screws on the West side and a 5/32 hex wrench. The URS goes vertically, with the attenuator label to the East and connector ports on top.
12. _____ Attach the URS Front Restraint to the top of the URS Mounting Canister using the two 8-32 socket head screws supplied. Tighten down the two 8-32 pan head screws located on the wall of the Restraint until they are flush with the surface of the URS Device. It may be necessary to loosen the Phillips screws on this restraint.
11. _____ Using the Occultor ACP, move the occultor to approximately 135°.
12. _____ Remove the top sun shield from the environmental housing. This requires removing eight ¼-20 socket head screws and four eye bolts from the top of the housing (Note: some units do not have the eyebolts installed). Be careful not to scratch the dome when removing the shield
13. _____ Remove the sponge pads from around the camera housing, and clean up any standing water.
14. _____ Clean the dome using soft paper or cloth and distilled water.
15. _____ Remove the outer ring of screws that holds down the dome plate, so it will be easier to remove for the Dome calibration.
16. _____ Connect the blue Detector cable to the back of the URS (on top), in the port labeled "Detector".
17. _____ Connect the fan power supply cable to the URS port labeled "Fan".

18. _____ Connect the black mesh Lamp cable to the URS port labeled "Lamp".
19. _____ Mount the URS Device on the WSI, with the URS Base Plate facing West.
20. _____ If desired, attach the URS Device to the occultor base plate via the URS Mounting Legs using four 1/4-20 bolts.
21. _____ Place the Halogen Lamp Power Supply on a convenient surface, with the Integrating Sphere System Controller on top. They should be facing so that the meters can be seen by a user touching the URS attenuator rod.
22. _____ Connect the other end of the blue Detector cable to the back of the System Controller (SC-5500 Integrating Sphere System Control), port labeled "Silicon Germanium".
23. _____ Connect the power cable labeled "URS Fan Pwr Supply" to the Fan Power Supply, which is attached to the URS. Plug the other end of this power cable into the power strip supplied with the field cal kit. Put the fan power supply on the URS so it won't strain the cable.
24. _____ Connect the other end of the black mesh Lamp cable to the back of the Power Supply (LPS-200-H Halogen Lamp Power Supply), in the port labeled "Output".
25. _____ Connect the 37-pin connector into "Digital Output Control" output on the System Controller and tighten down the screws.
26. _____ Connect the other end of this cable into the "Remote" port on the Power Supply.
27. _____ Plug the power cord for the SC-5000 System Controller into its power port, and plug the other end into the power strip.
28. _____ Plug the power cord for the LPS Power Supply into its power port, and plug the other end into the power strip.
29. _____ Plug the power strip into a convenient power source, and turn on the power strip. You should hear the URS fan turn on.
30. _____ Turn on the Power Supply by toggling the switch to 1. There is an initial self-check, and the light on "Start" should be on during this self-check. This lasts about 15 seconds.
31. _____ If the system was last used with the URS device, it should say "5.940 I-Set" on its bottom line. If it has some other value, touch the "Options" button, then push the button with the up triangle until the window shows "URS-600 Derated", then push "Stop". (Note, the URS was calibrated with the lamps at a slightly derated current setting, in order to provide longer life.) (If there is no text on the display, then the one of the IC's may have come loose in shipping – it's Ok to remove the cover and make sure everything is well seated.)
32. _____ Push "Start". This should start the lamp ramping up, and I-Out should start to increase. The green light should also come on.
33. _____ **Note the start time in the lamp log, along with date and other entries.**
34. _____ Turn on the System Controller by toggling the switch to 1. After it finishes the start-up cycle, it will show an output in Amps. Push "Auto" for auto gain. Then set the system for 4 ½ digit accuracy by pressing "Options", then "Up" until 4 ½ shows, then "Cal".
35. _____ You should start to see the readout on the System Controller increase. If not, verify that the shutter is open on the URS Device and the variable attenuator is at least partially open.

36. _____ Open the variable attenuator all the way by turning the micrometer handle as indicated to a hard stop. The handle can turn a total of approximately 40 turns from full open to full close.
37. _____ Pull out the Offset Filter by unscrewing the PVC Cover, and pulling the small metal Pushrod to its fully extended position.
38. _____ When 20 minutes have passed, verify that the lamp current on the power supply, I-Out is 5.940. Record this lamp current of about 5.940: _____
39. _____ On the System Controller, the photodiode current should be near 1.1E-6. Note it here and on the lamp log. It should be similar to previous values. Note the photodiode current: _____
40. _____ Set the Sensor ACP On, with the switch set in Computer. (The other switch settings do not matter for this procedure.)

A3. Program Details

1. _____ Most segments of the calibration program will allow you to decide whether to do them. A response of Y or Yes will start the segment, and a response of N or No will skip the segment.
2. _____ Most of the calibrations will give you the choice between pressing "Enter" after each image, or going into automatic mode. The first mode is more convenient if you are wanting to inspect the images, but the second is the normal mode which is more convenient.
3. _____ Many of the calibrations will have a "Setup" phase, when it is doing pre-programmed self checks, to try to determine the best combination of URS setting and WSI exposure settings to use for the given calibration.
4. _____ If the program is not successful in the setup phase, it will give you a list of things to check, such as verifying that the shutter is actually open. If you can't find a reason for the problem, you can try running program \calib\camchk to acquire images for test and evaluation. Also, if for example the program says that the signal is too bright, you can try starting the program again, skipping to the section you were on, and try using a slightly lower variable attenuator setting.
5. _____ Most of the calibrations will have a phase in which they actually acquire the data which will be saved and used to process the calibrations. Most of these take some time, as the WSI is automatically acquiring images at a variety of exposures and in a variety of filter selections during the time.
6. _____ Throughout the code, yellow is used when the program is reporting values, purple means you should wait for it to complete a process, and blue means that it is waiting for information it requested from you.
7. _____ The program may ask you to read the photodiode output. This is the current output on the System Controller. If you do not see four digits, then press the Options button, then Up until you see the 4 ½ digit display, and then press Cal.
8. _____ If you need to exit the program before the end, finish the section you're in and respond N or No to the question of whether you wish to run the next section.

A4. Remove the URS and Set Up the Uniformity Device

1. _____ **Push STOP on the Power Supply before you turn off the power.**
2. _____ **Enter the lamp stop time in the log.**
3. _____ Push in the filter flag on the URS-600 and put on rod cover.
4. _____ Turn off the power to the System Controller by toggling the switch to 0.
5. _____ Turn off the power to the Power Supply by toggling the switch to 0.
6. _____ Turn off the power strip.
7. _____ Disconnect the blue Detector cable from the back of the URS (on top), in the port labeled "Detector".
8. _____ Disconnect the power supply cable from the URS port labeled "Fan".
9. _____ Disconnect the black mesh Lamp cable from the URS port labeled "Lamp".
10. _____ Disconnect the other end of the black mesh Lamp cable from the back of the Power Supply at the port labeled "Output".
11. _____ Lift the URS off the WSI and set somewhere safe.
12. _____ Lift the Uniformity Device onto the WSI, with the 0 point to the West.
13. _____ Insert the two Uniformity alignment blocks into the spaces on the East and West side of the occultor plate, to hold the hemisphere approximately centered over the dome.
14. _____ Plug the uniformity power cord into the port labeled "Output" on the back of the Power Supply.
15. _____ Turn on the power strip.
16. _____ Turn on the Power Supply by toggling the switch to 1. There is an initial self-check, and the light on "Start" should be on during this self-check. This lasts about 15 seconds.
18. _____ If the window does not say "4.167 I-Set", touch the "Options" button, then push the button with the up triangle until the window displays "HLS-100-50 50 Watts", then push "Stop". Now it should say "4.167 I-Set". **Do not run the uniformity lamp at the URS lamp current; always run it at 4.167.**
19. _____ Push "Start". This should start the lamp ramping up to a current of 4.167 A.
20. _____ **Note the start time in the Uniformity lamp log, along with date and other entries.**
21. _____ You do not need to turn on the System Controller for this calibration.
22. _____ If the light does not come on or the current does not start to ramp up, there may be no lamp in the uniformity device, or it may have broken in shipment. Instructions for changing the lamp are given in the Appendix Secn A6.

A5. Turn off the Uniformity Device

1. _____ **Push STOP on the System Controller before you turn off the power.**
2. _____ **Enter the lamp stop time in the log.**
3. _____ Turn off the power to the Power Supply by toggling the switch to 0.
4. _____ Turn off the power strip.
5. _____ Disconnect the uniformity power cord from the back of the Power Supply at the port labeled "Output".
6. _____ Remove the Uniformity device and put it somewhere safe.

7. _____ When you are finished with the system, disconnect the rest of the cables, and pack the components back in the field kit cases. Check the list to make sure you have everything packed.

A6. Install a new lamp in the Uniformity Device

1. _____ Be sure that power is off on the Power Supply, and the lamp has had time to cool.
2. _____ Loosen the two set screws on the small lamp housing cylinder using a .035" allen wrench (supplied with the field kit).
3. _____ Remove the lamp housing from the hemisphere, then carefully pull out the lamp, while holding the lamp with clean lint-free paper. It is fairly tight to pull out; you don't need to loosen any of the screws.
4. _____ Push in a new lamp. If possible, seat both pins all the way down. If not, seat it so that one pin is all the way down, and then make sure the lamp is not tilted in its housing.
5. _____ Reinstall the lamp housing, with one screw to the top and one to the left.
6. _____ Switch to a new log for this lamp.

3. Maintenance of the Field Cal Device, and Replacement Parts

The WSI Field Kit contains the components listed in Table 3-1. All components are in shipping containers. All but the small hand-carry lamp case include roller wheels.

The maintenance steps are the following:

Batteries should be removed from the inclinometer and the radio transmitters when they are not in use, and replaced if necessary prior to trips. These use one 9V and three AA batteries. Plastic drop cloths (9 ft x 12 ft x .7 mil, for example) can be purchased for about $1 at hardware stores. Wet drop cloths should not be put back in the field kit. Sufficient new drop cloths to use in case of rain should be purchased for each trip.

Calibration lamps should be hand carried, not shipped, and handled with great care. They should not be subject to vibration stress. Never touch the glass with bare hands.

Logs of lamp use should be kept up to date, as instructed in the User Log. It is not clear how often they need to be recalibrated. Labsphere was unable to provide recommended hours – it can be fairly long, because the photodiode device will monitor any changes, and the photodiode results are used to adjust the calibration. We recommend recalibration after 200 hours.

The manuals for the URS-600 device, LPS-200-H Halogen Lamp Power Supply , and SC-5000 System Controller have been included in the Field Kit. These devices were all provided by Labsphere. The manuals for the inclinometer (Anglestar Protractor), two-way radio, and Brunton transit are included in this operations manual in the appendix.

In case of problems, users are welcome to contact Janet Shields, Marine Physical Lab, (858) 534-1769, jshields@mpl.ucsd.edu. If we are unavailable, then for problems specific to the Labsphere devices, contact Labsphere at (603) 927-4266.

The calibration lamps are:

For the URS device, IHLS-DM-45SF
For the hemisphere, DZE/FDS OC-03032

The URS lamp must be calibrated spectrally, both with and without the offset filter in place. These results are used to compute an effective lamp calibration for each lamp integrated in the WSI filter passbands, as described in Section 4.3. These values must be further corrected based on cross calibrations with standard FEL lamps, as we found problems with the Labsphere spectral calibrations. This correction should be based on measurements acquired at MPL if possible. If this is not possible, the values can be corrected using calibrations from any standard FEL lamp. In this case, it is important to be careful that the target presented to the WSI has the same size on the image that the URS source has, and the FEL response is integrated over the WSI passbands.

Table 3 - 1
WSI Field Cal Kit Contents

1. **URS Lamp Case 9.5"W x 7.5"D x 4.5"H** (will be hand-carried)
   Primary and spare lamp for URS
   Two spare lamps for Uniformity device

2. **Absolute Device Case 37"W x 21"D x 19"H**
   URS-600 Source
   URS-600 Mounting Canister

3. **Uniformity and Geocal Case 30"W x 29"D x 21"H**
   Uniformity Device; 20" Diameter Hemisphere w/floor and lamp sticking out
   Unif Device lamp and power cable attached to device
   GeoCal Device 25" Diameter x 3" high ring

4. **Power Supply and Parts Case 34"W x 27"D x 22"H**
   LPS-200-H Halogen Lamp Power Supply 17" x 16" x 5.25"
   SC-5500 Integrating Sphere System Control 17" x 16" x 5.25"
   Case includes a space 16" x 7" x 11" to hold the parts consisting of:
   - Inclinometer and controller
   - Pocket transit
   - Transit tripod 21" long
   - True North Alignment Device
   - URS Mounting Canister Legs and Front Restraint
   - URS Offset Filter Push Rod
   - SC-5500 Power Cable
   - LPS Power Cable
   - URS Fan Power Supply
   - URS Fan Power Supply Cable
   - URS Lamp Power Cable
   - URS SiGe Detector Cable
   - Digital Interface Cable
   - Power Strip
   - Spare 9V battery for Inclinometer
   - Plastic sheet or drop cloths
   - 2 radio transmitters
   - Spare Fasteners
   - A folder for paperwork and instructions, which should include:
     - Field Cal Operations Manual
     - Log folder for Absolute URS Device Lamps 1-4
     - Log folder for Uniformity Device Lamps 1-2
     - User Log folder (master plus one for each unit to be calibrated)
     - WSI Calibration Logs, SGP and IOP
     - WSI Calibration Logs, TWP
     - WSI Calibration Logs, NSA

Field Cal Kit Contents list
Labsphere Manual

4. Principles and Use of the Software

The primary software package for data acquisition is the program FieldCal. This program is documented in in-house Memo AV03-011t, which is repeated in Section 4.1 (with minor edits representing different table numbers etc). The program may evolve in the future, in which case a new memo will be issued. The data are processed using Program FieldCalProc, which is documented in Memo AV02-039t and repeated in Section 4.2. Derivation of the inputs to the FieldCalProc program is discussed in Section 4.3.

4.1. The Field Cal Acquisition Program, FieldCal

Program Fieldcal was written for the DOS based ARM WSIs. It is used in conjunction with the field calibration device to acquire radiometric and angular calibrations in the field. The program guides the user in performing the following calibrations: Dark, Shutter, Linearity, Absolute, Dome, Uniformity and Geometric. The procedures for calibrating the system and running the program are given in the WSI Field Calibration Log, which will be provided to the sponsor and will also be included in the Operations Manual. This memo outlines the structure of the Fieldcal program. The files that make up Fieldcal are listed in Table 4-1. A logic outline for the program is shown in Table 4-2.

The program is designed to require minimal user interaction, and yet allow flexibility where practical. For example, the program is designed to determine a reasonable choice of source brightness and exposure for each measurement, and then automatically acquire the calibration data. The details of this logic are included in in-house notes and in many of the calibration subroutines.

The individual segments of the program may be either run or skipped as desired by the user. A response of Y or Yes will start the segment, and a response of N or No will skip the segment. Also, most of the calibrations will give the user the choice between using a slow mode or fast mode. In the slow mode, the user has longer to view the images, but must press "Enter" after each image; in automatic mode, images are shown for a short fixed period. The first mode is more convenient if the user wishes to inspect the images, but the second is the normal mode which is more convenient.

Many of the calibrations have a "Setup" phase, when the system is doing pre-programmed self-checks, to try to determine the best combination of URS setting and WSI exposure settings to use for the given calibration. Following this, most of the calibrations have a phase in which they actually acquire the data which will be saved and used to process the calibrations. Most of these take some time, as the WSI is automatically acquiring images at a variety of exposures and in a variety of filter selections during the time.

Since the program had to be written for DOS, there was less flexibility in making the output user-friendly than we would have liked. However, to aid the user, some color

conventions have been used for the output on the monitor. Throughout the code, yellow is used when the program is reporting values; purple means the user should wait for it to complete a process, and blue means that it is waiting for information it requested from the user.

The program may ask the user to read the photodiode output or adjust the aperture to adjust the light level. This photodiode output is the current output on the System Controller, which will be located by the WSI environmental housing. (Automated controls available from Labsphere were not felt to be sufficiently robust or cost efficient for this application.) Small radio transceivers have been provided to aid in communication between a person outdoors at the environmental housing and one indoors running the program.

If the user needs to exit the program before the end, the cleanest approach is to finish the section in progress and respond N or No to the question of whether to continue with the next section. This method allows the program to close any open files and free memory that was being used by the program. Ctrl-C'ing out of the program is not recommended. Data may be lost if the program isn't allowed to properly close files and free memory.

Program FieldCalProc is designed to process the calibration data acquired by this program and is documented in Memo AV02-039t.

We should probably note that although fairly extensive tests of portions of the code were completed, we performed less test of the complete code than we would normally desire, because we didn't want to run too many hours on the calibration lamps, and we only had one instrument in-house for test. As we try the program on different instruments, with different responsivities and other characteristics, we may find that we have to modify some of the logic that we used within the program.

