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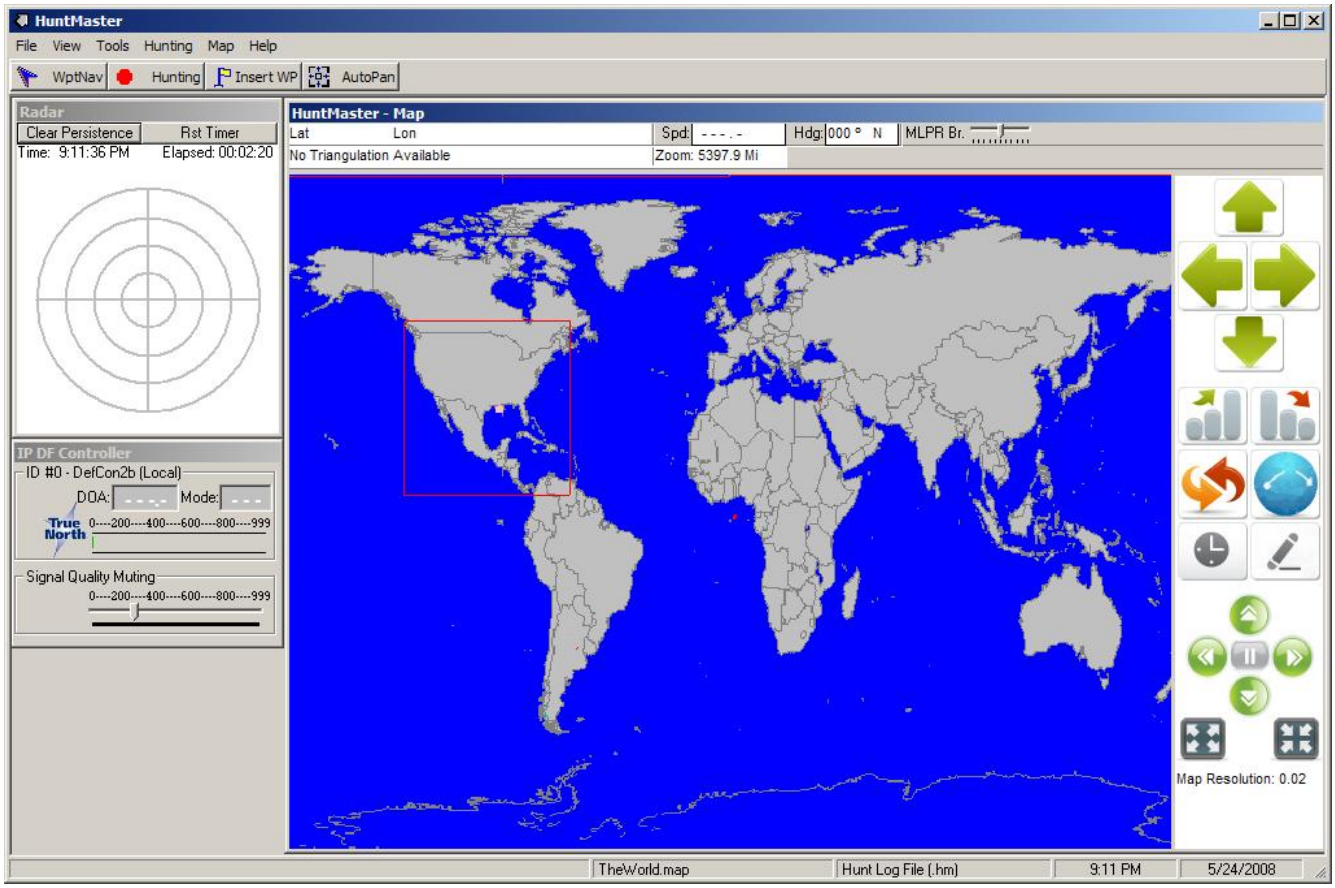
OPERATOR'S MANUAL
HUNTMASTER EXPRESS / NET
DF MAPPING PROGRAM



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NOTES

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SECTION I - GENERAL DESCRIPTION

A. INTRODUCTION

Welcome to HuntMaster. You are about to enter into the age of advanced radiolocalization technology! This software package when connected to an appropriate Radio Direction Finding Instrument and provided of a GPS localization receiver makes up a complete radiogoneometric system with mapping and triangulation capabilities. This Software is intended for professional localization of any RF signal. Been specially suited for object localization (by means of beacons), interference localization, and intelligence information gathering. HuntMaster is also capable of logging all DF and GPS information for later analysis. HuntMaster's Net Edition increases direction finding capabilities by allowing real time triangulation from various fixed or mobile remote DF sites by means of TCP/IP (Internet) data links.

