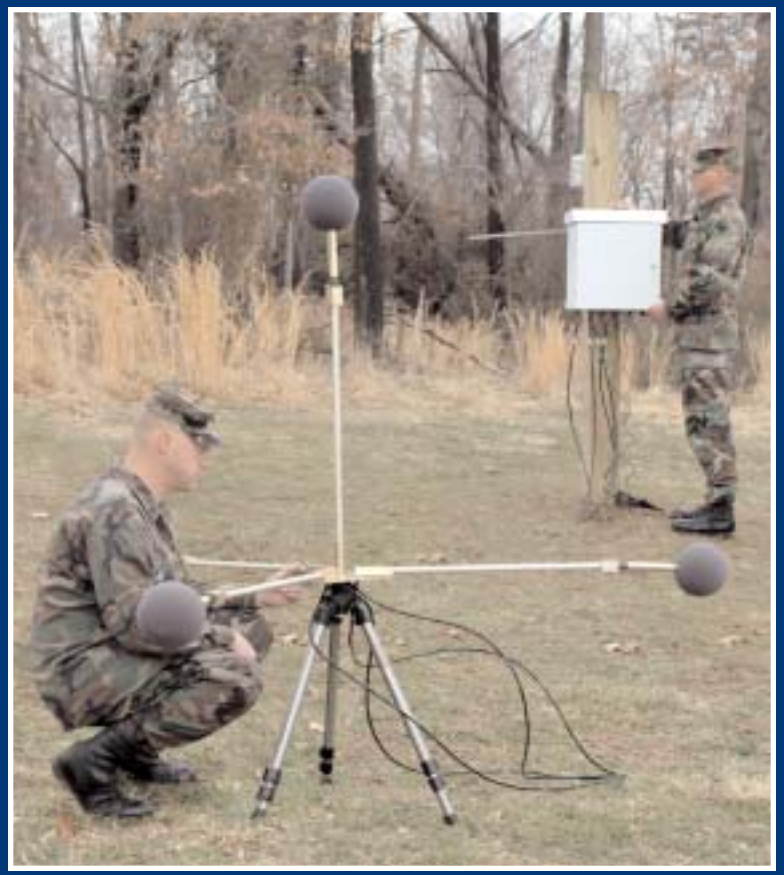

Unattended Transient Acoustic MASINT System (UTAMS)

Installation and User Quick Reference Guide

August 2004

U.S. Army Intelligence and Security Command

U.S. Army Research Laboratory

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Safety Warning

WARNING: This system has high-voltage components located inside the electronics unit. Do not open this unit. There are no user-serviceable parts inside.

System Description

The Unattended Transient Acoustic MASINT System (UTAMS) consists of four sensor stations linked via radio to a base station. Each sensor station includes two tripods, four-microphone acoustic array, global positioning system (GPS) antenna, electronics unit, radio box, radio antenna (Yagi or "rubber ducky"), outside temperature sensor, AC/DC-to-DC converter, and cables. The base station consists of a Toughbook laptop computer, radio box, omni-directional radio antenna, and cables.

Each acoustic array is placed on a tripod in a favorable position for detecting events, leveled, and oriented. The electronics unit is mounted on a pole, hard wired to AC power, and connected via cables to the array, GPS antenna, outside temperature sensor, and tripod-mounted radio.

The base station is placed in an appropriate location for an operator to monitor, and the components are connected via cables. All system monitoring is conducted from the base station.

Each acoustic array develops its own line of bearing (LOB), azimuth and elevation, from the array to the launch or detonation event. The intersection of these LOBs is the location of the origin of the event, provided as an azimuth, elevation, and range relative to a user-selected reference point or as a grid coordinate.

CAUTION: Two versions of the UTAMS now exist. Not all of the components of the two versions are identical. One difference is the method to power the sensor stations. If the electronics units in your system do not have a DC Power connector (1), then this manual does not apply to your system.