Table 4-1. FieldCal Files and Subroutines

Filename(.C)	Subroutines within file
Fieldcal	Main, GetBasicInfo, ShowURSInstall, ExitProg
ACPUtil	enable_fltrchgr, read_fltr, move_fltr, PositionFilter, ReadMeters, camera_on, camera_off
Basicam	CameraInit, load_ops, cam_get, dos_tick, SetExposure, GrabImage
DarkCor	DarkCor
Delay	Delay
DiskIO	LoadRaw, SaveRaw
Display	VgaViewImage, ViewImage, Rescale, AutoRescale, GraphHisto, bios_write, bprint, crt_cls, crt_src, sidebar_clr, GetImageDisplayMode, DisplayFailureScreen, DisplayHemiList, ShowDomeInstall
GetROI	GetROICenter, GetUniROICenter, CursorOnOff, ShowROI, GetAvginROI, DrawBox, GetROI, GetUniROI
HdrUtil	MakeHeaderSkeletons, EmbedHeader0, EmbedHeader1, EmbedHeader2, EmbedAbsHeader3, SetDefaultHeader0Vals, SetDefaultHeader1Vals, XferHdrParams, SaveBasicHeaderInfo, ReadBasicHeaderInfo
Imgsetup	ImageSetup, GetImageSize, GetActiveImage, initimg, mem_alloc
Initcond	GetInitialConditions
Julian	Julian
AbsCalib	GetAbsoluteCalibInfo, DoAbsoluteCalib, DoMoreAbsoluteGrabs, DoSpectralGrabs, GetGoodExposure, GetEndAbsoluteStuff, SaveAbsoluteParams, AbsoluteSelfCheck, ReadCheckVars, GetL, GetA, CompareA, DoRelativeChecks
DomCalib	GetDomeCalibInfo, DoDomeCalib, DoMoreDomeGrabs, DoDomeSpectralGrabs, DoNoDomeSpectralGrabs, GetEndDomeStuff, GetNoDomeStartPD, GetGoodDomeExposure, SaveDomeParams, DomeSelfCheck
DrCalib	GetDarkCalibInfo, DoDarkTest, DoDarkGrabs, DarkSelfCheck, SaveDarkParams
GeoCalib	GetExpND, GetGeometricCalibInfo, DoGeometricCalib, SaveGeometricParams, ReadLatLong
LinCalib	GetLinearityCalibInfo, DoLinearityCalib, DoMoreLinearityGrabs, LinearitySelfCheck, GetLinearityEndStuff, SaveLinearityParams
ShCalib	GetShutterCalibInfo, DoShutterCalib, DoMoreShutterGrabs, ShutterSelfCheck, GetEndShutterStuff, SaveShutterParams
UniCalib	GetUniformityCalibInfo, DoUniformityCalib, DoMoreUniformityGrabs, UniformitySelfCheck, GetEndUniformityStuff, SaveUniformityParams, DarkImageSetup, DarkImageFree
TimeDate	GetDate, GetDateString, GetTime, GetTimeString

Table 4-2. Fieldcal Logic Outline

System Setup
- Allocate Memory
- Setup display
- Setup filter changer ports
- Turn on camera system
- Setup headers and default variable values

Get Basic Info From User
- Site
- Calibration number
- Operator initials

Get Initial Conditions
- Save RunWSI6M input files
- Grab red, blue, NIR, clear and dark images

Do Dark Calibration

Do Dome Calibration
- Do dome calibration with old dome
- Do dome calibration with no dome

Do Shutter Calibration

Do Linearity Calibration

Do Absolute Calibration
- with ND3 filter
- with ND2 filter
- with ND1 filter

Do Dome Calibration with new dome

Do Uniformity Calibration

Do Horizon Geometric Calibration

Prompt user to perform North Alignment Procedures

4.2. The Field Cal Processing Program, FieldCalProc

This section describes new software for performing calibrations using data acquired with the Field Calibration Device (FCD) developed for ARM, as described in in-house documents 'WSI Field Calibration Device Design' (J. Shields, 9/2000) and 'Supplemental Development of the ARM Whole Sky Imagers Field Calibration Device' (J. Shields, 5/2001). The original memo, from which this is extracted, serves primarily as an operator manual; therefore, discussions of the nuts and bolts of the calibrations are kept to a minimum. FieldCalProc, which incorporates a Graphical User Interface (GUI), was written using IDL 5.5 in a Microsoft Windows environment, and has been tested on IDL 5.3 and 5.4. Trial runs of the software have been made using actual data collected using the FCD. While every attempt has been made to assure the software runs as expected, bugs are bound to be present, and should be reported to the author when found.

The software was written and tested using a Dell Dimension 4100 desktop computer with an Intel® Pentium III 933 Mhz processor and Windows® 2000 Professional operating system. On slower computers, the calibrations may be performed more efficiently by minimizing the number of other processes that are run simultaneously with FieldCalProc. As stated in the next section, scrolling output information is sent to a display window during calibrations. Since this can slow the processing down, an option exists to erase previously displayed information.

The calibrations covered by FieldCalProc include shutter, linearity, dome, absolute, and uniformity. Additionally, FieldCalProc may be used to perform uniformity calibrations for a separate ARM instrument, the Diffuse Field Camera NIR sensor. This option is discussed in a separate memo. The software is designed to perform a full suite of calibrations from the FCD with a minimum of interaction on the part of the user. In all but one calibration (uniformity), the user is required only to select which calibration to run and perhaps designate the location of input files in the directory tree.

4.2.1. GUI Basics

FieldCalProc may be started using two different methods. The first option is the **FieldCalProc.sav** file, which allows the software to be run without the source code. If this file is available, simply double-clicking on it should start the software (IDL does *not* need to be running). If this doesn't work, chances are the '.sav' type is not associated with runtime IDL (IDLRT). Under Windows this can be done by right clicking on the file, choosing **Open With...** and selecting **IDLRT**. Other operating systems probably require something similar. Alternatively, the program may be run from compiled source code by typing **fieldcalproc** at the IDL command line. At this point the GUI should appear, along with a warning to keep output files closed during the calibration. This warning only applies to word processing programs that do not allow files that have been opened for editing to be simultaneously used by other programs (e.g., Microsoft® Word). When this warning is dismissed, a second dialog box appears giving the user an option to change the default path where output files are written. Whatever directory is selected

cannot be modified without restarting FieldCalProc. The default input directory is the current working directory when FieldCalProc is started. If this is the directory the input files are stored in, the software will automatically select any input file that matches the form specified for a particular calibration. If the input files are stored elsewhere, a new input directory can be established when the first calibration is run. It is wise to keep data from different calibration sets in separate directories (e.g., all calibrations from a specific date would be placed in a single input directory), as this eliminates the need for the user to select from multiple input files when performing a calibration.

Figure 4-1 shows the FieldCalProc GUI. The GUI lists the calibrations on buttons at the left, with a scrolling output window filling most of the space to the right. To run a calibration, the user simply clicks on one of the buttons shown. Additional buttons at the bottom left of the GUI allow the user to erase the contents of the output window and end the calibration session.

Except for the **Finalize Calibration Constants** option, the order in which calibrations are performed does not matter. The **Finalize Calibration Constants** option cannot be run prior to the absolute calibration. When a specific calibration is run, relevant information is shown in the output window. As additional information is displayed, the old lines scroll toward the top of the output window, eventually disappearing beyond the top edge. When the calibration finishes, the current window is replaced with one that has horizontal and vertical scroll bars (if needed), allowing the user to view all output. As additional calibrations are performed, the output information is added to the existing log.

If any fatal error occurs during a calibration, the calibration is aborted and any applicable error messages, along with the current date and time, are written to a log file called **Errors_FCP.out**. This file resides in the current output directory (specified in the output window), and new errors are appended to the file as they occur. Whenever any error occurs, this file should be sent to the author for examination. If a non-fatal error occurs, it will also be written the error log file, but the calibration will not be aborted. If FieldCalProc is being run using IDLRT, no line numbers will be written to the error log file.

4.2.2. Calibrations

Each calibration type has different input/output files, and some have input options that are specified by the user, rather than contained in an input file. This information, as well as any other differences, is given below under each calibration heading.

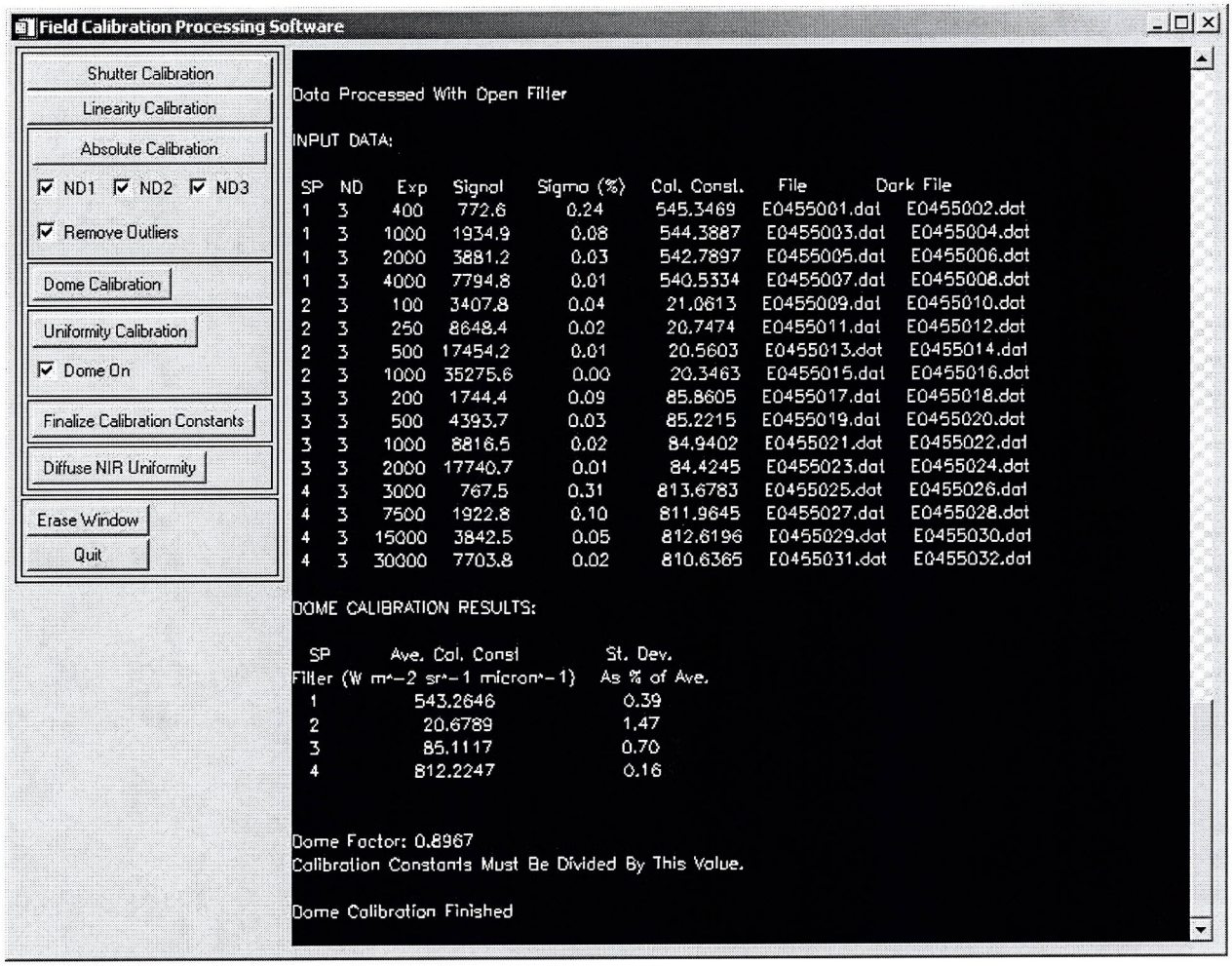


Figure 4-1. FieldCalProc GUI with ex ample output.

4.2.3. Shutter

The input file created in the acquisition program for the shutter calibration has the form **S*sum.log**, where the * is replaced with the calibration number. If this file is not found in the current directory, a dialog box will appear, asking the user to specify the location of the file. A similar dialog box appears if multiple files with this form are found in the same directory. An output file with the form **FieldCal_Shutter_S*sum.out**, that contains information similar to that given in the output window, is saved to the output directory at the end of the calibration. A plot of the regression line determining the effective shutter opening time is also saved in the form **ShutterPlot_S*sum.ps**.

4.2.4. Linearity

The linearity calibration follows similarly to the shutter calibration. Input and output files are of the same form, only an **L** replaces the **S** used in the shutter calibration. As with the shutter calibration, a plot of the linearity is included in the output.

4.2.4. Absolute

The absolute calibration requires several input files, depending on how many neutral density (ND) filters need to be analyzed. Three checkboxes next to the absolute calibration button specify the three possible filters. The default is to have all ND filters analyzed. The user can click on the box next to the filter number to remove or add a filter. The input file formats for ND1, ND2, and ND3, are **A*sum.log**, **B*sum.log**, **C*sum.log**, respectively.

In addition to the log files for each ND filter to be calibrated, a second file is required that contains additional input parameters that are independent of the calibrations. There are three such files, one for each available spectral radiance source. The file form is **FCP_Input*.dat**, where the * represents the lamp number (at the time of this writing, only three calibrated lamps were available). Each file contains the spectral radiances (also referred to as LBAR values) from a Labsphere URS-600 Uniform Radiance Standard. The LBAR values contain a correction to account for an offset in the URS-600 calibration and scattering effects. The LBAR corrections will be documented in a separate memo. Other parameters in the file include the standard photodiode current, absolute calibration constant corrections for standard response, and various calibration constant ranges that will be used to assess the quality of the absolute calibration results.

When an absolute calibration is performed, the user is initially asked to select an input parameter file (if more than one is available or none is found in the default input directory). Similarly, the user may be asked to identify the appropriate absolute calibration log file. This file is checked against the input parameter file to ensure the same lamp was used for both. If not, the calibration is cancelled. If the lamp used for the calibration is unclear, it is listed under 'Lamp #' in each absolute calibration header file. The software assumes that the same lamp was used for all ND filters processed. The output files for this calibration are of the form **FieldCal_Absolute_*sum.out**.

The absolute calibration can be run with an option that removes outliers in the data. The outlier algorithm is based on Chauvenet's criterion, but has been modified for the minimal number of data points found here. With the option set (the default), if an outlier is found, it will be removed prior to calculation of the calibration constant, and a note will be made in the output. If the user wishes to remove data that are not picked out by the outlier detection algorithm, the data will need to be manually removed from the input log file.

The calibration constants determined here are in raw form, and should be finalized using the **Finalize Calibration Constants** option discussed below. The output files produced in the absolute calibration will be modified when the finalization occurs.

4.2.5. Dome Calibration

The dome calibration is performed similarly to the absolute calibration, except that two input files are required. The files represent dome-on and dome-off cases, and are both produced using the same ND filter. The dome-on case has input log file form **D*sum.log**, while the dome-off case has input log file form **E*sum.log**. The output is written to a file with the form **FieldCal_Dome_D*sum.out**. The **Remove Outliers** option under the absolute calibration button applies to this calibration as well. The dome factor determined with this calibration will be applied when the calibration constants are finalized.

Note: If field calibrations include both an old and a new dome, then the processing program must be run twice. The first run will include the old dome, and generate calibration constants appropriate for the instrument with the old dome. The second run will use the new dome data, and will generate calibration constants appropriate for the instrument with the new dome.

4.2.6. Uniformity

The uniformity calibration is somewhat more involved than the other calibrations, mainly due to a larger number of input files and manual determination of the image center. If the uniformity calibration data is for the dome-off case, the checkbox next to the uniformity calibration button should be toggled off. The calibration requires the following input files: one dark current file for each exposure used; 12 raw image files for each of four spectral filters, representing each 30° camera orientation; and possibly one file containing photopic map uniformity information for the case being calibrated (dome-on or dome-off). The dark and raw image files have the form **U*.dat**, where * represents the calibration number, while the photopic maps are called either **PhotopicMapCal_Dome.inp** or **PhotopicMapCal_NoDome.inp**. As of this writing, we feel that due to data quality issues, no photopic map should be used in the uniformity calibration (as discussed in memo AV02-037t).

The software first asks the user to identify the dark files used in the calibration. There should be one dark file for every exposure used in the uniformity calibration. The **Shift** or **Control** keys may be used to select multiple files. Similarly, the user will then be prompted to identify the raw images in the calibration. If all spectral filters were analyzed, there should be 48 total images, although the software will accept any multiple of four. If an incorrect number of files are selected, the calibration will be aborted during processing.

In order to produce a final uniformity image, the center row and column and horizontal and vertical radii in the raw imagery must be found (the image center and radii are used

to apply the photopic map and to determine the ROI location). This can be done by determining the row and column of the left, right, top, and bottom edges. Adding the left and right edge columns and dividing the result by two gives the center column. Similarly, adding the top and bottom edge rows and dividing the result by two gives the center row. Subtracting the left edge column from the right edge column and dividing by two gives the horizontal radius. Similarly, subtracting the bottom edge row from the top edge row and dividing the result by two gives the vertical radius. This manual determination of image coordinates is discussed further below.

The image edge finder is a separate GUI that sits on top of the FieldCalProc GUI. Figure 4-2 shows the edge finder GUI. The left side of the GUI contains a sample image (the first NIR raw image), while the right side displays various output fields divided into cells. The top cell shows the window scaling for the image. This can be modified for easier edge locating using the **Rescale** button. The next cell down gives the cursor coordinates, which change as the cursor is moved around the image. These coordinates can be used to identify the edge columns and rows. The next cell contains the pixel values for the nine pixels surrounding the cursor. Below this cell are editable fields for the image center and radii. Finally, the bottom button is used to finish the center-finding operation.

As the image center finder appears, the sample image is displayed. Since this portion of the calibration requires a fair amount of work on the part of the user, an automated center-finder that uses edge detection has been included. White crosses at four locations represent the image edges, as found by the automated routine. The image center and radii based on these edge coordinates are displayed in the appropriate fields. The horizontal and vertical radii may vary, as some images are elliptical. The software uses the mean of the two values for the image radius. Because image edge contrast can vary widely, this technique has not been entirely successful. If the edge coordinates shown on the image do not seem correct, the user may need to manually determine the image center and radii, as discussed above. When the center and radii appear to be satisfactory, the GUI can be removed by clicking the **Done** button.

After the image center finder is removed, the software looks for the photopic map image file. If it cannot locate it in the current directory, the user is prompted to enter its location. If no photopic image map will be used, the user can simply cancel out of the file locater. Once this is done, the final images (one in each spectral filter) are produced and normalization factors are determined. The final NIR image is displayed as a sample in a separate window. Several output files are produced during the uniformity calibration and stored in the output directory. In addition to **FieldCal_Uniformity_*.out**, data files containing the uniformity image for spectral filter **x** are given in **Uniformity_SPx_*.dat**, rolloff results calculated by averaging values along the 0, 90, 180, and 270° azimuth lines are given in **Rolloff_SPx_*.dat** (data file) and **Rolloff_SPx_*.ps** (plot). The plot files can be used as quick looks to ensure the uniformities came out reasonably.