HuntMaster is not just a graphical displaying tool. Based on advanced data processing algorithms the software takes advantage of every bit of information provided by the RDF Instruments in use. That information in conjunction with a moving map display, with GPS vehicle tracking is used to triangulate the unknown position of any RF Signal Source. The use of a Maximum Likelihood Probabilistic Region (MLPR) Display overlaid on top of the map gives detailed information of the most probable area for the unknown signal source (transmitter) to be located. The MLPR is a state-of-the-art Econometric Model Algorithm that drastically improves the ability to chase and localize any class of RF Source.

A Radar like display is used to filter out any unwanted multipath distorted bearings, helping the DF Operator in his hard work of selecting which measurements to trust on, and which to discard as inaccurate. By giving an easily readout of dozens of RDF measurements at a glance, the DF Operator can now take a much better decision based on a much larger dataset. This filtering does create much better and reliable bearing information set from which to triangulate the signal source.

Refer to the front-cover illustration for all references to HuntMaster's main-screen.

B. HARDWARE AND OPERATING SYSTEM REQUIREMENTS

HuntMaster is written for Windows 2000/XP. We recommend that the host computer be a Pentium III 900 MHz or better with at least 256 MB of RAM. The computer monitor should have at least 1024x768 pixels with a color display. If the software is intended to be connected locally to a DF Processor and or GPS Receiver, then one or two RS-232 serial (COM) port have to be available. If serial ports are not available (as is the case with most current laptop units), a USB port can be used via an appropriate USB-to-serial adaptor. Be advised, however, that these adaptors do not always function transparently. The selected adaptor should therefore be tested to verify that it works properly with the DF Processor been used and the selected GPS Receiver with regards to both speed and compatibility. We have found that certain models do not work well with all the supported host receivers and therefore strongly recommend that the selected

adaptor be tested thoroughly. For further information on how to connect 'RDF Products' DF processors, refer to the DFP-1000B Operator's Manual for important additional information on this topic.

C. RDF UNITS SUPPORTED

HuntMaster Version 5.0.9 and above can operate with two different sets of RDF Units, depending on the vendor's you have ordered the software from. This are:

- Any 'RDF Products' unit of the DFP-10x0B series. This are: DFP-1000B, DFP-1010B, DFR-1000B or DFR-1010B.

- Using HuntMaster's SoftDoppler Module and appropriate Hardware. SoftDoppler is a Software DF Processor for Quasi-Doppler DF antenna arrays.

USING 'RDF PRODUCTS' DF UNITS

To use HuntMaster with a 'RDF Products' DF Processor Unit please proceed to the 'RDF Products Units as DF Processor' topic for additional information.

If you already have an 'RDF Products' DF System setup running, then: execute DefCon2b and HuntMaster. DefCon2b will let the DF Operator to control the RDF Unit from the PC computer, while at the same time it forwards all the DF information retrieved from the DF Unit to HuntMaster. Therefore, remember to run DefCon2b each time you intend to use HuntMaster. If DefCon2b is closed, then HuntMaster will stop displaying new DF data.

USING 'SOFTDOPPER' DFING

To use HuntMaster's SoftDopper DF Processor you will be required to purchase additional hardware. A quasi-doppler antenna, and a Digital Interface Unit (DIU) are required pieces of equipment. Please proceed to the 'SoftDoppler as DF Processor' topic for additional information.

D. 'RDF PRODUCTS' UNITS AS DF PROCESSOR

The complete HuntMaster radiogoneometry system using any of 'RDF Products' Series B Units as HuntMaster's DF Processor consist of the following items:

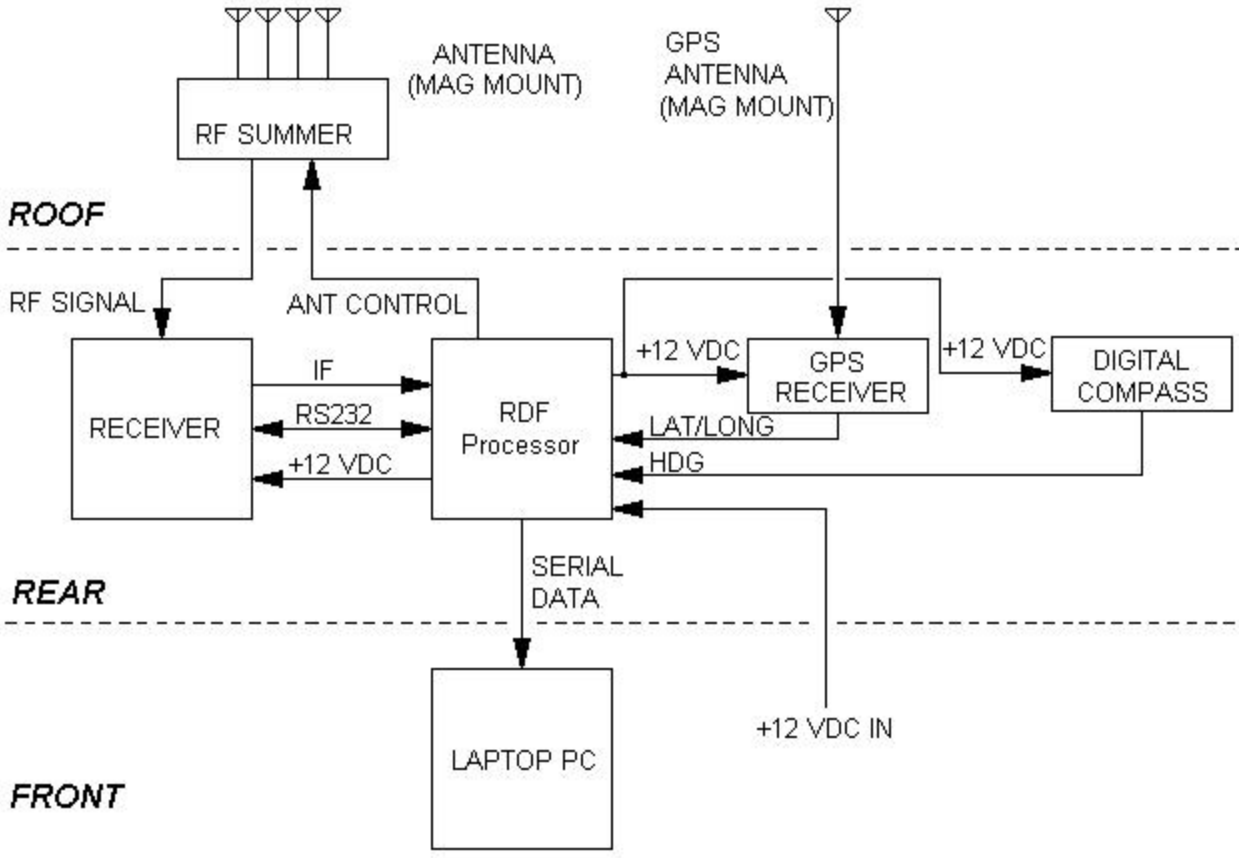
- 'RDF Products' Series B RDF Unit connected to laptop's COM Port & 12v DC. All 'RDF Products' unit of this Series up to date are: DFP-1000B, DFP-1010B, DFR-1000B or DFR-1010B

- Appropriate Radio Receiver (connected to RDF Unit)

- Adcock Radio Direction Finding Antenna (connected to RDF Unit)
- GPS receiver (connected to RDF Unit or to a computer's COM Port)
- A digitized map, or satellite image of the region where localization will take place
- HuntMaster software running on PC computer
- 'RDF Products' DefCon2b Remote PC Control of the RDF Unit. Make sure to have an up-to-date copy of DefCon2b installed in the computer. For HuntMaster to communicate, you will require DefCon2b Ver. 1.2.5 or above. DefCon2b is a PC control program provided by 'RDF Products' that does interface between the Hardware RDF Unit, and HuntMaster. This software lets the operator to control the RDF Unit from the same PC screen where he is operating HuntMaster.

Note: For additional information on 'RDF Products' configuration, connection and operation refer to the Operator's Manual provided with those units, or contact 'RDF Products' at: www.rdfproducts.com.

The connection diagram of the above equipment is the following:



To run HuntMaster using these RDF units, please proceed as follows:

1. Run DefCon2b, and make sure that the DFP and DefCon2b are communicating properly. If not, check that the DF Processor unit is connected to one of the PC's COM Ports, and that DefCon2b's COM Port settings are set accordingly.
2. Run HuntMaster. You will see all the DF information retrieved by DefCon2b on HuntMaster's screen.

Please remember that for HuntMaster to operate properly DefCon2b will have to be open at all times. If DefCon2b is closed, then HuntMaster will stop receiving DF Data from the DFP unit.