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System Components

System components should be carefully unpacked and inventoried according to the following list:

Tripod,
with vertical pole (5)
without vertical pole (4)

Computer Power Cable (1)

Acoustic Array Arm/ Base Plate/ Cable Assembly (4)

Microphone (16)

Toughbook Laptop Computer (1)

Windscreen (16)

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System Components *(continued)*

Electronics Unit (4)

Radio Box and cable, Sensor Station (4) Base Station (1)

Outside Temperature Sensor & Cable (4)

AC/DC-to-DC Converter and cables (4)

GPS Antenna and Cable (4)

Radio-Electronics Unit Cable (5)

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System Components *(continued)*

Laptop Computer-to-Radio Box Cable (1)

Base Station Radio Power Cable (1)

Yagi Antenna Bracket Assembly (4)

Yagi Antenna (4)

Omni-directional Antenna Bracket Assembly (1)

Omni-directional Antenna (1)

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Crimper Tool
(1)

CAUTION: *Fragile components!* Handle the microphone array carefully to avoid bending the arms.

If you encounter problems and want assistance, please call 301-394-5000 (DSN 290-).
You can also send an unclassified email to OIFSensors@arl.army.mil
or a classified e-mail to OIFSensors@arl.army.smil.mil
to ask for help from the design team.

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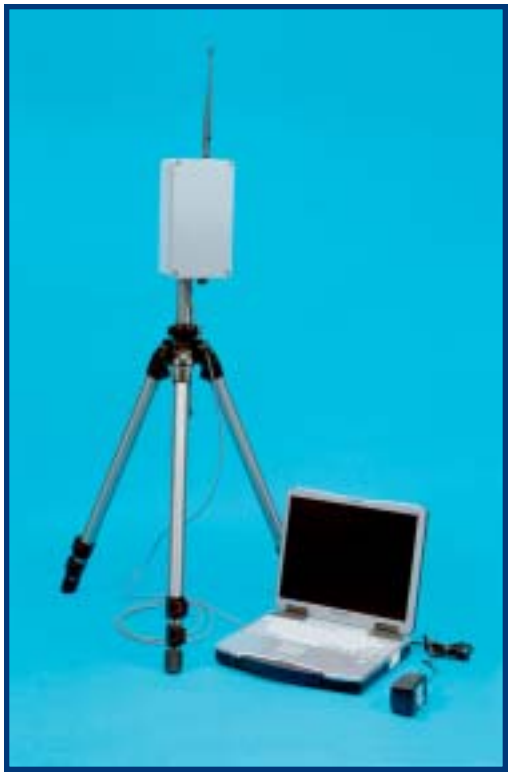
Base Station Setup



- Select a location for the base station where it can be readily monitored by an operator and such that appropriate sensor station locations can be selected (see *Acoustic Array Location* section of this manual).
- Deploy the tripod.
- Mount the radio box and omni-directional antenna on the tripod, pointing straight up, using the brackets provided.
- Connect the laptop computer to an AC power source providing 100-240V AC, 0.6-1.2A, 50-60Hz, using the computer power cable.
- Connect the laptop computer-to-radio box cable to the serial port of the laptop computer.
- Connect the laptop computer-to-radio box cable to the radio-electronics unit cable and connect the radio-electronics unit cable to the Radio Box.
- Connect the laptop computer-to-radio box cable to the base station radio power cable and connect the base station radio power cable to an AC power source providing 100-240V AC, 50-60Hz.
- Follow procedure in the *Electronics Unit Cable Connections/Startup* section to connect AC power. A standard U.S. 120V plug should be attached to the end of the waterproof connector, rather than the 3-pin MIL power connector.
- Turn on the computer and double-click on the icon to start the software.
- Refer to the software manual for details on software operation.

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Acoustic Array Location

Sites for each acoustic array should be selected to maximize the likelihood of direct sound propagation from anticipated mortar launch positions to the array. Usually, this implies elevation on a hill, tower, or building. In general, a location should be chosen that is away from large reflectors such as walls, cars, rock formations, etc. Care should be taken to avoid high noise areas, such as near roads, streams, or noisy equipment. Vegetation should not be touching the tripod or array arms and should be far enough away so that branches will not hit the array structure in moderate wind (potential for false alarms). Sensor station sites must be within 2km of the base station location for adequate communications when using the Yagi antenna in conjunction with the radio box, or within 500 meters when using the rubber ducky antenna. The baseline (distance) between two acoustic arrays should be approximately 500 meters or more. The larger the baseline, the more accurate the range solution via triangulation will be. The range accuracy will naturally degrade for longer range detections and/or smaller baselines. The arrays should be as far apart as possible while maintaining radio contact between the sensor stations and the base station. For normal operation with four sensor stations, do not select locations in a straight line.