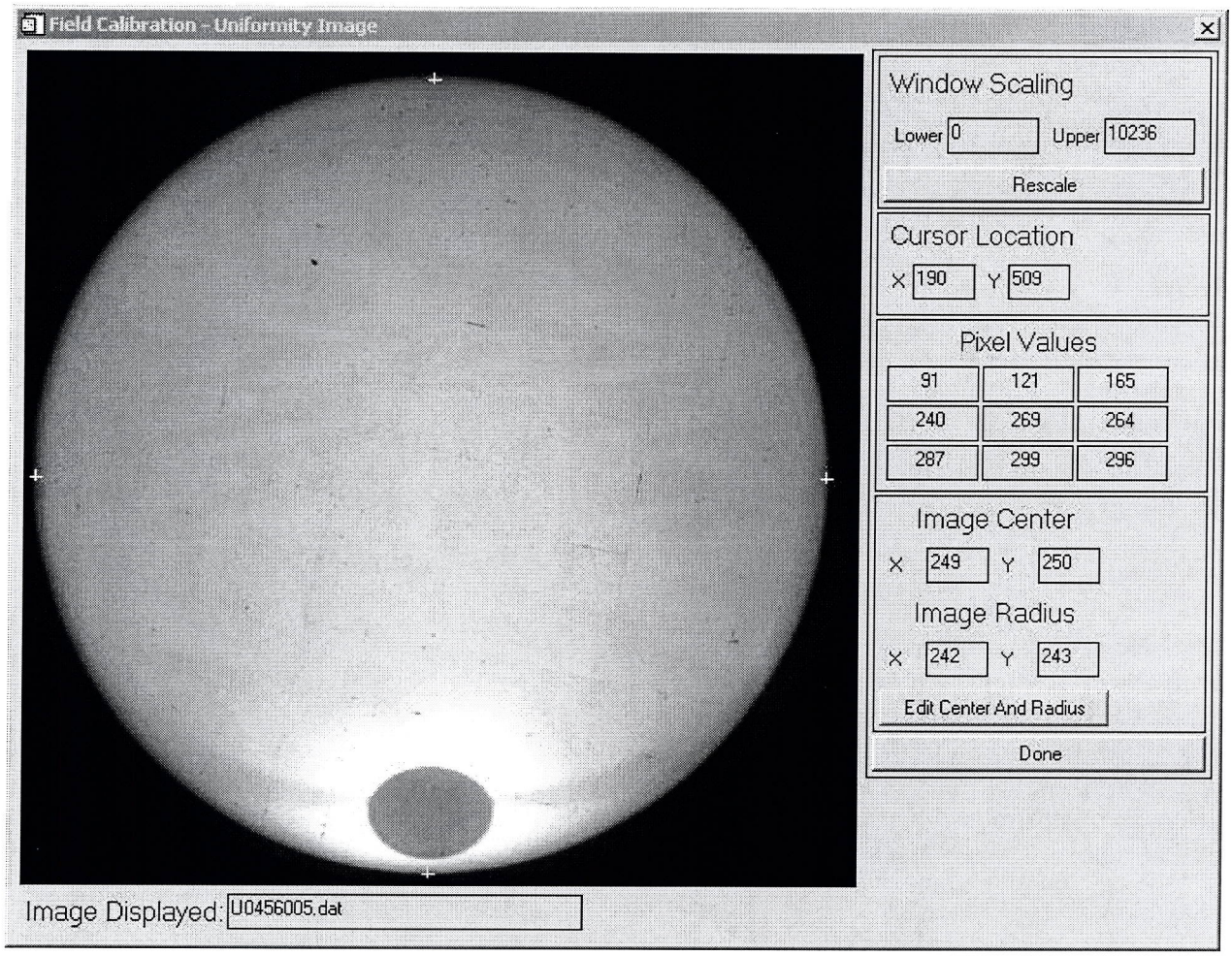


Figure 4-2 Image edge finder GUI.

4.2.7. Finalize Calibration Constants

The last step in the calibration process is to determine the final calibration constants. This step uses the corrections for standard response found in the input parameter file, normalization factors from the uniformity calibration, and the dome calibration factor in calculating the final constants. The resulting calibration constants are appended to the absolute calibration output files listed above. Therefore, the absolute calibration output files must remain in the output directory until this step is complete.

To correct each calibration constant for standard response, the calibration constant is multiplied by the appropriate standard response factor. To correct each calibration constant for dome transmittance, the calibration constant is divided by the dome calibration factor. Prior to applying the ROI correction, a determination is made for each calibration constant of whether the ROI correction is necessary. This is done by comparing the uniformity normalization factor determined using the ROI from the absolute calibration with the uniformity normalization factor determined using the image

center. If the difference is greater than 1% for a given calibration constant, it is corrected by multiplying by the ratio of the two normalization factors.

The **Finalize Calibration Constants** option may be rerun within a calibration session, if needed. For instance, if the absolute calibration and uniformity calibration have been performed, finalizing the calibration constants will produce final constants that have been corrected for standard response and any applicable ROI corrections. If the dome calibration is done after the constants have been finalized, the option can be used again to apply the dome factor. The ROI and standard response corrections will not be reapplied, and the output files will be noted to that effect.

4.3. Determining the Input Values for FieldCalProc

Program FieldCalProc, discussed in Section 4.2, is the program that processes the field calibration measurements. This program has several input values in the input file. The most complicated to derive are the effective target radiance values, Lbar. We recommend that these values be derived by MPL personnel. This memo provides an overview of how these Lbar values are derived, as well as the other values in the input file.

At present there are three calibrated lamps used with the URS, and one uncalibrated lamp. These lamps have been designated Lamps 1 – 4. Several values are required in order to compute the effective radiance of the target. These are:

a) The spectral radiance of the target for each lamp. These values are provided in Labsphere.
b) The part numbers for the CCD and filters used in each WSI unit.
c) The spectral responsivity curve for each CCD, and the spectral transmittance curves for the filters.
d) A URS offset correction, as documented in Memo AV03-014t.
e) A scattering correction, as documented in Memo AV03-015t.
f) The IDL Program xx.

The spectral radiance of the target for each lamp was measured at Labsphere, and the values were provided in a table. These tables are currently resident in Files xx, as well as in the Labsphere documentation .

The part numbers for each WSI unit are available from MPL on request. The current version numbers for each instrument are as follows:

Unit 3 Version 4	Manus
Unit 4 Version 4	MPL
Unit 6 Version 3	Nauru
Unit 7 Version 1b	Barrow
Unit 8 Version 2	Atqasuk
Unit 9 Version 1	Darwin
Unit 10 Version 1	SGP

Unit 11 Version 1 MPL

For each unit, several spectral curves must be used to compute the effective spectral radiance of the target in the WSI wavebands. These are:

Blue filter curve
Red filter curve
NIR filter curve
ND2 filter curve
ND3 filter curve
IR blocker filter curve
Camera relative QE curve

The filter curves are generally measured at OptoCal, and the files set up by MPL personnel. The camera QE curve also includes the effect of the filter in the fisheye lens. Also, QE is multiplied by wavelength, to generate a relative responsivity curve. These data are available in data files and other hard-copy documentation available at MPL.

Program XX is used to integrate all these curves using the equation

Xx

This computation results in the first estimate of effective target radiance for the WSI passbands.

However, these results must be corrected for the URS offset and the scattering factor. The URS offset depends only on the lamp (not on the WSI), and on the choice of whether the URS is run with or without the offset filter. The scattering factor depends only on spectral filter. The URS offsets and the scattering correction are shown in Table 4-3, and explained in Memos AV03-014t and AV03-015t.

To correct the Lbar values in Table 4-3 for the offsets and scattering factors, we need to multiply by the correction values and divide by the scattering factor. Memo AV03-015t shows these results for Unit 4 Version 2.

The input files for the FieldCalProc program have names which indicate Unit, Version, and Lamp. File FCPUnit4Vers2Lamp3.dat is shown in Table 4-4. This file contains the part numbers, extracted from the part listings resident at MPL. The next part of the file lists the LBAR Radiance Values. These are computed as discussed above.

The Standard Photodiode Current values are the values of the photodiode current at the time of the Labsphere calibration. These will only change if new lamps are purchased.

Table 4-3
URS offsets (FEL Lamp / URS Lamp results with and without offset filter)
and Scattering Offset

ND Filter	SP Filter	Lmp 1 w f	LMP 1 wo f	LMP 2 w f	LMP 2 wo f	LMP 3 w f	LMP 3 wo f	Scat
1	1	1.497	1.454	1.355	1.328	1.365	1.345	1.24
1	2	1.152	1.400	1.078	1.341	1.093	1.360	1.11
1	3	1.184	1.367	1.130	1.313	1.138	1.329	1.11
1	4	0.311	1.277	0.286	1.280	0.308	1.313	1.1
2	1	1.497	1.454	1.497	1.328	1.365	1.345	1.24
2	2	1.152	1.400	1.152	1.341	1.093	1.360	1.11
2	3	1.184	1.367	1.184	1.313	1.138	1.329	1.11
2	4	0.311	1.277	0.311	1.280	0.308	1.313	1.1
3	1	1.497	1.447	1.497	1.312	1.365	1.304	1.24
3	2	1.152	1.392	1.152	1.316	1.093	1.322	1.11
3	3	1.184	1.364	1.184	1.304	1.138	1.313	1.11
3	4	0.311	1.273	0.311	1.288	0.308	1.316	1.1

The Standard Response Correction is a correction that adjusts the radiance of a given instrument to the radiance which would have been measured by a standard spectral response. This is explained in Memo AV98-071t, and the standard response is given in Memo AV01-001t. These parameters may also be derived using Program XX.

The Calib Constant Range is a range of expected calibration constant results. Similarly, the Calib Constant Ratio Range and the Calib Constant ND3/ND1 and ND2/ND1 ranges are expected ranges for these calibration constant ratios. These ranges were estimated based on historic data, and based on expected possible variations. These input values do not need to be changed as a function of unit number. However, if at some time in the future we find that new filters are somewhat different in response from those currently in the instruments, these expected ranges could be adjusted accordingly.

Table 4-4
File FCPUnit4Vers2Lamp3

```
Unit #:                  04v2
Filter Changer:          114
Camera:                  967
Lamp:                    3
Blue Filter:             33
Red Filter:              30
NIR Filter:              04
ND2 Filter:              03
ND3 Filter:              05
```

IR Blocker: 03

LBAR Radiance Values:

SP	ND	Offset 0	Offset 1
1	1	332.78	4.237
2	1	195.90	0.479
3	1	247.09	0.505
4	1	67.94	0.061
1	2	334.84	4.329
2	2	220.40	0.732
3	2	248.77	0.538
4	2	78.92	0.070
1	3	322.75	4.254
2	3	246.64	1.149
3	3	254.97	0.679
4	3	70.68	0.063

Standard Photodiode Currentt 0, Offset 1):

1.216E-6 1.217E-6

Standard Response Correction:

SP	ND	Correction
1	1	0.99820
2	1	1.0000
3	1	0.97615
4	1	0.97949
1	2	1.0091
2	2	1.0656
3	2	0.98041
4	2	1.0024
1	3	0.99986
2	3	1.1635
3	3	1.0057
4	3	0.98475

Calib Constant Range:

SP	ND	Min	Max
1	1	0.5	20.
1	2	9.0	400.
1	3	35.	2500.
2	1	0.007	0.15
2	2	.50	110.
2	3	5.0	110.
3	1	0.03	0.65
3	2	2.	45.
3	3	20.	410.
4	1	.14	2.8
4	2	16.	360.
4	3	180.	3600.

Calib Constant Ratio Range With Respect To Red:

SP	ND	Min	Max
1	1	.006	0.32
1	2	0.02	1.0

1	3	0.03	2.0
2	1	0.80	18.
2	2	0.80	16.
2	3	0.80	16.
4	1	0.04	1.0
4	2	0.02	0.5
4	3	0.02	0.50

Calib Constant ND3/ND1 Ratio Range (Min, Max):

SP	Min	Max
1	25.	500.
2	140.	2800.
3	130.	2600.
4	260.	5200.

Calib Constant ND2/ND1 Ratio Range (Min, Max):

SP	Min	Max
1	4.0	400.
2	15.	300.
3	14.	280.
4	26.	520.

5. Additional Calibration and Lamp Logs

Three other documents that should be noted in this Operations Manual are the lamp logs, and the calibration log. There is a log for each of the URS lamps, in the format shown on the next page. There are four URS lamps at the present time; three of these are calibrated, and one is uncalibrated and used primarily for test. Also, there is a log for each of the Uniformity device lamps, in the format shown on the following page. None of these lamps requires calibration. Finally, there is a log for each of the WSI units, to keep track of the calibrations and calibration numbers. This is in the format shown in the third log in this section.

A notebook of all of the URS lamp logs, and an additional notebook of all of the Uniformity lamp logs, has been assembled and is included in the field kit. In addition, three notebooks have been assembled for the calibration logs. These three note books contain: SGP and IOP units (10, 4, and 11), TWP units (3, 6, and 9) and NSA units (7 and 8).

ARM WSI Field Calibration

URS-600 Lamp Log, URS Lamp #1

Lamp Serial Number: IHLS-100-150 #1
Lamp Model: GE DZE/FDS
Lamp Calibration Date: 17 Jan 02
Lamp Operating Current: 5.94 Amp

Date	Site	Oper	Time On	Time Off	Cum Time	Photodiode Current*	Remarks

*Read Photodiode current on the Integrating Sphere System Control with the aperture set fully open and the filter flag out.

ARM WSI Field Calibration

Uniformity Device Lamp Log, Lamp #1

Lamp Serial Number: HLS-100-50 (50Watt) #1 page _____
Lamp Model: L7389A
Lamp Calibration Date: Not required
Lamp Operating Current: 4.167 Amp

Date	Site	Oper	Time On	Time Off	Cum Time	Photodiode Current*	Remarks

*Read Photodiode current on the Integrating Sphere System Control with the aperture set fully open and the filter flag out. Photodiode current not applicable to Uniformity Device

ARM WSI Field Calibration

Log of Field Calibrations

Unit # 10, SGP

Page _____

Each time a WSI unit is calibrated, a new calibration number is assigned. For EACH unit, there should be a calibration #1, 2, etc. A calibration may consist of a full set run at one time (eg dark, dome, shutter, linearity, etc), or a calibration may consist of a partial set. Thus, if Unit 3 has already had calibrations 1 and 2, you should assign calib 3 for your first full data set, and then if you take a partial set the next day it would be calib 4.

Date	Site	Oper Initials	Calib #	Calibration Components Completed (Check off)								
				Dark	Dome	Shutter	Lin	Abs	Dome	Unif	Align	Geo

Appendix:

This section includes Xeroxes of the following vendor documents:

Brunton Transit
Anglestar Protractor System (Inclinometer)
Motorola Talkabout Two-way Radio
Motorola Accessories

The **BRUNTON** Co.
620 East Monroe
Riverton, WY 82501
PH: 307.856.6559
FAX: 307.856.1840
WEB: brunton.com

INSTRUMENTS PRECISION INSTRUMENTS PRECISION IN

LINE **CLASSIC**
INSTRUMENT TRANSIT
ITEM MANUAL

Owner's Purchase Record

Model _____

Date of Purchase _____

Dealer Purchased From: _____

_____

Serial #:

Printed in U.S.A.
form 51-600 rev 0011

POCKET TRANSIT
INSTRUCTION MANUAL

1 -- Important Information

Congratulations on your purchase of the finest pocket transit instrument in the world. The Brunton Pocket Transit is not just a compass. It combines a surveyor's compass, prismatic compass, clinometer, hand level and a plumb into a single instrument. Use the Brunton Pocket Transit to measure azimuth (compass bearing), vertical angles, inclination of objects, percent grade, slopes, height of objects and for leveling.

Even though all Brunton Pocket Transits are made to be rugged, durable and withstand the rigor associated with outdoor use, care must be taken to assure long-life of your instrument. Avoid impacts, dropping, extreme temperatures, store in its case and the Brunton Pocket Transit will perform.

1.1 Opening The Pocket Transit

Rotate the pocket transit until the flat cover faces up, and the small window is positioned away from you. Unlatch the cover from the base. (Fig 1)

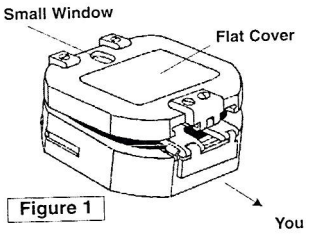


Figure 1

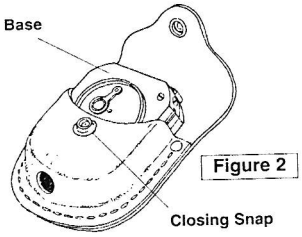


Figure 2

1.2 Protecting The Mirror

While in storage, Brunton recommends placing the pocket transit in the case, with the base against the closing snap. (Fig 2)

1.3 Direct Reading

Why are EAST & WEST switched?

Because the pocket transit is a ***direct reading*** compass. Read azimuth **directly** where the needle points on the graduated circle.

With the large sight toward the object, read azimuth directly where the north end of the needle points (white tip - 2001, 2061, 5005LM and 5006LM models, or "N" tip - 5007, 5008 and 8700 Com-Pro models). (Fig 3)

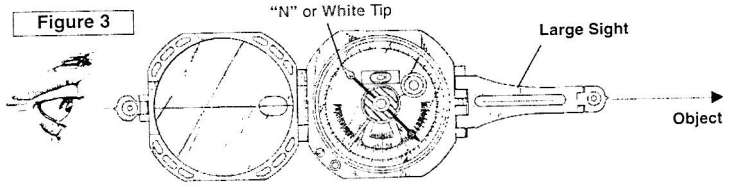


Figure 3

With the small sight toward the object, read azimuth directly where the south end of the needle points (**black** tip - 2001, 2061, 5005LM and 5006LM, or "**S**" tip - 5007, 5008 and 8700 Com-Pro models). (Fig 4)

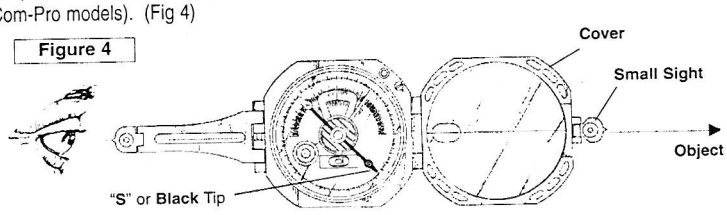


Figure 4

Detailed explanation of sighting an azimuth is in section 4.

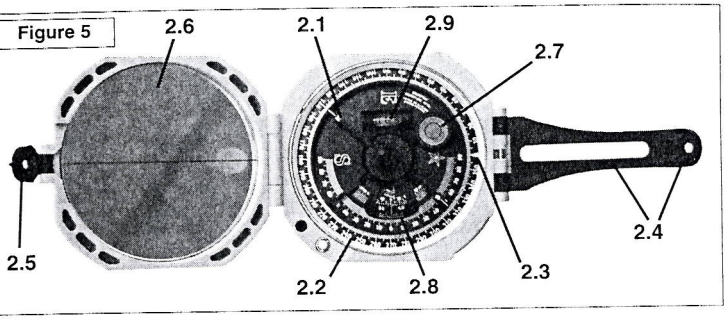
2 -- Orientation

Orientation provides a description of important pocket transit parts. A detailed description of its operation is provided throughout the manual.

2.1 Needle (Fig 5)

The needle is induction damped, which allows the needle to seek magnetic north and come to a complete rest in a minimum amount of time, without accuracy degradation.

Figure 5



2.2 Graduated Circle (Fig 5)
In combination with the needle, the 1° graduated circle allows accurate 1/2° azimuth readings on both the Degree (0° through 360°) and Quadrant (0° through 90°) graduated circles.

2.3 Zero Pin (Fig 5)
The zero pin is the pointer used for magnetic declination adjustment. If no adjustment is necessary, the pin should point at 0°.

2.4 Large Sight w/ Peep Sight (Fig 5)
The large sight and the attached peep sight are used for precise azimuth measurement.

2.5 Small Sight (Fig 5)
Attached to the cover, the small sight is used for precise bearing and inclination sighting.

2.6 Mirror (Fig 5)
Located on the inside of the cover, the mirror and mirror center line are used for accurate azimuth measurements, when using the transit as a prismatic compass.

2.7 Round Level (Fig 5)
Use the round level to level the pocket transit for azimuth measurement.

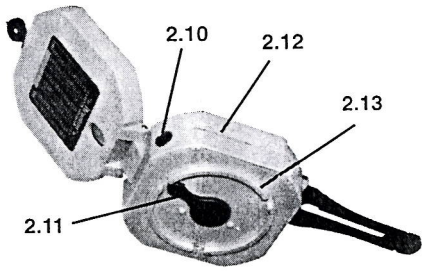
2.8 Vernier (Fig 5)
The adjustable vernier is used in inclination measurements.

2.9 Long Level (Fig 5)
The long level for inclination measurement. Adjust the long level using the vernier adjustment - 2.11.

2.10 Circle Adjusting Screw (Fig 6)
With a screw driver, rotate the graduated circle by turning the circle adjusting screw.

Com-Pro Model Shown

Figure 6



2.11 Vernier Adjustment (Fig 6)
Use the vernier adjustment to adjust the vernier and long level for inclination measurements.

2.12 Ball & Socket Tripod Mount (Fig 6)
The slots on both sides of the body are for mounting to an optional Brunton tripod.

2.13 Alidade Mount -- *Com-Pro Models Only* (Fig 6)
The circular extension with slots, located on the bottom of the body, is for the attachment of a optional Brunton alidade (protractor). Only the Com-Pro models have this feature.

3 -- Magnetic Declination

The Earth is completely surrounded by a magnetic field, and an unobstructed magnetized object will orient itself with the earth's magnetic north and south poles. Magnetic declination (variation) is the difference between true geographic north (north pole) and magnetic north (in northern Canada), with respect to your position. It is important to note magnetic declination at your position, because magnetic declination varies and fluctuate slowly at different rates around the world. (Fig 7, p.5)

East Declination

West Declination

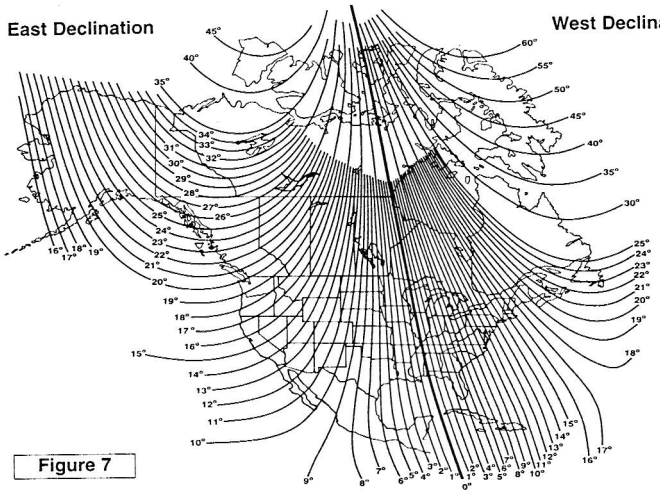


Figure 7

LINES OF EQUAL MAGNETIC DECLINATION 1995

The isogonic chart shows North America, only. Use an isogonic chart, or current United States Geological Survey (USGS), Bureau of Land Management (BLM), or another map to determine magnetic declination at your position. Declination can be east, west or even 0°, from your current position. At 0° declination, true north and magnetic north are aligned.

Example: If magnetic declination at your position is 15° east, then magnetic north is 15° east of true geographic north. Figure 8 displays true geographic north and magnetic north, as indicated in the legends of USGS and BLM maps.

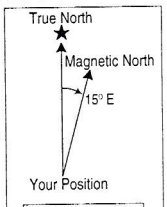
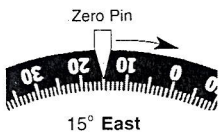


Figure 8

Most maps use true north as a reference. When adjustment for magnetic declination is complete, azimuth readings will be with respect to true north, same as the map.

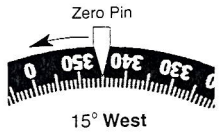
To adjust for magnetic declination, rotate the graduated circle by turning the circle adjusting screw. Begin with the zero pin at 0°. For **East** declination, rotate graduated circle ***clockwise*** from the zero pin. (Fig 9A) For **West** declination, rotate graduated circle ***counter-clockwise***. (Fig 9B) If magnetic declination is 0°, no adjustment is necessary. (Fig 9C)

Figure 9A



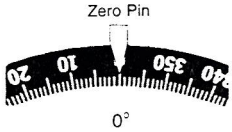
15° **East** Declination

Figure 9B



15° **West** Declination

Figure 9C



0° Declination

4 -- Azimuth Measurement

Azimuth is a term used for direction. Azimuth is normally measured clockwise, in degrees with true north being 0°. Bearing is a term often used when measuring with a quadrant type instrument. From this point forward, description of pocket transit use will involve the 0° through 360° graduated circle, and assume the pocket transit is adjusted for magnetic declination. Example of Azimuth: If a mountain is directly east of your position, the azimuth from your position to the mountain is 90°. If the mountain is directly south of your position, it would be at 180°.

Caution: The magnetic needle is highly sensitive. When sighting an azimuth, keep the pocket transit away from magnetic materials, such as watches, belt buckles, rings, knives, cigarette lighters, ... etc.

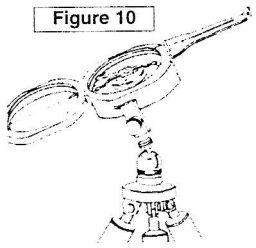
4.1 Azimuth Using a Tripod or Unipod

When the greatest accuracy is required, mount the pocket transit on a Brunton non-magnetic

tripod using Brunton's Ball and Socket head. See section 11 for ordering information.

1. Adjust pocket transit for magnetic declination.
   - See section 4, Magnetic Declination, for help.
2. Mount transit to the ball and socket head.
3. Open both the cover and large sight, until they extend parallel to the body. (Fig 10)
4. Flip small sight and peep sight up. (Fig 10)
5. Rotate transit until large sight points at object.
6. Level the transit by centering bubble in round level.
7. Sight azimuth by aligning peep sights with object. (Fig 11)

Figure 10



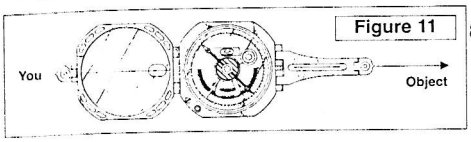


Figure 11

8. Read azimuth where the "N" end of the needle points at graduated circle -- 60°. (Fig 12)

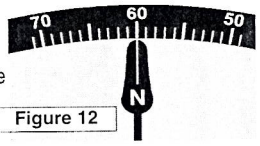


Figure 12

4.2 Azimuth Measurement Waist-Level

This method is often used when object is above or below the observer.

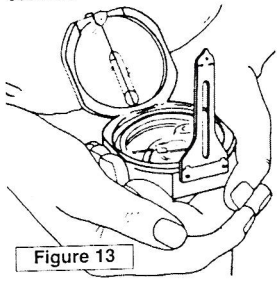


Figure 13

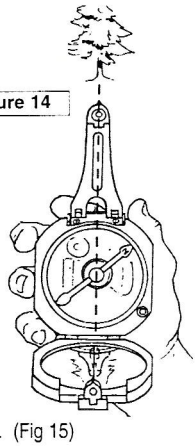
4.2.a Using "N" End of Needle

This method is often used when the object lies as much as 45° above, or 15° below the observer.

1. Hold transit waist high and in your left hand.
2. Open cover toward your body to approximately 45°.
3. Open large sight, until perpendicular to the body. (Fig 13)

4. Press left forearm against your waist and steady with right hand.
5. Level compass using round bubble level.
6. Look into the mirror, and bisect the large sight and the object with mirror center line. (Fig 14)
   - Check that bubble is centered in round bubble level.
7. Read azimuth where the "N" end of needle points at the graduated circle.

Figure 14



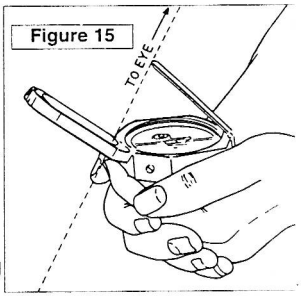
If object is more than 45° above you, open mirror further toward your body, and adjust large sight so that it leans over the bottom case. Then repeat the procedures described in 4.2.a.

4.2.b Using "S" End of Needle

Use this method when object is more than 15° below the observer.

1. Hold transit waist high and in your left hand.
2. Open cover away from your body to approximately 45° from level. (Fig 15)
3. Open large sight, until it leans over the body at approximately 45°. (Fig 15)
4. Press left forearm against your waist and steady with right hand.
5. Level compass using round bubble level.
6. Look just over the large sight, and at the object through window opening on mirror. (Fig 15)
   - Adjust mirror and large sight so the image of the large peep sight are bisected by the mirror center line.
   - Check that bubble is centered in round bubble level.
7. Read azimuth where the "S" end of needle points at the graduated circle. (Fig 16)

Figure 15



4.3 Using as a Prismatic Compass

Occasionally, objects may interfere with sighting using

methods previously mentioned, or user may encounter circumstances which require the transit be held at eye-level to sight an object. If this is the case, follow the procedures below.

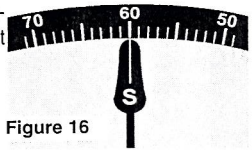


Figure 16

1. Open cover away from your body to approximately 45°, and open small sight. (Fig 17)
2. Lift large sight until perpendicular to the body, or leans slightly away from the base. (Fig 17)
3. Hold instrument at eye-level, with large sight toward you.
4. Align large sight and small sight on top of the cover with object.
   - OR - Sight object through the lower portion of large sight and the window in the mirror.
5. Level round bubble level in the reflection of the mirror.
6. Read azimuth in the reflection of the mirror, where the "S" end of needle points at the graduated circle.

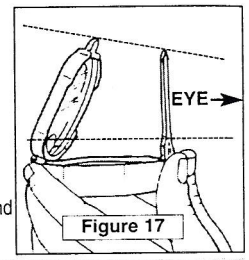


Figure 17

5 -- Vertical & Percent Grade Measurement

The Brunton Pocket Transit is capable of measuring vertical angles with accuracy better than 1°, with readings to 10 minutes. It can also display percent grade, without any calculation.

The bottom scale is incremented from 0° to 90° and is used for vertical inclination. The scale on the vernier is also used for vertical (inclination) measurement, but it is incremented from 0 to 60 minutes. (Fig 18) Closer to the center, the second scale increments from 0% to 100%. This scale is the percent grade scale.

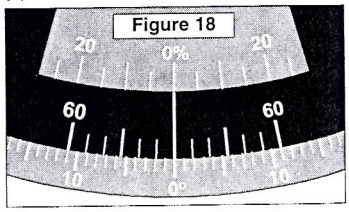


Figure 18

5.1 Inclination and Percent Grade Using Tripod

Use a tripod, or unipod for greatest inclination accuracy possible.

1. With pocket transit attached to the tripod using the ball and socket mount, tilt the head 90°. (Fig 19).
   - Transit should be on its side.
2. Lock into position using the clamp screw.
3. Align sights with object behind transit. (Fig 19)
4. Adjust vernier until bubble is centered in long level.
5. Read inclination at vernier's center line from the degree scale -- 26°. (Fig 20)

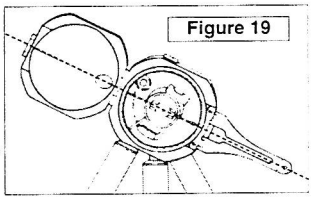


Figure 19

5.1.a -- inclination to the nearest 30 minutes

When 30 minute readable accuracy is required, use the vernier scale (0--60 min. with 10 min. increments).

1. Read inclination at vernier's center line -- 26° + ??.
2. Find minutes by determining whether the 30 or 60 min. line is closest to a degree marking.
   - A Loupe or magnifier may be required.

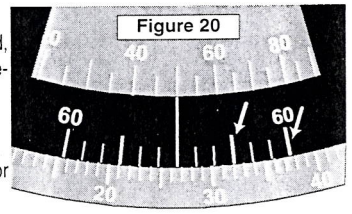


Figure 20

Since the 30 minute line is closest, the total angle is 26° + 30' (***26° 30' or 26.50°***)

5.1.b -- percent grade

When percent grade is required use the percent scale directly above the vernier.

1. Read nearest percent grade at the vernier's center line -- 50%. (Fig 20)

For greater accuracy, *calculate* the percent grade using the following equation.

Percent Grade = [tan(θ) x 100]

Measure the angle of inclination, θ = 26.5°. Then calculate the tangent of 26.5° using a calculator. Finally, move the decimal two places to the right (multiply by 100).

Example: Tan(26.5°) = .499 = 49.9% Grade

5.2 Inclination Using Prismatic Compass

The pocket transit can also measure angles of inclination without a tripod.

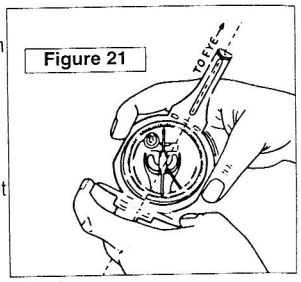


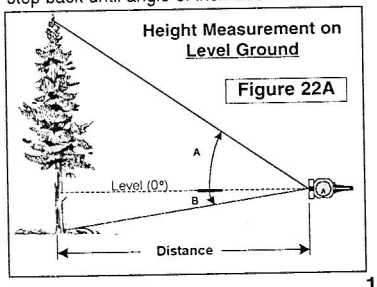
Figure 21

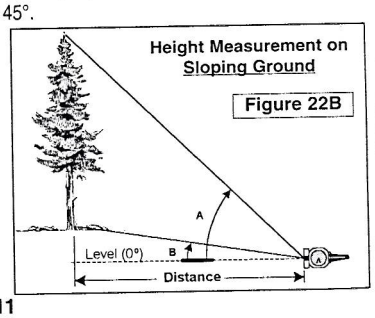
1. Open small sight and large sight as far as possible.
2. Flip peep sight up on large sight, .
3. Position Cover to approximately 45°.
4. With large sight pointing toward you, position transit at eye-level with cover open to the left. (Fig 21)
5. Sight object behind transit, aligning small sight, window and peep sight with object.
6. In mirror, adjust vernier until bubble in long level is centered.
5. Read inclination or percent grade at vernier's center line.

5.2.a Height Measurement Using Vertical Angles

1. Sight inclination, as described in section 5.2.
2. Apply height calculation as shown in Figure 22A or 22B.

Note: **Do not** calculate tangent of an angle by adding tangents of two smaller angles. Example: Tan(60°) ≠ Tan(30°) + Tan(30°) Find Tan(60°) from a table, use a calculator, or step back until angle of inclination is less than 45°.





Level Ground

Height = (TanA + TanB) x Distance

Example: A = 36°, B = 10° & Distance = 50 ft.

Height = (Tan(36°) + Tan (10°)) x 50'
Height = (.727 + .176) x 50
Height = (.903) x 50
Height = 45.15 ft. **= 45'**

Sloping Ground

Height = (TanA - TanB) x Distance

Example: A = 38°, B = 10° & Distance = 75 ft.

Height = (Tan(38°) - Tan (10°))} x 75'
Height = (.781 - .176) x 75
Height = (.605) x 75
Height = 45.38 ft. **= 45'**

5.2.b Height Measurements Using % Grade

1. Sight % Grade using level or sloping ground, same as in Figures 22A & B, p. 11.
2. Apply height calculation, as show in figures 23A & 24B.

Level Ground — Figure 23A

Height = (A + B) x Distance

Example: A = 72.7%, B = 17.6% & Distance = 50 ft.

Height = (72.7% + 17.6%)} x 50'
Height = (.903) x 50'
Height = 45.15 ft. **= 45'**

Sloping Ground — Figure 23B

Height = (A - B) x Distance

Example: A = 78.1%. B = 17.6% & Distance = 75 ft.

Height = (78.1% - 17.6%) x 75'
Height = (.605) x 75'
Height = 45.38 ft. **= 45'**

6 -- Compass Use with a Topographic Map

A United States Geological Survey (USGS) topographic map is a 2-dimensional drawing of 3-dimensional terrain. Hills, valleys, ridges, cliffs and other terrain are represented through a series of contour lines. Each line represents constant elevation in feet or meters above sea level. Find the contour interval in the legend of the topo-map. With practice, you'll begin to recognize contours, labeling and identify passable routes.

6.1 Map Azimuth

1. On the topo-map, place a "point" at a starting position and an "X" at a destination.
2. Draw a line connecting both marks.
3. At the starting position, draw a true north line. (Fig 24, p.13)

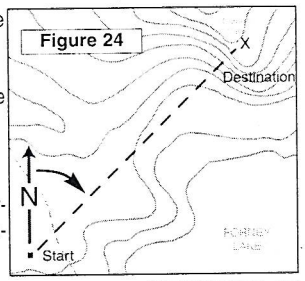
- Use true north indicator in the legend, or the edge of printed topo-map for reference.