If only two sensor stations are deployed, select locations for the arrays such that the baseline is perpendicular to the most likely direction of incoming mortar fire. This is important because the range errors from triangulation can be very large when an event is detected outside the two arrays close to the line formed by extending the baseline through and outside the arrays. In some of these cases, the LOBs will not intersect, and a range solution will not be available; in other cases, the LOBs will intersect at many points, and the accuracy of the range solution will be degraded. However, in all of these cases, the bearing accuracy of the system will not be degraded.

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Mounting the Components

- Select an appropriate acoustic array site (see *Acoustic Array Location*)
- Plant a pole (not provided) within 10 ft. of where the tripod-mounted microphone array will be placed. The pole must extend at least 6 ft. above ground and be placed in a hole at least 3 ft. deep. The pole must be planted firmly enough in the ground to support the weight of the electronics unit and temperature sensor and not collapse in wind conditions expected at the site.

- Mount the electronics unit on the pole using the supplied pole brackets and hose clamps. The solar shield (1) must be facing up, and the connectors (2) must be facing down. To minimize sound reflectance off the unit, it should be placed with an edge or a short side facing the array.

- Properly ground the electronics unit.

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Mounting the Components *(continued)*

- Mount the temperature sensor on the opposite side of the pole via the long wood screws supplied.
- Deploy the tripod with the vertical pole within 10 ft. of the electronics unit.
- Mount the radio box on the vertical pole of the tripod using the brackets provided.
- For most cases it will be necessary to use the Yagi antenna (1).
- Mount the Yagi antenna via its bracket assembly on the vertical pole of the tripod such that

the short rods are vertical (see figure) and the main shaft is pointed towards the base station location to within ±20˚.

- Connect the Yagi antenna cable to the radio box.
- The rubber ducky antenna (2) can be used if the distance to the base station is less than 500 meters, if this sensor station is located on top of the same building or tower as the base station, or for troubleshooting.
- Place the GPS antenna so that the cable will

reach the electronics unit with the flat (magnetic) side down. The curved side must have a clear view of the sky. Do not mount vertically.

- Secure the GPS antenna in place, either via its magnetic base or other means, but do not cover the curved side with tape or anything else.
- If necessary, the GPS antenna can be placed directly on the ground.

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Acoustic Array Assembly

CAUTION: *At all times, be very careful not to bend the aluminum microphone arms. This will change the critical microphone spacing and degrade the system's accuracy.*

- Place the base plate tube (with microphone arms attached) into the flange on the tripod (see figure).
- Firmly lock the tube in position by rotating the flange ring and the flange set screw (see figures) clockwise.
- Carefully unwrap the Velcro™ that secures the three horizontal microphone arms to the vertical arm. Gently extend each arm (one at a time), being careful not to bend the arm.
- Insert the two alignment pins of the numbered mounting block of the arm into the corresponding holes in the numbered base plate (see figure). You will need to pull the cable forward slightly while inserting the pins in the holes.

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Acoustic Array Assembly *(continued)*

- Apply the vice-grip tool to seat the microphone arm onto baseplate firmly (see figure).
- Insert four of the pan head screws provided with the array through the baseplate and into the mounting block (see figure).
- Attach the remaining two arms to the baseplate in the same manner.
- Carefully attach one microphone to the end of each of the four arms. The connector will only mate in the correct orientation.
- Firmly lock the microphone on the arm by twisting the black collar clockwise (see figure).
- While holding the microphone in one hand, carefully push a foam windscreen onto the microphone with a twisting action until end of the microphone sits approximately in the center of the windscreen (see figure). As always, take care not to bend the microphone arms.