4. Using the Alidade (Com-Pro models only), or a protractor, find the angle from the starting position to the destination, "X".

Remember, the true north line is 0°.

From the start position in the field, sight azimuth determined from the map, and you will be facing the destination. See section, 4 - Azimuth Measurement, for help.

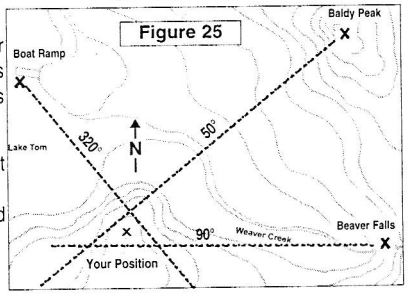
Figure 24



6.2 Triangulation

Triangulation is a method used to find your approximate position, using a compass and a map. Make sure the pocket transit is adjusted for magnetic declination.

Figure 25



1. Identify three landmarks in the field, that you can identify on a topo-map.
2. Sight an azimuth to each land mark and document.
3. Draw an azimuth line on the map for each azimuth.
4. Your position is within the small triangle, or position formed by the intersection of the three lines. (Fig 25)

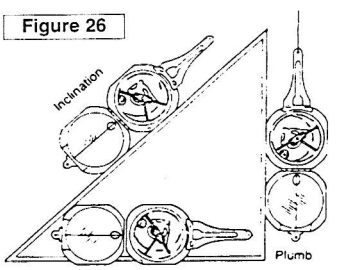
7 -- Additional Measurement

7.1 Level

The transit can be used as a level, to run level lines, or to determine points of elevation which is the same as the users eyes.

1. Adjust Vernier to 0° inclination, using the lever on the back of the body.
2. Place transit on its side, on an object, or use the tripod. (Fig 26)
3. Tilt instrument until the bubble is centered in the long level.

Figure 26



7.2 Plumb Bob

1. Suspend the transit in an open position from the large peep sight. (Fig 26)
2. Use the small sight as the pointer.

7.3 Inclination

1. Place instrument on its side on and object. (Fig 26)
2. Move lever on the back of the body until the bubble in the Long Level is centered.
3. Read inclination in either degrees or % grade.

8 -- Prospecting

If you were to discover gold, silver, or another valuable mineral deposit, you would want to "stake a claim". It would be necessary to construct a map of your claim, and tie (locate) your claim relative to some known position. Your Brunton Pocket Transit is ideally suited for this job, since it is essentially the same instrument used by geologists, mining engineers for prospecting and mapping around the world, since 1896.

8.1 Laws Governing Prospecting

In 1872 the General Mining Laws were enacted, and since then more laws have been passed governing the western United States. ***Currently, state laws vary widely and the federal laws concerning mining claims are quite vague. A discussion of the law is beyond the scope of this manual and it is strongly advised that you contact your state and federal agencies for information concerning "staking a claim".***

Following, is general information on mining claims for basic understanding. RULES AND LAWS MAY HAVE CHANGED.

1. **Lands Open to Mining Claims** - Lands available for mining claims can be determined by examining records from the Federal Land Office and the U.S. Bureau of Land Management (BLM), for your state. Generally, mining claims are limited to western states, where public land still exists. This includes public lands administered by the U.S. Forest Service, and U.S. BLM. It excludes national parks, monuments, state owned land and privately owned lands.
2. **Qualification** -- An individual must be a United States citizen, or one who has declared their intention to become a citizen. A corporation must be organized under the laws of the United States, or one of the fifty states. There are no restrictions as to age or residency.
3. **Federal Requirements** - The location must be distinctly marked on the ground so that its boundaries can be readily traced. All records of mining claims shall contain the name, or names of of the locators, the date of the location and such a description of the claim or claims located by reference to some natural object or permanent monument as will identify the claim.
4. **State Requirements** - Each mining district may make regulations not in conflict with the laws of the United States, or with the laws of the state or territory in which the district is situated governing the location, manner of recording and amount of work necessary to hold position of a mining claim. THis means the details of location are left to the states.
5. **Type of Claims** - There are four types of claims: lode claims, placer claims, mill sites, and tunnel sites. *Only lode claims are discussed here.*
6. **Lode Claims** - A lode is defined as a zone or belt of mineralized rock lying within boundaries clearly separating it from the neighboring rock. The dimensions of a lode claim are a maximum of 1,500 feet along the lode or vein, and no more than 300 feet to either side of the vein; end lines must be parallel.

Following, is an example of state regulations -- Nevada lode claim location requirements.

1. Erect a *discovery monument* at the point of discovery, and post thereon a *location notice*

containing: (a) the name of the claim, (b) the name and mailing address of the locator, (c) the date of location, (d) the number of linear feet along the vein each way from the discovery monument, with the width claimed on either side of the vein, and (e) the general course of the vein. (NRS 517.010)

2. All monuments must consist of (a) a tree cut of 3 or more feet above the ground and blazed, (b) a rock pile 3 or more feet in height, or (c) a 4-inch diameter post at least 4 1/2 feet in length set 1 foot in the ground. (NRS 517.030)
3. Within 20 days of posting the location notice, mark the boundaries of the claim by placing monuments at the four corners and center of each side line. (NRS 517.030)
4. Within 90 days of posting the location notice, prepare two copies of a claim map (scale of 500 feet to the inch) showing the position of the claim monuments, the relationship of the claim monuments and the relationship of the claim group to a survey corner, or claim location marker. The marker must be a rock pile 4 feet in diameter and 4 feet high, or a steel post 3 inches in diameter and 5 feet high. The description must also include the section, township and range. The map need not be perfect, but "in accordance with the locator's abilities." (NRS.030) The maps must then be filed with the county recorder. (NRS 517.040 (2))
5. Within 90 days of posting the location notice, record duplicate location certificates with the county recorder containing the following information *(NRS 517.050):
   a. The name of the lode or vein.
   b. The name of the locator or locators, together with the post office address of such locator or locators
   c. The date of the location.
   d. The number of linear feet claimed in length along the course of the vein each way from the point of discovery with width of each side of the center of the vein, and the general course of the lode or vein as near as may be.
   e. A statement that the location work consisted of making the maps as provided in (NRS 517.040).
   f. The location and description of each corner, with the markings thereon.
6. Only one location may be claimed on each location notice or location certificate (NRS

517.020, 517.050).

7. Penalty for late recording: "any record of the location of a lode mining claim which shall not contain all the requirements named in this section recorded on or after July 1, 1971, shall be void, and every location of a mining claim recorded on or after July 1, 1971, shall be absolutely void unless a certificate of location thereof substantially complying with the above requirements is recorded with the county recorder of the county in which the claim is located within 90 days after the date of location." (NRS 517.050 (2))

Other states commonly require some form of discovery work other than preparation of a map. This may consist of digging a shaft or drilling a specified footage of discovery holes. *Check the mining statutes of every state to determine its specific requirements.*

8.2 Surveyed Land

In locating your mining claims and constructing your claim location map, it will be helpful to understand how lands are divided up by the rectangular system of surveys. This system is the basis for the identification, administration and disposal of public lands.

Figure 27 illustrates how lands are divided by survey. Lines running north-south are called range lines. R22E stands for Range 22 East of the principal meridian. Lines running east-west are township lines. T22S stands for Township 22 South of the base line. On a topo-map, the range lines are shown at the top and bottom of the printed map. Township lines are shown on the east-west margin of the map.

By specifying the township and range, a township area of land is located. The large squares in figure 27 are townships. For example, T22S, R22E specifies the township area with 36 sections, each numbered and 1 mi² (640 acres) apiece. This makes a township is 36 mi². A 1 mi² section of land is located by calling out the section number, township and range -- Section 4, T22S, R22E.

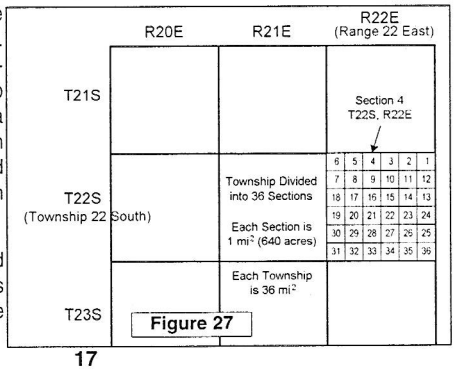


Figure 27

A section is further divided into quarter sections by straight lines connecting quarter section corners or opposite boundaries. There are eight monuments on each section. One monument on each corner and one midway between corners on the section boundary lines (not shown).

If your claim is in a surveyed area of public land, it will be located within a section shown on a topo-map. To locate your claim, it is then necessary to tie, or locate your claim relative to a section corner monument. The corner monument may be a pipe with a brass cap fastened to the top. It may be a brass tablet. 3 1/4 by 3 1/2 inches, attached to a rock outcropping and set in concrete. The brass is marked with letters and figures that give the section, township and range. It is marked so that it must be read while standing on the south side of the monument. The south side of the monument is marked with the date of the monument. (Fig 28)

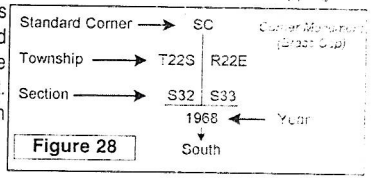


Figure 28

8.3 Sample Claim Location Map

Figure 29 on page 20, shows the location monument with claim extending 300 feet to each side of the vein center line and 1,500 feet long. The claim is tied or located to a section corner post by showing the bearing to the corner post, the number of feet to the post and the section, township and range.

The bearing is obtained with your Brunton Pocket Transit by selecting one of your claim corners as your tie point, and sighting from the tie point to the section corner post. The azimuth to the South East corner of Section 32, T22S, R22E was found to be 110°. (Fig 29, p. 20). Note, the distance to the section corner must also be provided.

8.4 Location On Unsurveyed Land

Not all of the U.S. has been surveyed. As of 1970, about 500,000,000 acres were still unsurveyed. Most of the unsurveyed land is located in mountainous sections of the country. Since then, however, more has been surveyed. Check with the Federal Land office, or the U.S. Bureau of Land Management of your state.

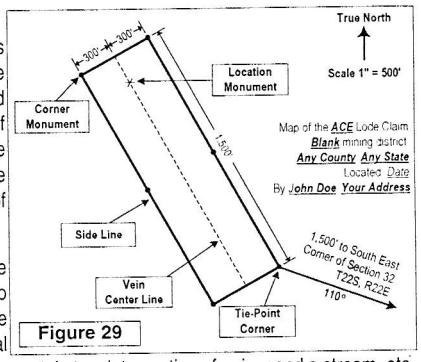


Figure 29

If your claim is located in one of the unsurveyed areas (no corner post to locate, or tie your claim), you must locate your claim in reference to some natural land mark. A natural land mark being a mountain top, intersection of a river and a stream, etc.

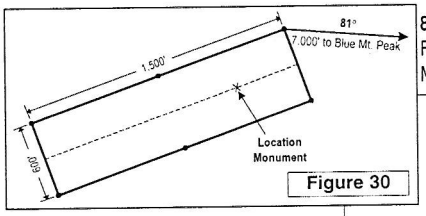


Figure 30

8.4.a Using Bearing & Distance

Figure 30 shows a claim tied to Blue Mountain Peak by an azimuth of 81°, and a distance to Blue Mountain Peak of 7,000 feet from a corner monument.

8.4.b Using Two Bearings

The claim in figure 31 is tied to two azimuth readings from a corner monument. Using this method, distance is not required, since the intersection of both azimuth lines determine the location.

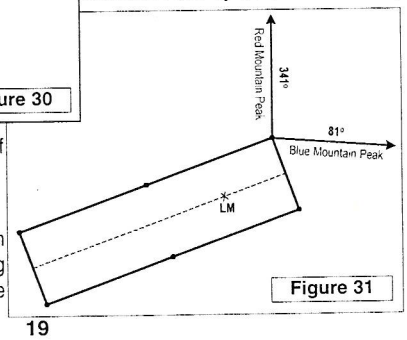


Figure 31

8.4.c Using Five Bearings

A more complete description of your claim can be determined by displaying the direction of the sides of your claim. The angles are found by standing on corner #1 and taking an azimuth to corner #2. Then standing on corner #2 and taking an azimuth to corner #3. Finally, from #3 to #4 and from #4 back to #1, thus completing the description.

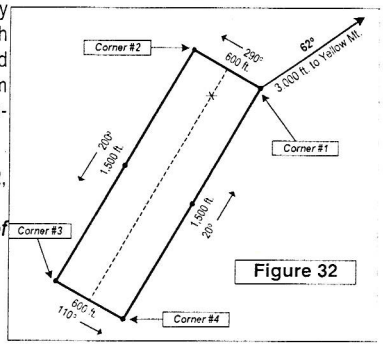
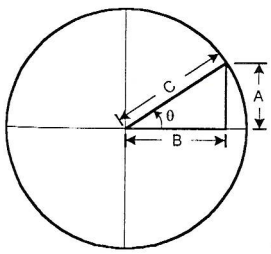


Figure 32

A description of the claim shown in Figure 32, would read:

Beginning at Corner #1, the NE corner of the claim.
Thence 600 feet, 290° to Corner #2.
Thence 1,500 feet, 200° to Corner #3.
Thence 600 feet, 110° to Corner #4.
Thence 1,500 feet, 10° to Corner #1.

9 -- Reference Material



$SIN(\theta) = A/C$ $\quad CSC(\theta) = C/A$
$COS(\theta) = B/C$ $\quad SEC(\theta) = C/B$
$TAN(\theta) = A/B$ $\quad COT(\theta) = B/A$

A = side opposite angle θ
B = side adjacent to angle θ
C is the hypotenuse

$C^2 = A^2 + B^2$

Inches	Feet	mm	cm
1/8	0.0104	3.1750	.31750
1/4	0.0208	6.3500	.63500
3/8	0.0313	9.5250	.95250
1/2	0.0417	12.700	1.2700
5/8	0.0521	15.875	1.5875
3/4	0.0625	19.050	1.9050
7/8	0.0729	22.225	2.2225
1	0.0833	25.400	2.5400
2	0.1667	50.800	5.0800
3	0.2500	76.200	7.6200
4	0.3333	101.60	10.160
5	0.4167	127.00	12.700
6	0.5000	152.40	15.240
12	1.0000	304.80	30.480

Conversions	Conversions
1 inch = 2.54 centimeters	1 centimeter = 10 millimeters
1 foot = 12 inches	1 centimeter = 0.01 meters
1 foot = 0.305 meters	1 centimeter = 0.394 inches
1 yard = 3 feet	1 meter = 100 centimeters
1 yard = 0.914 meters	1 meter = 3.281 feet
1 chain = 66 feet	1 meter = 1.094 yards
1 mile = 5,280 feet	1 kilometer = 1,000 meters
1 mile = 80 chains	1 kilometer = 0.6214 miles
1 mile = 1.609 kilometers	1 hectare = 10,000 meters^2
1 acre = 43,500 feet^2	1 hectare = 2.471 acres
1 acre = 0.4047 hectares	

10 -- Specifications

Magnetism: Models - 2001 & 2061 (*Alnico II Bar Magnet*)
Models - 5005LM & 5006LM (*Alnico V Bar Magnet*)
Models - 5007, 5008 & 8700 Com-Pro (*NdFeB Magnet*)

Accuracy: Bearing -- +/- 1/2° accurate
Inclination -- +/- 1° accurate (30 minute readable)

Size (Closed): Width -- [2001, 2061, 5005LM & 5006LM models] - 2.79 in. (7.09 cm)
Width -- [5007, 5008, 8700 models] - 2.76 in. (7.01 cm)
Length -- [2001, 2061, 5005LM & 5006LM models] - 3.09 in. (7.84 cm)
Length -- [5007, 5008, 8700 models] - 3.14 in. (7.97 cm)

Height -- [2001, 2061, 5005LM & 5006LM models] - 1.31 in. (3.34 cm)
Height -- [5007, 5008, 8700 models] - 1.33 in. (3.38 cm)

Weight -- [2001, 2061 models] - 6.8 oz (19.3 g)
Weight -- [5005LM & 5006LM models] - 7.1 oz (20.1 g)
Weight -- [5007, 5008, 8700 models] - 5.7 oz (16.2 g)

11 -- Service

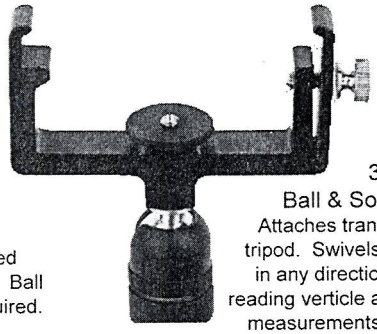
Engraving - A Brunton Pocket Transit with a cast aluminum body can be personalized with engraving (up to 18 characters, including spaces). Com-Pro models have a decal which can have up to 6 lines of text (approximately 20 characters per each line, including spaces). Call Brunton at (307) 856-6559 for details.

Balancing - Brunton Pocket Transits can be balanced for use in a specific part of the world. Special balancing is required for use in the southern hemisphere. Call Brunton for details.

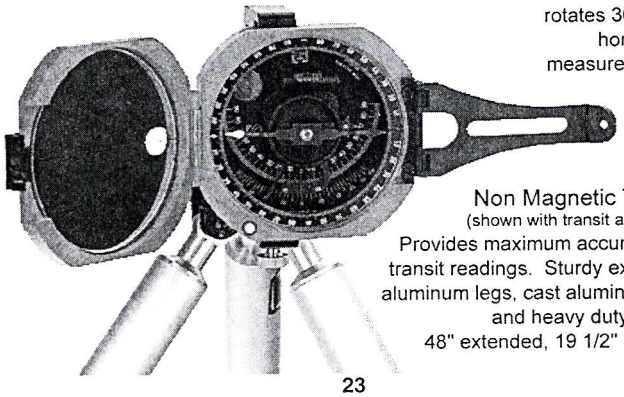
Repair - Brunton's repair department is capable of handling repairs, or conversions of any genuine BRUNTON Pocket Transit. Periodic maintenance and calibration is highly recommended and will prolong the life of your pocket transit. Call Brunton for details.

Accessories

3051
Jacob Staff
Thimble
Attaches transit to steel tipped wooden rod or Jacob's staff. Ball and socket head is also required.



3040
Ball & Socket
Attaches transit to tripod. Swivels 90o in any direction for reading verticle angle measurements and rotates 360o for horizontal measurements.

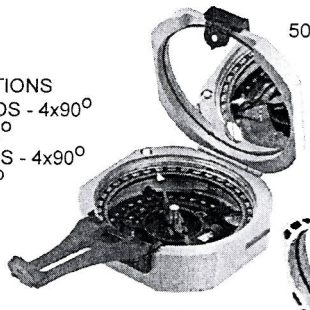


3051
Non Magnetic Tripod
(shown with transit attached)
Provides maximum accuracy for transit readings. Sturdy extruded aluminum legs, cast aluminum top and heavy duty joints. 48" extended, 19 1/2" closed.

Brunton Professional Instruments

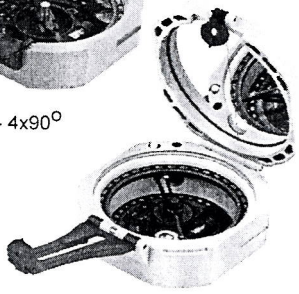
Pocket Transits

MODEL	NEEDLE/GRADUATIONS
2001	Conventional, QUADS - 4x90°
2061	Conventional, 0-360°
5005LM	International, QUADS - 4x90°
5006LM	International, 0-360°

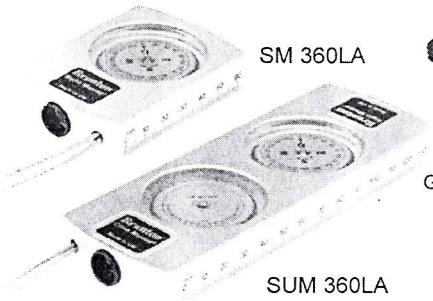


5006LM

5008



5007	COM-PRO, International, QUADS - 4x90°
5008	COM-PRO, International, 0-360°



SM 360LA

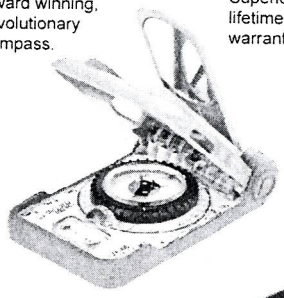
SUM 360LA

Sighting Compasses

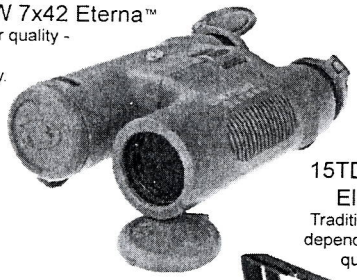
Gives bearing, height, distance or inclination to objects. Sturdy anodized aluminum body. Available with nylon or leather case.

Other Brunton Products

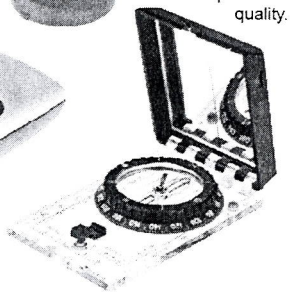
8099 Eclipse™
Award winning, revolutionary compass.



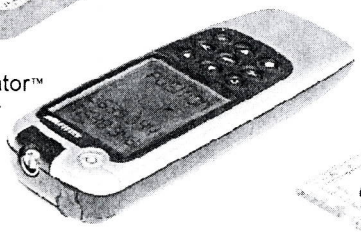
4006W 7x42 Eterna™
Superior quality - lifetime warranty.



15TDCL Elite™
Traditional, dependable quality.



Multi Navigator™
MNS™ system - more than a GPS!



Sherpa™
Hand held weather data center.

Brunton manufactures MNS™ (more than a GPS) systems, high quality optics, hand held data measuring devices and a complete line of recreational compasses. Refer to back cover for contact information on products, service or for full line catalogs.

Warranty Registration

Detach and return to: Brunton, 620 East Monroe Avenue, Riverton, WY 82501-4997

Name: _____

Address: _____

City: _____ State: _____ Zip: _____

Phone: _____

Model #: _____ Serial #: _____

Date Purchased: _____ Store: _____

City: _____ State: _____ Zip: _____

Amount Paid: _____

Do you own another Brunton / Nexus Product?

( ) Yes. Product: _____ ( ) No.

I decided to buy this product because of ...

( ) Recommendation ( ) Store Display ( ) Features
( ) Magazine ( ) Salesperson ( ) Gift
( ) Catalog ( ) Newspaper

This pocket transit will be used for ...

( ) Geology ( ) Archeology ( ) Mining
( ) Mapping ( ) Forestry ( ) Camping
( ) Hunting ( ) Backpacking ( ) Orienteering

Occupation: _____

Annual Income:

( ) < 20,000 ( ) 20,000 - 39,000
( ) 40,000 - 74,999 ( ) 75,000 - 99,999 ( ) > 100,000

SCHAEVITZ SENSORS

Anglestar Protractor System

INSTALLATION
OPERATION
SPECIFICATIONS

System Description

The AngleStar Protractor Systems are extremely adaptable and economical angle measurement devices. A system consists of a compact gravity-referenced clinometer connected to an associated liquid crystal display (LCD) readout.

The AngleStar clinometer is a precision measurement sensor that provides wide angular range with excellent linearity. Its small size and rugged construction make it adaptable even in the most difficult installations. The readout unit contains a standard nine-volt battery which provides power for the system electronics and Liquid Crystal Display. Clinometer angular position is displayed digitally to within 0.01 or 0.1 of a degree. The readout may be remotely mounted up to 200 feet from the clinometer making the system ideal for a wide variety of applications.

The AngleStar Protractor Systems are precise, flexible and yet economical angle measurement devices.

Note: Clinometers and readout units are matched at factory calibration and final test to yield performance specifications noted. Mixing clinometers and readout units will result in sub-standard performance.

Preparation for Use

A 9-volt battery is required to operate the system (An alkaline battery is recommended.) To access the battery terminals and cable receptacle, snap apart the readout unit housing at the groove around the edges by inserting and twisting a coin in the groove below the display window. Install the battery.

Check that the grommet on the cable assembly is approximately 4.5 inches from the clear connector plug. Insert the plug through the 0.4 inch diameter hole in the readout back cover and then into the receptacle between the battery and the power thumb wheel. Reassemble the readout housing halves and work the grommet into position in the cable exit hole in back cover.

Clinometer Installation

Prepare a clean, flat, vertically oriented mounting plane with two vertically aligned holes for No. 6 (.138 inch diameter) screws spaced at 2.274 inches.

Retain clinometer to mounting plane snugly with two No. 6 screws with flat washers.

Insert cable plug into clinometer connector receptacle.

Rotate POWER thumb wheel on readout unit, which applys system power and activates readout unit LCD.

Rotate clinometer about upper mounting screw until 00.0 is displayed on the LCD.

Secure clinometer mounting screws and recheck for 00.0 display on the LCD.

Readout Unit Mounting

If it is desirable to mount the Readout unit, select a flat surface at least 4.5 inches wide and 1.75 inches high. Any spatial orientation is satisfactory.

Snap apart the readout unit at the edge groove.

Mount the readout unit back cover tightly to the selected surface with four No. 4 or No. 6 screws through the small holes in the back cover pads.

Reassemble the readout unit halves.

Cable Routing

Route and retain the clinometer-to-readout interconnecting cable so it is not entangled by moving parts of objects on which the units are mounted.

System Operation

Vertical Reference

The clinometer is aligned to vertical, or gravity, reference. The readout unit display will present a minus (−) sign before the numeric angle for clinometer rotations counterclockwise from the reference position. No algebraic sign will be presented for clinometer rotations clockwise from the reference. Allow a few seconds after the clinometer comes to rest at a new position for the readout unit LCD to stabilize.

Alternate ZEROED Reference

When it is desired to display clinometer angles directly from a reference position other than vertical, follow the procedure outlined below.

Rotate the object on which the clinometer is mounted to the alternate reference position. Record the displayed angle.

Remove the sticker from the face of the non-rotating ZERO thumb wheel in the readout unit. Insert a small screwdriver blade into the hole in the center of the thumb wheel to engage a slot in a zero adjusting potentiometer. Rotate the potentiometer with the screwdriver until the readout unit LCD displays 00.0

Clinometer rotations from this new "ZERO", or alternate reference position, may be read directly on the readout unit LCD. Minus (−) readings indicate counterclockwise clinometer rotations from the alternate reference. Readings with no algebraic sign indicate clockwise clinometer rotations.

To return to the readout unit display to indicate zero for the original clinometer vertical alignment, rotate the object to which the clinometer is mounted until the readout unit LCD displays 00.0. Using the small screwdriver, rotate the potentiometer adjustment in the zero thumb wheel until the readout unit LCD displays the previously recorded alternate reference angle.

An active zero knob is available at no charge for customers who need to continually adjust zero.

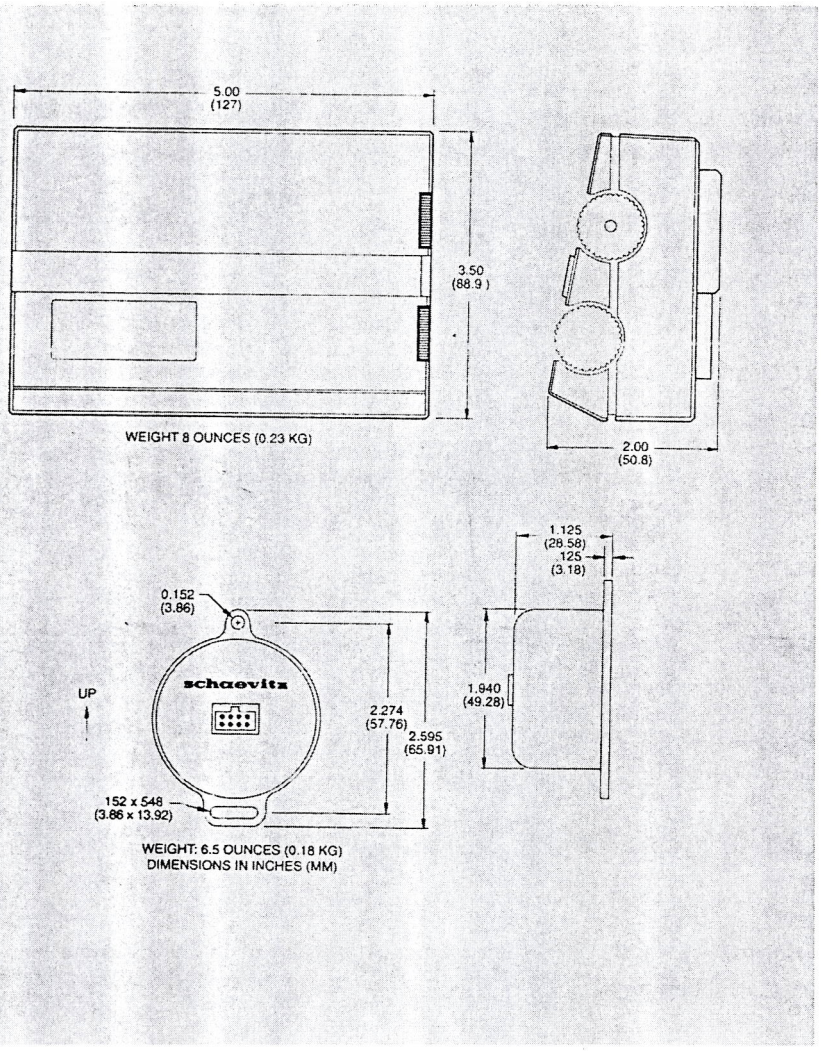
Notes:

1. For alternate reference measurements, the system linear range is adjusted by the alternate reference angle. For example, if the alternate reference angle is 20 degrees clockwise from vertical, the system linear range from this angle is 25 degrees clockwise and 65 degrees counterclockwise.

2. The linearity specifications applies only to vertically aligned clinometers and vertically referenced readout units.

3. When the system is operated in the presence of electromagnetic radiation, such as radio transmitters or walkie-talkies, the angle data shown on the readout LCD may be in error. Accuracy will be regained when the radiation is stopped.

4. If the battery voltage drops below the level required for accurate system operation, the legend "LoBat" will appear in the upper left field of the readout unit LCD. Change the battery as described in the Preparation for Use section.



SYSTEM SPECIFICATIONS

Standard (P/N 02506-01)	
Linear range	±45 deg.
Threshold & resolution	.1 deg.
High resolution (P/N 02543-01)	
Linear range	±19.99 deg.
Threshold & resolution	.01 deg.
90 Degree (P/N 02538-01)	
Linear range	0-90 deg.
Threshold & resolution	.1 deg.
* Linearity – null to 10 deg.	±.1 deg.
– 10 to 45 deg.	±1% deg.
Null repeatability	±.1 deg.
Cross axis error	1% of reading
Sensor time constant	.3 second
Sensor frequency response	0.5 Hz
Voltage supply	9 volt battery
Battery life (approx.)	1000 hours
Temperature range	0 to 130 deg. F (-18 to 55 deg. C)
Interconnect Cable	4 conductor, AWG 26, PVC
Standard Length	4 feet (1 meter)
Maximum Length	200 feet (61 meters)

*NOTE: Linearity specification applies to Standard and High Resolution systems only.

Schaevitz Sensors
1000 Lucas Way
Hampton, VA 23666
Phone (757) 766-1500 / Fax (757) 766-4297

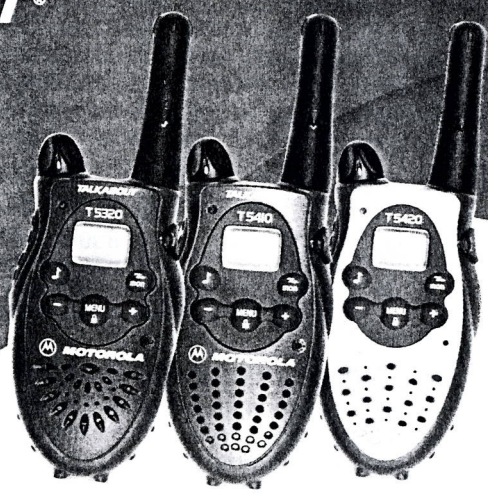
09110037-000

MOTOROLA

User's Guide

TALKABOUT®

TWO-WAY RADIO



6864110R10-O

Models T5320, T5410, and T5420

- American National Standards Institute (ANSI) / Institute of Electrical and Electronic Engineers (IEEE) C95. 1-1992
- Institute of Electrical and Electronic Engineers (IEEE) C95.1-1999 Edition
- National Council on Radiation Protection and Measurements (NCRP) of the United States, Report 86, 1986
- International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998
- Ministry of Health (Canada) Safety Code 6. Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz, 1999
- Australian Communications Authority Radiocommunications (Electromagnetic Radiation - Human Exposure) Standard 1999 (applicable to wireless phones only)

To assure optimal radio performance and make sure human exposure to radio frequency electromagnetic energy is within the guidelines set forth in the above standards, always adhere to the following procedures:

PORTABLE RADIO OPERATION AND EME EXPOSURE

Antenna Care

Use only the supplied or an approved replacement antenna. Unauthorized antennas, modifications, or attachments could damage the radio and may violate FCC regulations.

DO NOT hold the ante
affects call quality and
needed.

Two-way Radio Opera
When using your radio
vertical position with
from the lips.

Body-worn Operation
To maintain compliance
wear a radio on your bc
supplied or approved c
Use of non-Motorola-ap
exposure guidelines. If
body-worn accessories
ensure the radio **and i**
body when transmitti

Data Operation
When using any data fe
position the radio anc
the body.

Approved Accessorie
For a list of approved M

ELECTROMAGNETIC INTERFERENCE/COMPATIBILITY

Note: Nearly every electronic device is susceptible to electromagnetic interference (EMI) if inadequately shielded, designed or otherwise configured for electromagnetic compatibility.

- **FACILITIES**
  To avoid electromagnetic interference and/or compatibility conflicts, turn off your radio in any facility where posted notices instruct you to do so. Hospitals or health care facilities may be using equipment that is sensitive to external RF energy.
- **AIRCRAFT**
  When instructed to do so, turn off your radio when on board an aircraft. Any use of a radio must be in accordance with applicable regulations per airline crew instructions.
- **MEDICAL DEVICES**
  Pacemakers
  The Advanced Medical Technology Association recommends that a minimum separation of 6 inches (15 centimeters) be maintained between a handheld wireless radio and a pacemaker. These recommendations are consistent with the independent research by, and recommendations of, the United States Food and Drug Administration.

Persons with pa
- ALWAYS ke pacemaker
- not carry th
- use the ear interference
- turn the rad interference

Hearing Aids
Some digital wir such interferenc discuss alternat
Other Medical D
If you use any o device to determ may be able to a

Safety and Genera
Check the laws and
Always obey them.
When using your rac
- Give full atte
- Use hands-f

- Pull off the road and park before making or answering a call if driving conditions so require.

OPERATIONAL WARNINGS

- **FOR VEHICLES WITH AN AIR BAG**
  Do not place a portable radio in the area over an air bag or in the air bag deployment area. Air bags inflate with great force. If a portable radio is placed in the air bag deployment area and the air bag inflates, the radio may be propelled with great force and cause serious injury to occupants of the vehicle.
- **POTENTIALLY EXPLOSIVE ATMOSPHERES**
  Turn off your radio prior to entering any area with a potentially explosive atmosphere, unless it is a radio type especially qualified for use in such areas as "Intrinsically Safe." Do not remove, install, or charge batteries in such areas. Sparks in a potentially explosive atmosphere can cause an explosion or fire resulting in bodily injury or even death.

Note: The areas with potentially explosive atmospheres referred to above include fueling areas such as below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles, such as grain, dust or metal powders, and any other area where you would normally be advised to turn off your vehicle engine. Areas with potentially explosive atmospheres are often but not always posted.

- **BLASTING CAPS A**
  To avoid possible inte
  you are near electrica
  off two-way radio." O

OPERATIONAL CAUTIO

- **ANTENNAS**
  Do not use any port
  antenna comes into c
- **BATTERIES**
  All batteries can caus
  conductive material s
  terminals. The condu
  circuit) and become q
  particularly when plac
  objects.