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Electronics Unit Cable Connections

CAUTION: *Failure to correctly match the microphone number on the cable to the corresponding number on the electronics unit connector will result in erroneous LOBs from the array.*

NOTE: *Not all connectors on the electronics unit will be used for normal operation.*

- Connect the four microphone cables of the acoustic array to the corresponding microphone connectors of the electronics unit (see figure).
- Connect the GPS antenna cable to the electronics unit (see figure).
- Connect the temperature sensor cable to the electronics unit.
- Connect the radio-electronics cable to the radio box with either a Yagi or rubber ducky antenna already installed.

CAUTION: *Make sure either the Yagi antenna or the rubber ducky antenna is attached to the radio box before connecting the radio cable to the electronics unit, otherwise damage to the radio box could occur.*

- Connect the radio-electronics unit cable to the electronics unit.

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Electronics Unit Cable Connections *(continued)*

WARNING: *All modifications to the electronics unit power supply components and cables should be performed by a certified electrician.*

NOTE: *Only use the DC Power connector (1) of the electronics unit. The AC power connector (2) of the electronics unit is not used during normal operation of this system.*

- Check to ensure the power source is in the range of either 85-270V AC, at 47-440Hz or 9-36V DC.
- Connect the AC/DC-to-DC converter to the electronics unit via the DC output cable.
- Connect the AC/DC-to-DC converter to the power source via the appropriate AC or DC input cable.
- Keep the AC/DC-to-DC converter out of direct sunlight.
- The electronics unit begins operating within minutes of powering it up. Proper setup and operation will be verified when the base station is operational.

CAUTION: *Do not bury the power cable in the same trench as the other cables. It must be buried at least six inches away from the other cables.*

- All of the cords between the acoustic array and the electronics unit should be buried at least several inches deep to prevent personnel from tripping over them.

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Array Alignment/Accuracy

The UTAMS requires a precise alignment setup of the acoustic arrays in order to produce an accurate GPS location of a mortar event. Five alignment procedures (Survey Team, Visual Reference, Array-to-Array, GPS Aiming Point, and Compass Aiming Point) are described below. The five procedures are different and will produce various levels of system accuracy. The order of appearance of the alignment procedures in this manual is the order of best to least accurate. When setting up a system, different alignment procedures can be used for the individual arrays of the system. Setup of the acoustic sensor arrays requires careful alignment of the array, and the precision of the "tools" used to align the arrays will determine the accuracy of the system.

While the map position of each sensor station is automatically obtained by its inherent GPS receiver and transmitted via radio to the base station, the operator must manually determine the azimuth orientation of each array and enter this data into the base station laptop computer. The "Align Arrow" engraved on the array baseplate defines the orientation direction of the array. It is important to note that the arrays do *not* have to be pointed towards "North". Also, the arrays can be, but do *not* have to be, pointed all in the same direction. When using the Survey Team procedure, after the operator has deployed the sensor stations, the Survey Team then measures the location and orientation of each array. When using the Visual Reference procedure, the arrays are pointed towards one or individual objects for which overhead imagery is available on the map display of the base station laptop computer. When using the Array-to-Array procedure, each array is pointed towards another array for which line-of-sight is available. When using the GPS or Compass Aiming Point procedures, the arrays are pointed towards any operator-selected distant object. If a magnetic compass is used to measure the azimuth orientation of the arrays, these measurements must be corrected for the local declination angle before being entered into the base station laptop computer.

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Survey Team Alignment

This procedure requires the support of a Survey Team (such as a gun crew) to survey each array location and establish north headings.

Additional Support Required: Survey Team

Setup:

- Deploy the four sensor stations and the base station (see the *Acoustic Array Assembly*, *Acoustic Array Location*, and *Base Station Setup* sections of this manual).
- Be sure to level all of the arrays by adjusting the tripod leg lengths while observing the built-in circular level of the baseplate.
- Sandbag the arrays in place, being careful not to disturb the level of the arrays.
- Have Survey Team determine the orientation of each array and enter this data into the base station laptop computer.

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Visual Reference Alignment

This procedure requires the identification of one or individual distant objects to which there is line-of-sight (LOS) from the arrays and for which there is Overhead Imagery available on the map display of the base station laptop computer.

Additional Items Required: Overhead Imagery.