BATTERY CHARGER SA

Save these Charger Inst

1. Do not expose the ch
2. Do not operate the ch
   or damaged in any wa
3. Do not disassemble th
   dropped or damaged

4. Never alter the AC cord or plug provided with the unit. If plug will not fit the outlet, have proper outlet installed by a qualified electrician. An improper condition can result in a risk of electric shock.
5. To reduce risk of damage to cord or plug, pull the plug rather than the cord when disconnecting charger from AC receptacle.
6. To reduce the risk of electric shock, unplug the charger from the outlet before attempting any maintenance or cleaning.
7. Use of an attachment not recommended or sold by Motorola may result in a risk of fire, electric shock, or personal injury.
8. Make sure that the cord is located so that it will not be stepped on, tripped over, or subjected to damage or stress.
9. An extension cord should not be used unless absolutely necessary. Use of an improper extension cord could result in a risk of fire and/ or electric shock. If an extension cord must be used, make sure:
   - That the pins on the plug of the extension cord are the same number, size and shape as those on the plug of the charger.
   - That the extension cord is properly wired and in good electrical condition, and
   - That the cord size is18 AWG for lengths up to 100 feet, and 16 AWG for lengths up to 150 feet.
10. The supply cord of this charger cannot be replaced. If the cord is damaged, call-Motorola Product Services at:

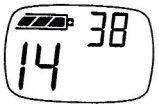
1-800-353-2729 (U. S. A.)

1-800-461-4575 (Canada)

1-888-390-6456 TTY (Text Telephone)

Getting Started

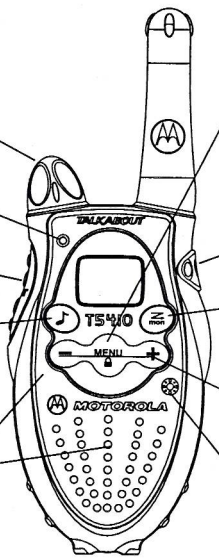
Turning On/Off Your Radio

Turn Knob	Display	Normal
		Turn knob knob cour The radio that your r
		T5320 will and T542(Code (0-3

Radio Etiquette

Your radio has multiple Channels be talking on the Channels. For ur someone who is already using the heard. Try changing the Channel to or mon (T5320 and T5420) to check holding down mon or mon; Channel

Diagram of Your Radio



Use ⏻ to:
- Turn power on/off
- Adjust volume

LED Indicator Light

Use PTT to:
- Talk on the radio
- Save a setting

Use ♪ to:
- Transmit call tone

Removable Accessory Cover

Speaker

Use ⊛ to:
- Lock the keypad (when held down and not in a menu)
- Exit the menu (when pressed while in a menu)

Accessory Jack Cover

Use mon (T5320 and T5420) or mon (T5410) to:
- Monitor Channel Activity

Use ∈ ∋ to:
- Scroll through menus

Microphone

Power

Batteries

T5320, T5410, and T5420 radi
rechargeable battery. A Recha
your radio.

Call 1-800-353-2729 (USA) or
or visit our website: **www.moto**

Installation

1. With back of radio facing yo
   Latch up to release the Bat
2. Lift cover off.
3. Insert 3 AA batteries as sho
4. Reposition Battery Cover, p
   Cover down to secure.

Meter

The battery meter in the upper left

The radio will power off when t
protect the rechargeable batter
the radio chirps after releasing

Battery Life

The following chart lists the approximate battery life during Two-way use* for AA Alkaline and NiCd batteries.

AA Alkaline	27 Hours
NiCd	12 Hours

*Two-way use is defined as 90% standby time, 5% talk time, and 5% receive time.

Note: Remove batteries before storing your radio for extended periods. Batteries corrode over time and may cause permanent damage to your radio.

Battery life will be reduced if you regularly use Hands-Free (VOX) accessories, or Scan.

Charging Desk Stand

The Charging Desk Stand provides drop-in charging convenience. The charging Desk Stand can be placed on any flat surface, such as a desk or workbench. Charge the NiCd battery overnight (16 hours) before using it for the first time.

1. With the radio OFF, remove the Battery Cover.
2. Insert the battery pack as indicated on the battery-pack label.
3. Replace the Battery Cover.
4. Plug the wire on the AC Power Supply into the plug on the desk stand.
5. Plug the AC Power Supply into a standard wall outlet.
6. Slide the radio into or
   red light will glow if th
7. The radio/battery will

You can also charge the

1. Plug the wire on the A
2. Plug the AC Power Su
3. Insert the battery pac
   pocket insert provided
4. Make sure that the co
   contacts in the pocket
   properly inserted.
5. The radio/battery will

Charging Status

The Solid Red Light Indic
charging.

Note: When moving bet
until the battery te

A depleted battery will re

Note: For optimal batter
16 hours. Do not s

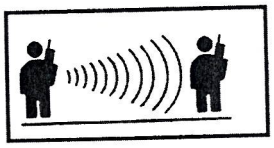
Talking and Listening

To communicate, all radios in your group must be set to the same Channel (1-14) and Interference Eliminator Code (0-38). T5320 models do not have Interference Eliminator Codes. You must set the Interference Eliminator Code to 0 on a T5410 or T5420 to communicate with a T5320.

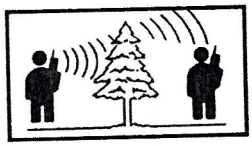
- To maximize clarity, hold radio 2 to 3 inches from mouth.
- Press and hold (PTT) and speak into the microphone.
  LED Indicator Light glows continuously when transmitting.
- To receive messages, release (PTT).

Talk Range

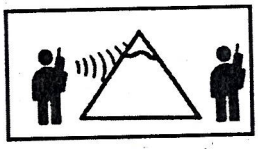
Your radio has been designed to maximize performance and improve transmission range. It is recommended that you do not use the radios closer than 5 feet apart.



Optimal Range Outdoors
Flat, open areas



Medium Range Outdoors
Buildings or trees
Also near residential buildings



Minimal Range Outdoors
Dense foliage or mountains
Also inside some buildings

Channel

1. With radio On, press (-
2. Use (- and (+ to chan
3. Press (PTT) to set new C

Interference Eliminator

The interference eliminato
providing you with a choic

- To set the code, press
- Then press (- or (+
- Press (PTT) to save the c

You must set the Interfere
communicate with a T532

You can specify a differer
combination, press (MENU) anc
and then press (- or (+ t
channel and code combin
repeat these steps.

Volume

Rotate (VOL) while holding d
a comfortable listening lev
to decrease volume.

Monitor Button
Pressing and holding (T5410) or (T5320 and T5420), lets you hear the radio's volume level when you are not receiving so you can adjust the volume. It is also used to check activity on current Channel before transmitting.

Time-out Timer
The Time-out Timer feature helps extend battery life by preventing accidental transmission. The radio will emit a continuous warning tone after is pressed for 60 continuous seconds and will stop transmitting.

Keypad Lock
To avoid accidentally changing
see the icon. This sequence
functions. Once locked, you wil
decrease Volume, transmit, ser
To unlock, press and hold fo

Scan (T5410 Only)
By Scanning, you can monitor C
the one that interests you. More
has accidentally changed Chan
To start scanning, briefly press
code is set to 0, then the radio
the Code in use on that Channe
38, the radio will check for activ
Transmissions using Code 0 are
stops on that Channel and disp
While the radio is scanning,
activity is detected on a Channe
whatever transmissions are dete
Code on which activity was dete
If you want to respond to the trar
you can respond. To stop scanr

Scan Advance

If scan stops on a Channel that you don't want to listen to, briefly press either the ∈ and ∋ to resume scanning for the next active Channel.

Nuisance Delete

If scan continuously stops on an undesired Channel:

- Press and hold either ∈ or ∋ for at least 3 seconds.
- Then release.

These steps will temporarily remove the undesired Channel from being scanned. To restore the deselected Channel to the Scan List, turn the radio Off and then On. You cannot remove your Home Channel from the Scan List. The Home Channel is the Channel your radio was set to when you activated Scan.

Alerts

Channel Busy Indicator

The radio also has a Channel Busy Indicator where the LED will also flash twice per second to indicate the Channel is in use.

Call Tone

The Call Tone obtains others' attention before you start talking. Press ♪ to allow users using the same Channel and Code will hear your Call Tone. T5320, T5410, and T5420 have 5 Call Tones from which to choose. Setting the Call Tone to ▯ disables ♪.

To Set the Call Tone

- With the radio on, pres
  the display.
  Current Call Tone setti
- Press ∈ and ∋ to ch
- Press MENU or PTT to set

Roger Beep/Talk Confir

When you turn on this fea
finish transmitting. It's like
finished talking.

- To enable Roger Beep
  your radio On. Now, w
  friends know you're fin
- To disable the Talk Co
  On while pressing and

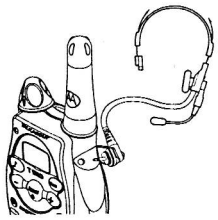
Accessories

To Use Audio Accessor

1. Make sure radio is Off
2. Turn radio On and low
3. Press MENU or MON while
4. To transmit, press PTT
5. To receive, release PTT

Hands-Free Use/VOX With Compatible VOX Accessories (T5420 Only)
VOX allows you to transmit "hands-free" by talking while using VOX accessories connected to the radio. See the Motorola Talkabout Accessory Brochure for the available VOX accessories.

- Turn radio Off.
- Insert plug of audio accessory firmly into Accessory Jack.
- Turn radio On. Radio will display: «ξ.
- Lower radio volume BEFORE placing accessory on head or in ear.
- To transmit, speak into Accessory Microphone and to receive, stop talking.
- VOX operation can be disabled by pressing (PTT) or removing audio accessory.



There is a short delay between when you start talking and the radio transmits.

Note: To order accessories, please refer to: **www.motorola.com/talkabout**

Setting Sensitivity Level

Adjusting your radio's Sensitivity Level helps to minimize the possibility of unintended noises triggering a transmission, or enhances the ability to pick up quiet voices.

- Press (MENU) as needed to display «ξ.
- Select Sensitivity Level of 1, 2, or 3 by using ⊂ or ⊃:
  3 = **High Sensitivity,** for quiet environments
  2 = **Medium Sensitivity,** for most environments
  1 = **Low Sensitivity,** for noisy environments

Note: When you connect a VOX accessory, the radio will automatically be set to the last chosen sensitivity level.

Belt-clip(Included)
Motorola T5320, T5410, and T5

To Attach

1. Align belt-clip post with hole
2. Gently push until it clicks into

To Remove

1. Push release tab on top of be
2. Pull belt-clip from the radio b

Front Cover (Included)
Your radio has a removable fron your lifestyle.

Do not operate the radio with

To Remove

1. With a 1/8 inch flathead scre the top of the front cover and
2. Gently pry the cover away fr
3. Pull the top of the removable

To Attach

1. Reinsert housing tabs at the b
2. Press down to snap cover int

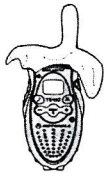
There are many accessories (sold separately) available for T5320, T5410, and T5420 radios. For more information refer to the brochure we've included with your radio, contact place of purchase or call Motorola at:
1-800-353-2729 USA 1-800-461-4575 Canada 1-800-739-7834 (TTY)

Troubleshooting

Problem	Solution
No Power	Reposition, replace or recharge batteries.
Erratic Display	Reposition, replace or recharge batteries.
Message Not Transmitted	Make sure button is completely pressed while you transmit. Reposition, replace or recharge batteries. Shared Channel may be in use, try another Channel.
Message Not Received	Confirm radios have same Channel settings and/or Interference Eliminator Code (helps minimize interference - T5410, T5420). Make sure (PTT) is not inadvertently being pressed. Reposition, replace or recharge batteries. Obstructions, and operating indoors or in vehicles may interfere with communication. Change your location. Check to make sure volume is turned up. Set Eliminator Code to 0 on a T5410 or T5420 to communicate with a T5320.

Problem	Solution
Hearing Other Conversation or Noise on a Channel	Shared C Set Elimir with a T5
Limited Talk Range	Steel/conc in vehicles improve tr Wearing r decrease
Heavy Static or Interference	Radios to your dista Radios to

Use and Care



To clean the radio, use a soft damp cloth.

Do not immerse in water.

Do not use alcohol or cleaning solutions.

If the radio gets wet...

Turn it off and remove batteries.

Dry with soft cloth. Battery contacts may be wiped with a dry, lint-free cloth

Do not use until completely dry.

Limited Warranty for Motorola Personal Accessories Purchase

I. What This Warranty Co

Defects in materials and work sold or certified by Motorola. package: (a) wireless cellula via "Personal Radio Service" Radio Service), together with subject to the following excep products.

- Battery Exception. This lim charged capacity falls belo
- Software Exceptions. This media (such as CD-ROM) and/or certified by Motorola embodied in media and tha software that is downloade

II. What the Period of Cov

Subject to the following excep purchased by the first end-us

- 90-Day Warranty Exception embodied in media or (b) a warranty, as described in S

- Limited Lifetime Warranty Exception. The warranty is a limited lifetime warranty for the lifetime of ownership by the first end-user of the following products, only: (a) decorative covers, including bezel, PhoneWrap™ or case (any model); and (b) ear buds and boom headsets that transmit mono sound through a wire connection (this does not include ear buds or boom headsets that either transmit stereo sound or that are wireless, or both).
- Repair / Replacement Exception. The warranty is for the balance of the original warranty or for 90 days from the date returned and delivered to the first end-user, whichever is longer.

III. Who is Covered

This warranty extends to you only if you are the first end-user purchaser.

IV. What We Will Do to Correct Warranty Problems

At no charge to you, we have the option to repair or replace the Products that do not conform to the warranty, or to refund the Products' purchase price. We may use functionally equivalent reconditioned/refurbished/pre-owned or new Products or parts. No software updates are provided.

V. How to Get Warranty Service

PLEASE CALL US – DO NOT SHIP:

USA
Cellular 1-800-331-6456
Paging 1-800-548-9954
FRS Radios 1-800-353-2729
1-888-390-6456 TTY (Text Telephone)

Canada
All Products 1-800-461-4575
1-888-390-6456 TTY (Text Telephone)

Accessories and software -- call the number designated for the product with which they are used.

You will receive instructions
designated resource. If inst
freight, duties and insuranc
return the Products, you mu
comparable proof of purcha
of your service provider (if t
and location of the installati
address and telephone nun
parts such as antennas, bat
OF PURCHASE.
For Products we ask you sh
our expense for the freight a
additional information is nee
above.

VI. What This Warranty D

- Products that are operate
software not furnished or
("ancillary equipment"), or
result of such use. Among
chargers, adaptors, and p
Any of these voids the wa
- Someone other than Motc
installs, maintains, alters,
voids the warranty.

- Rechargeable batteries that: (a) are charged by other than the Motorola-approved battery charger specified for charging such batteries; (b) have any broken seals or show evidence of tampering; (c) are used in equipment other than the Product for which they are specified; or (d) are charged and stored at temperatures greater than 60 degrees centigrade. Any of these voids the warranty.
- Products that have: (a) serial numbers or date tags that have been removed, altered or obliterated; (b) board serial numbers that do not match each other, or board serial numbers that do not match the housing; or (c) nonconforming or non-Motorola housings or parts. Any of these voids the warranty.
- Defects or damage that result from: (a) use of the Products in a manner that is not normal or customary; (b) improper operation or misuse; (c) accident or neglect such as dropping the Products onto hard surfaces; (d) contact with water, rain, extreme humidity or heavy perspiration; (e) contact with sand, dirt or the like; or (f) contact with extreme heat, or spills of food or liquid.
- Physical damage to the surface of the Products, including scratches, cracks or other damage to a display screen, lens or other externally exposed parts.
- Failure of Products that is due primarily to any communication service or signal you may subscribe to or use with the Products.
- Coil cords that are stretched or that have any broken modular tabs.
- Leased Products.

Flat-rate repair rates may apply tc
information about Products needi
please call the telephone number
repair availability, rates, methods

VII. Some Other Limitations

This is Motorola's complete warra
remedies. This warranty is given i
warranties, including without limita
fitness for a particular purpose, ar
law. Otherwise, they are specifica
No warranty is made as to coverac
Products, whether through a servi
No warranty is made that the softv
combination with any hardware or
parties, that the operation of the so
or that all defects in the software p
In no event shall Motorola be liable
for damages in excess of the purcl
incidental, special or consequentia
profits, loss of business, loss of infc
of or in connection with the ability c
these damages may be disclaimed

VIII.Patent and Software Provisic

At Motorola's expense, we will defe
finally awarded against you, to the

Products directly infringe a United States patent. Our obligation is conditioned on: (a) you notifying us promptly in writing when you receive notice of the claim; (b) you giving us sole control of the defense of the suit and all negotiations for its settlement or compromise; and (c) should the Products become, or in Motorola's opinion be likely to become, the subject of a claim of infringement of a United States patent, you permit us, at our option and expense, either to: procure for you the right to continue using the Products; replace or modify them so that they become non-infringing; or grant you a credit for such Products, as depreciated, and accept their return. The depreciation will be an equal amount per year over the lifetime of the Products, as established by Motorola.

Motorola will have no liability to you with respect to any claim of patent infringement that is based upon the combination of the Products or parts furnished under this limited warranty with ancillary equipment, as defined in VI., above.

This is Motorola's entire liability with respect to infringement of patents by the Products.

IX. State Law and Other Jurisdiction Rights

Some states and other jurisdictions do not allow the exclusion or limitation of incidental or consequential damages, or limitation on the length of an implied warranty, so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights, which vary from jurisdiction to jurisdiction.

To obtain information on Motorola F
warranty service, accessories and
Products, please call:

USA

Cellular 1-800-331-6456
Paging 1-800-548-9954
FRS Radios 1-800-353-2729
TTY (Text Telephone) 1-888-390-6

Accessories and software -- call the
product with which they are used.

DO NOT SHIP PRODUCTS TO TH

To correspond with Motorola about
http://www.motorola.com or at:

USA

Motorola, Inc.
600 North U.S. Highway 45
Libertyville, IL 60048

FCC License Not Required

FCC Changes or modifications not expressly approved by Motorola may void the user's authority granted by the FCC to operate this radio and should not be made. To comply with FCC requirements, transmitter adjustments should be made only by or under the supervision of a person certified as technically qualified to perform transmitter maintenance and repairs in the private land mobile and fixed services as certified by an organization representative of the user of those services. Replacement of any transmitter component (crystal, semiconductor, etc.) not authorized by the FCC equipment authorization for this radio could violate FCC rules.

Software Copyright Notice

The Motorola products described in this manual may include copyrighted Motorola and third party software stored in semiconductor memories or other media. Laws in the United States and other countries preserve for Motorola and third party software providers certain exclusive rights for copyrighted software, such as the exclusive rights to distribute or reproduce the copyrighted software. Accordingly, any copyrighted software contained in the Motorola products may not be modified, reverse-engineered, distributed, or reproduced in any manner to the extent allowed by law. Furthermore, the purchase of the Motorola products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents, or patent applications of Motorola or any third party software provider, except for the normal, non-exclusive, royalty-free license to use that arises by operation of law in the sale of a product.

Patent Information

This product is manufacture
patents:
5896277 5894292 5864752
D389158 5894592 5893027
D389827 D389139 592982
D416893 D433001

Export Law Assuranc

This product is controlled un
America and Canada. The G
Canada may restrict the exp
destinations. For further infor
the Canadian Department of

- **No license fee or airtime charges!**
- **Audible Call Tones**
  Multiple distinct ringing options so your group can identify who's calling
- **Keypad Lock**
  Prevents your settings from being accidentally changed
- **Batteries (not included)**
  Requires 3 AA Alkaline batteries or one NiCd rechargeable battery
- **14 channels each with 38 codes (38 codes on T5410 & T5420 only)**
  Privacy feature to help minimize interference
- **Durable, fixed antenna**
  Maximizes talk range
- **"Roger" Beep/Talk Confirmation Tone**
  Signals others you're done talking
- **Call Button**
  Get others' attention before you start talking
- **Scan (T5410 Only)**
  Easily finds your group's channel and code by searching all combinations
- **Talk Hands-Free (VOX) (T5420 Only)**
  "Voice activation" (VOX) lets you talk hands-free when used with optional accessories
- **Weather-resistant**
- **1 Year Limited Warranty**
  For warranty details call 1-800-353-2729
- **User's guide included**
- **Low Battery Alert**
  Audible tone and visual display tell you your battery is running down
- **Quick release Swivel Belt-clip included**
- **Illuminated display**
  Easy to read your settings in dark places
- **Up to 2 mile range***
  * Range will vary based on terrain and conditions

Motorola® Talkabout®

T5320, T5410 & T5420 Proof of Purchase

⚠ WARNING CHOKING HAZARD
SMALL PARTS
Not for children under 3 years.
This product is not intended to be used as a toy or plaything.

1-8[illegible]353-2729 o[illegible]motorola.com/talkabout

To order your accessories

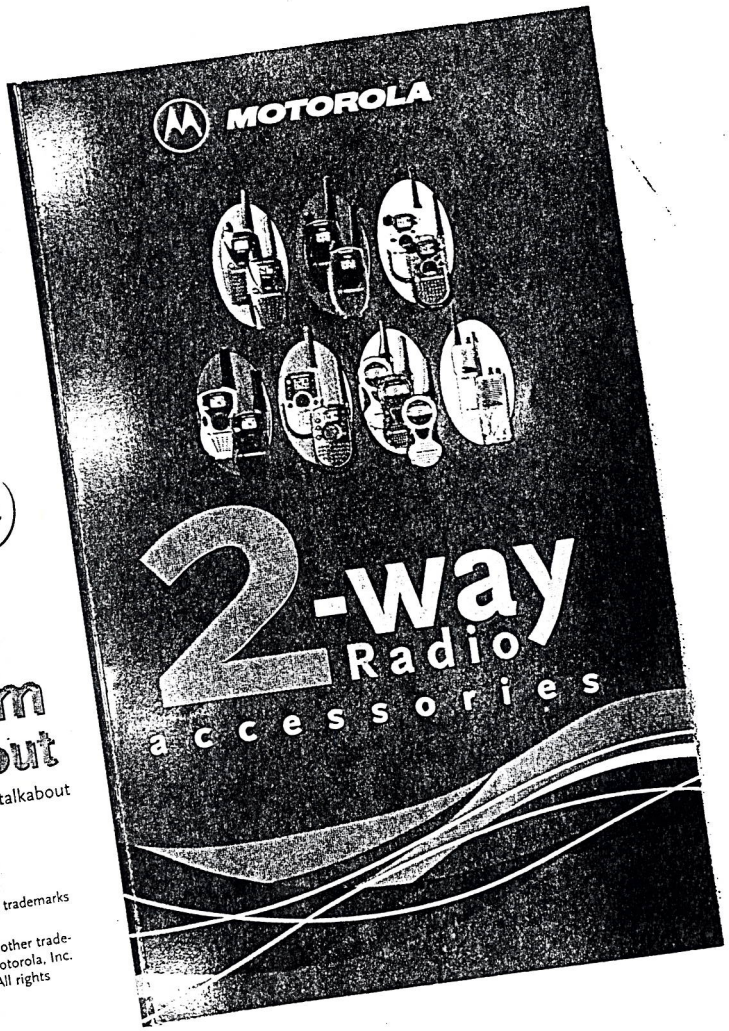
or for additional information see your local retailer

or call 800.353.2729

That's: 800.353.2729 • 7am – 7pm CST.

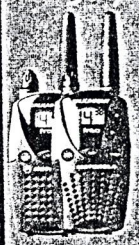
or visit our website at motorola.com/talkabout

That's: www.motorola.com/talkabout



two-way radios

fr50/60



Motorola Talkabout fr50/60 Radios

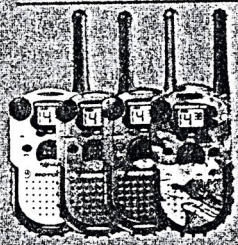
(from left to right)
fr50 Available in Dark Slate
fr60 Available in Midnight Blue

T5000 Series

Motorola T5000 Series Radios*

(from left to right)
T5100 Available in Midnight Blue
T5200 Available in Rosewood

TA200/250



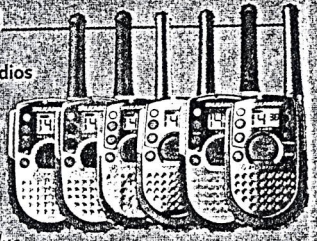
Motorola Talkabout TA200/250 Radios

(from left to right)
TA200 Available in Sunstreak Yellow only
250 Available in Sunstreak Yellow, Cobalt Blue, Shadow Anthracite, Advantage Classic®

280/289

Motorola Talkabout TA280 SLK/T289 Radios

(from left to right)
TA280 SLK Available in Graphic Black, Baltic Purple
T289 Available in Advantage Classic®, Black Chrome, Ice Blue, Purple Haze



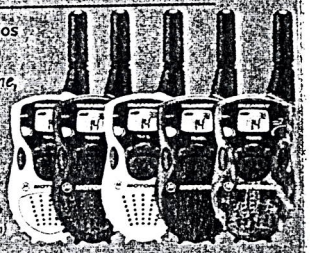
2-way radios

*Expected availability June 2001

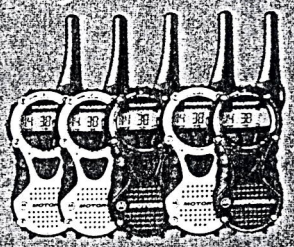
T6200 Series

Motorola T6200 Series Radios

(from left to right)
T6200 Available in Wild Lime, Nordic Blue
T6210 Available in Citrus Yellow
T6220 Available in Ever Green, Advantage Timber®, Graphite Black (photo not shown)



T6300 Series



Motorola T6300 Series Radios

(from left to right)
T6300 Available in Bimini Blue, Smoke Black
T6310 Available in Deep Purple
T6320 Available in Liquid Lime, Amazon Green

Distance

Motorola Distance and Distance DPS Radios

(from left to right)
Available in Dark Pewter, Sunstreak Yellow, Advantage Classic®

to order call [illegible] Distance DPS

earbuds•headsets•microphones

Motorola Hands-Free Accessories allow discreet communication in high-noise areas or quiet environments. Enjoy the added benefit of communication without removing the radio from belt or carry case when optional VOX capable accessory is used with VOX capable Talkabout radios.*

The Motorola Earbud allows you to clearly hear messages in high noise areas or in quiet environments without disturbing others. This lightweight earpiece fits comfortably inside the ear.

#53726

#50228

#53726 Compatible with fr50, fr60, TA280 SLK, T289, Spirit GT/GT+, T5000-Series, and T6000-Series radios

#50228 Compatible with TA200/250, Distance, Distance DPS radios

The Motorola Flexible Ear Receiver is a lightweight earpiece and is fitted to position outside the ear. It adjusts to comfortably fit either ear.

#53728

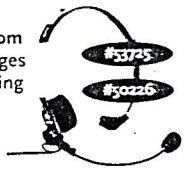
#50227

#53728 Compatible with fr50, fr60, TA280 SLK, T289, Spirit GT/GT+, T5000-Series, and T6000-Series radios

#50227 Compatible with TA200/250, Distance, Distance DPS radios

* fr50 and fr60 radios are not VOX capable

The Motorola Headset with Swivel Boom Microphone allows you to hear messages in quiet environments without disturbing others or in a high noise area with complete clarity. *(VOX capable)*

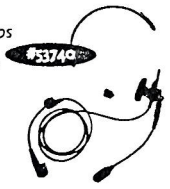


#53725

#50226

#53725 Compatible with fr50, fr60*, TA280 SLK, T289, Spirit GT/GT+, T5000-Series, and T6000-Series radios*

#50226 Compatible with TA200/250, Distance, Distance DPS radios



#53740

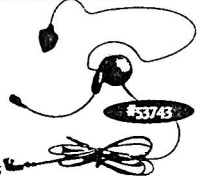
#53740 Compatible with fr50, fr60*, TA280SLK, T289, Spirit GT/GT+, T5000-Series, T6000-Series radios*

#56320

The Motorola Earpiece with Boom Microphone allows discreet communication in high-noise environments. Available November 2000. *(VOX capable)*

#56320 Compatible with fr50, fr60*, TA280 SLK, T289, Spirit GT/GT+, T5000-Series, and T6000-Series radios*

The Motorola Lightweight Headset with Boom Microphone is ideal for fast-paced busy environments. *(VOX capable)*



#53743

#53743 Compatible with fr50, fr60*, TA280 SLK, T289, Spirit GT/GT+, T5000-Series, and T6000-Series radios*

#50256

The Motorola Earbud with Inline Microphone allows discreet communication in high-noise environments. *(VOX capable)*

#50256 Compatible with TA200/250, Distance, Distance DPS radios

to order call
800.353.2729

Motorola
Push-To-Talk Accessories
allow discreet communication in high-noise areas or quiet environments.

#53727

#50229

The Motorola Earbud with Push-To-Talk Microphone allows discreet communication without removing radio from belt or carry case. Easily attach mic to lapel or shirt for convenient use.

#53727 Compatible with fr50, fr60, TA280 SLK, T289, Spirit GT/GT+, T5000-Series, and T6000-Series radios

#50229 Compatible with TA200/250, Distance, Distance DPS radios

The Motorola Remote Speaker Microphone allows hands-on, Push-To-Talk control. This compact microphone attaches to your lapel or shirt for low-profile communication.

#53724

#50225

#53724 Compatible with fr50, fr60, TA280 SLK, T289, Spirit GT/GT+, T5000-Series, and T6000-Series radios

#50225 Compatible with TA200/250, Distance, Distance DPS radios

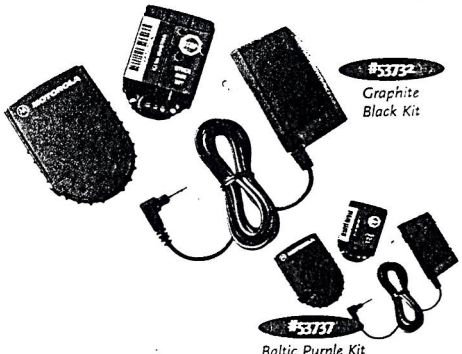
Batteries and Battery Kits

Motorola Battery options provide the versatility of a rechargeable NiMH battery or a 3 AA Alkaline battery operation.

#53720

The Motorola NiMH Rechargeable Battery provides up to 11 hours of use. That's up to one hour talk time and 10 hours standby time.

#53720 Compatible with TA280 SLK, T289, Spirit GT/GT+ radios



#53732 *Graphite Black Kit*

#53737 *Baltic Purple Kit*

to order call
800.353.2729

Baltic Purple

Graphite Black

The Motorola Alkaline Battery Kit allows you to operate your radio on three AA alkaline batteries (not included). Alkaline batteries will provide up to 30 hours of use. That's about three hours of talk time and 27 hours of standby time.

Available in Baltic Purple and Graphite Black.

#53733, 53734, 53735 Compatible with TA280 SLK radios

#53731 Compatible with TA280 SLK, T289 radios

The Motorola NiMH Rechargeable Battery Upgrade Kit provides up to 11 hours of use. That's almost one hour of talk time and 10 hours of standby time. Kit includes one NiMH rechargeable battery, one NiMH charger and one NiMH battery door.

Available in Baltic Purple and Graphite Black.

#53737, 53736, 53738 Compatible with TA280 SLK radios

#53732 Compatible with TA280 SLK, T289 radios

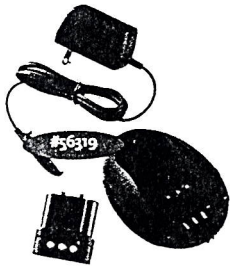
Motorola
NiMH Batteries and Battery Kits
allow repeated charging and use with Talkabout T6000 Series radios.

The Motorola T6000 Series NiMH Rechargeable Battery provides up to 12 hours of use. That's up to 2 hours of talk time and almost 10 hours of standby time.

#56318 Compatible with T6000-Series radios

The Motorola T6000 Series NiMH Rechargeable Battery Upgrade Kit provides up to 12 hours of use. That's up to 2 hours of talk time and almost 10 hours of standby time. Kit includes one NiMH rechargeable battery, one NiMH charger and one CommPort™ charging dock.

#56319 Compatible with T6000-Series radios



to order call
800.353.2729

earbuds
microphones
headsets
batteries
battery kits
power adapters
carry cases

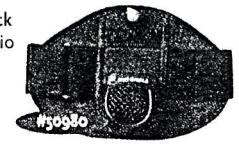
motorola.com/talkabout

6864110R67
BA-519A

carry cases

Motorola
Carry Cases provide flexibility and protection for your two-way radio, while helping to hold it securely.†

The Motorola Arm Pack lets you carry your radio on either arm. The comfortable, single strap provides quick and easy wearability.†



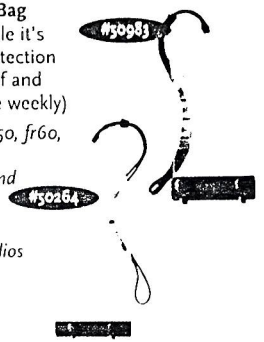
#50980 Compatible with TA200/250 radios

The Motorola Belt Case/Arm Pack provides an alternative carrying option. Front elastic strap helps keep radio secure.†

#56323 Compatible with TA280 SLK, T289, T6000-Series radios

to order call
800.353.2729

The Motorola Waterproof Bag allows radio operation while it's inside the bag. Perfect protection for your radio – waterproof and salt water resistant. (Rinse weekly)

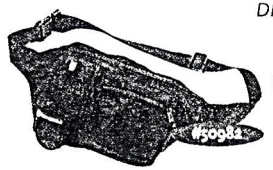


#50983 Compatible with jr50, jr60, TA200/250, TA280 SLK, T289, T5000-Series radios and T6000-Series radios

#50264 Compatible with Distance, Distance DPS radios

The Motorola Fanny Pack lets you carry your radio and other valuables comfortably. The pack has four separate compartments. The front clip helps hold your radio securely.†

#50224 Compatible with Distance, Distance DPS radios



#50982 Compatible with TA200/250 radios

The Motorola Belt Carry Case provides an alternative carrying option. Front clip helps keep radio secure.†

#50979 Compatible with TA200/250 radios

The Motorola Shoulder Pack lets you carry a radio on your shoulder. Perfect for biking and hiking.†

 # 50981 Compatible with TA200/250 radios

The Motorola Carry Case with Adjustable Strap helps provide maximum protection from everyday wear and tear. Included on the case is a pen holder and small pocket.†

 # 53741 Compatible with TA280 SLK, T289, Spirit GT/GT+ radios

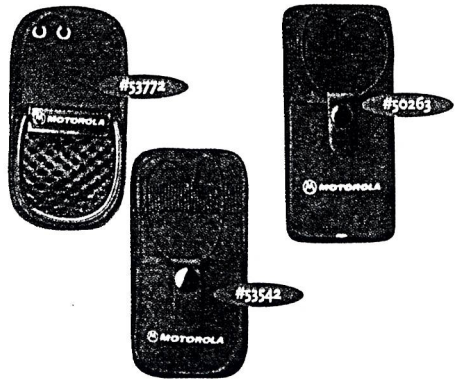
to order call
800.353.2729

The Motorola Belt/Bike Carry Case provides a flexible carrying option for your two-way radio. Easily attaches to belt or mounts to bike for convenient use.†

#53772 Compatible with fr50, fr60 radios

#53542 Compatible with Distance radios

#50263 Compatible with Distance DPS radios



† The carry case has been designed for your convenience and is not meant to secure your radio under all circumstances.

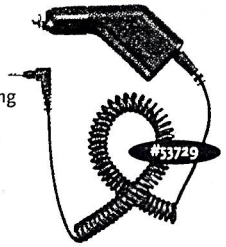
MOTOROLA
TALKABOUT

vehicle power adapters

Motorola
Vehicle Power Adapters
charge your NiMH battery while you're on the road.

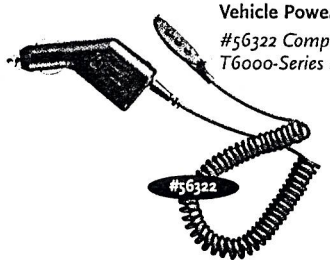
The Motorola Vehicle Power Adapter†† charges your radio in less than 3 hours while providing ample amount of cord giving you plenty of length for comfortable use.

#53729 Compatible with TA280 SLK, T289, and Spirit GT/GT+ radios



The T6000-Series Vehicle Power Adapter††

#56322 Compatible with T6000-Series radios



†† Radio must be powered by NiMH rechargeable battery when using Vehicle Power Adapter.

to order call
800.353.2729