Setup:

- Position the first assembled acoustic array at the selected location (see *Acoustic Array Assembly* and *Acoustic Array Location* sections of this manual).
- Select an object or terrain feature, for which there is LOS from the arrays and for which there is Overhead Imagery available on the map display of the base station laptop computer, to be the Aiming Point of the array. The Aiming Point must be at least 500 meters away from the array location, and there must be LOS from the array location to the Aiming Point.
- Lift up the whole array and tripod assembly, rotate it so that the Align Arrow on the baseplate points in the general direction of the Aiming Point, and place the array and tripod assembly back on the ground.
- Level the array by adjusting the tripod leg lengths while observing the built-in circular level of the baseplate (see *Survey Team Alignment* section of this manual for photos).
- Sandbag the arrays in place, being careful not to disturb the level of the arrays.
- Loosen the flange ring and set screw of the tripod. Without disturbing the level of the array, rotate the array so that the Align Arrow is pointing in the exact direction of the Aiming Point. Use the horizontal microphone arm #2 (opposite the Align Arrow) as a pointer/alignment guide. Retighten the flange ring and set screw.
- Step roughly 4 meters directly back from the array location to check that the Align Arrow and horizontal microphone arm #2 are pointing directly at the Aiming Point.
- Perform several iterations of the last 2 steps to ensure optimal alignment.
- Make a note of the array number and the object used as the

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Aiming Point.

- Repeat this procedure for the other three arrays or select another alignment procedure for the other arrays.
- Follow the steps in the software manual to determine the azimuth orientations of all four acoustic arrays (locating each array's Aiming Point on the map on the laptop computer screen and then walking the red line onto each array's Aiming Point by a series of trial and error guesses at the correct azimuth orientation for each array).

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Array-to-Array Alignment

The Array-to-Array Alignment procedure uses the location of each array, as measured by the internal GPS receiver of each sensor station, to determine the orientation of each array. Hence, line-of-sight (LOS) is required between each array and at least one other array. Here overall system accuracy is determined by the accuracy of the GPS location of each sensor station.

Additional Items Required: None.

NOTE: It is *not* necessary to have LOS between all of the arrays.

Setup:

- Position the four assembled acoustic arrays at the selected locations (see *Acoustic Array Assembly* and *Acoustic Array Location* sections of this manual).
- Select an array and assign it the name Array #1.
- Go to the site of Array #1.
- Select another array to which LOS exists from Array #1 and assign the other array the name Array #2.
- Make a note that Array #2 is the Aiming Point of Array #1.
- Lift up the whole array and tripod assembly of Array #1, rotate it so that the Align Arrow on its baseplate points in the general direction of Array #2, and place Array #1 back on the ground.
- Level Array #1 by adjusting the tripod leg lengths while observing the built-in circular level of the baseplate (see *Survey Team Alignment* section of this manual for photos).
- Sandbag the arrays in place, being careful not to disturb the level of the arrays.
- Loosen the flange ring of the tripod of Array #1. Without disturbing the level of Array #1, rotate the array so that the Align Arrow is pointing in the exact direction of Array #2. Use the horizontal microphone arm #2 (opposite the Align Arrow) of Array #1 as a pointer/alignment guide. Retighten the flange ring and set screw of Array #1.
- Step roughly 4 meters directly back from Array #1 to check that the Align Arrow and horizontal microphone arm #2 are pointing directly at Array #2.
- Perform several iterations of the last 2 steps to ensure the best alignment of Array #1 possible.
- Go to each of the other three sensor stations and repeat the last

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7 steps to align each array. Be sure to assign each array a unique number from 1 to 4 and make a note of the array number that is the Aiming Point for each array.

- Follow the steps in the software manual to determine the azimuth orientations of all four acoustic arrays (walking the red line on the laptop computer screen onto each array's Aiming Point by a series of trial and error guesses at the correct azimuth orientation for each array).

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GPS Aiming Point Alignment

The GPS Aiming Point Alignment procedure uses the location of a distant object (at least 500 meters away from the array to which there is line-of-sight (LOS) from the array), as measured by an additional GPS receiver (not included), to determine the orientation of each array. An additional GPS receiver, such as a Precision Lightweight GPS Receiver (PLGR) is required. Here overall system accuracy is determined by the accuracy of the GPS locations of each sensor station and each distant object (Aiming Point) selected. In choosing the additional GPS receiver consider that since the PLGR uses military "P" code, it may be more accurate than a commercial receiver. The accuracy of a PLGR will improve over a 10- to 15-minute period. The receiver cannot be moved during this period. Some commercial GPS receivers provide this refinement or "averaging" function.

Additional Items Required: Additional hand-held GPS receiver (not included).

Setup:

- Position the first assembled acoustic array at the selected location (see *Acoustic Array Assembly* and *Acoustic Array Location* sections of this manual).
- Select an object or terrain feature to be the Aiming Point of the array. The Aiming Point must be at least 500 meters away from the array location and to which there is LOS from the array location.
- Lift up the whole array and tripod assembly, rotate it so that the Align Arrow on the baseplate points in the general direction of the Aiming Point, and place the array and tripod assembly back on the ground.
- Level the array by adjusting the tripod leg lengths while observing the built-in circular level of the baseplate (see *Survey Team Alignment* section of this manual for photos).
- Sandbag the arrays in place, being careful not to disturb the level of the arrays.
- Loosen the flange ring and set screw of the tripod. Without disturbing the level of the array, rotate the array so that the Align Arrow is pointing in the exact direction of the Aiming Point. Use the horizontal microphone arm #2 (opposite the Align Arrow) as a pointer/alignment guide. Retighten the flange ring and set screw.
- Step roughly 4 meters directly back from the array location to

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GPS Aiming Point Alignment *(continued)*

check that the Align Arrow and horizontal microphone arm #2 are pointing directly at the Aiming Point.

- Perform several iterations of the last 2 steps to ensure optimal alignment.
- Take the additional hand-held GPS receiver and go to the Aiming Point location.
- Obtain the GPS map location of the Aiming Point. Recall that the accuracy of the GPS map location will improve by allowing the receiver to refine the location data over 10-15 minutes.
- Write down the GPS map location data and the array number you have assigned this array.
- Repeat this procedure for the other three arrays or select another alignment procedure for the other arrays.
- Follow the steps in the software manual to determine the azimuth orientations of all four acoustic arrays (locating each array's Aiming Point on the map on the laptop computer screen and then walking the red line onto each array's Aiming Point by a series of trial and error guesses at the correct azimuth orientation for each array).

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Compass Aiming Point Alignment

This procedure uses the array/processor box's internal GPS receiver to locate the position of each array and a hand-held compass to measure the orientation of each array.

Additional Items Required: One hand-held compass

Setup:

- Position the first assembled acoustic array at the selected location (see *Acoustic Array Assembly* and *Acoustic Array Location* sections of this manual).
- Select an object or terrain feature to be the Aiming Point of the array. The Aiming Point must be at least 500 meters away from the array location, and there must be line-of-sight from the array location to the Aiming Point.
- Lift up the whole array and tripod assembly, rotate it so that the Align Arrow on the base-plate points in the general direction of the Aiming Point, and place the array and tripod assembly back on the ground.
- Level the array by adjusting the tripod leg lengths while observing the built-in circular level of the baseplate (see *Survey Team Alignment* section of this manual for photos).
- Sandbag the arrays in place, being careful not to disturb the level of the arrays.
- Loosen the flange ring and set screw of the tripod. Without disturbing the array level, rotate the array so that the Align Arrow is pointing in the exact direction of the Aiming Point. Use the horizontal microphone arm #2 (opposite the Align Arrow) as a pointer/alignment guide. Retighten the flange ring and set screw.
- Step roughly 4 meters directly back from the array location to check that the Align Arrow

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Compass Aiming Point Alignment *(continued)*

and horizontal microphone arm #2 are pointing directly at the Aiming Point.

- Perform several iterations of the last 2 steps to ensure the best alignment possible.
- Step roughly 4 meters directly back from the array location once again with the hand-held compass and measure the azimuth orientation of the array (the direction from the array to the Aiming Point).
- Correct this angle for the local magnetic declination by adding or subtracting the local declination angle.
- Write down this corrected azimuth orientation and the array number. You will need to enter both in the base station laptop computer.
- Repeat this procedure for the other three arrays or select another alignment procedure for the other arrays.