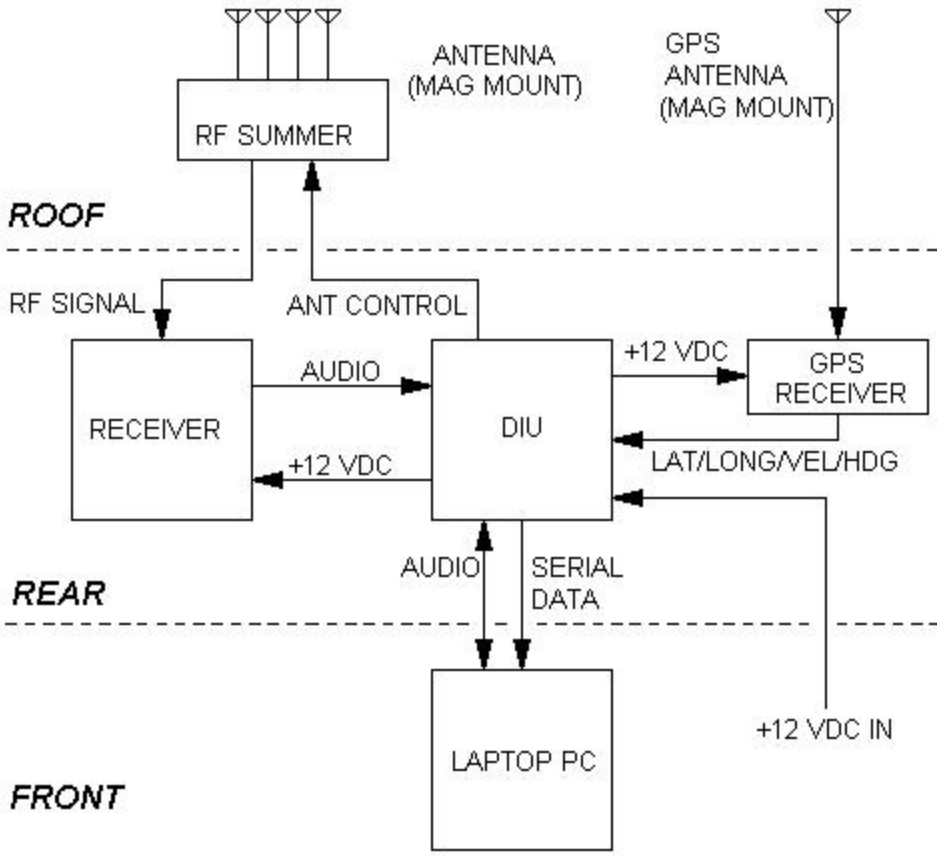
E. SOFTDOPPER AS DF PROCESSOR

The complete HuntMaster radiogoneometry system using SoftDoppler as the DF Processor consist of the following items:

- HuntMaster software running on laptop computer
- Digital Interface Unit (DIU) connected to laptop & 12v DC
- FM VHF/UHF Receiver (connected to DIU)
- 4/6/8 Elements Antenna w/switching array (connected to DIU & Receiver)
- GPS receiver (connected to DIU)
- A digitized map, or satellite image of the region where hunting will take place
- An external speaker w/enclosure (connected to DIU)

The laptop computer should meet the following minimum requirements to run HuntMaster suit: PC computer running Win2000/XP with at least 256Mb of RAM and a Pentium III 900Mhz Processor. The main requirement is a 16bit Full-Duplex A/D Audio Board with Line-In and Speaker Out jacks. With sampling rates from 8Khz to 48Khz. The FM Receiver should be a good communications grade receiver with a wide and linear IF & AF bandwidth (generally 9600bps ready radios meet this requirements). Of course selectivity should be as good as possible. Therefore it is not recommended to use a poor quality receiver unit, as this will compromise the overall performance of the SoftDoppler unit. The Antenna Array and switching circuit should be any compatible with the Roanoke Doppler unit. It is strongly suggested to use the wide antenna switcher array, posted by Joseph D. Moell (K0OV) in 'Homing In' webpage. The GPS receiver should be a 12 channel unit (if possible), with RS-232 serial connection. The unit must handle 4800bps NMEA signals to communicate with HuntMaster software. It is advisable to have a map of the hunting area so that the Map Module can show at all times the position of the vehicle over the map (please refer to the Map chapter for more details). Finally a good quality external speaker should be provided by the user to listen to received audio while hunting. The DIU has a built in 0.2W audio power amplifier with software volume control.

The connection diagram of the above equipment is the following:



Once you have successfully interconnected all items, you must proceed to setup the laptop audio board mixer, configure the SoftDoppler, and finally calibrate it. Please refer to the following section to continue with the installation.

F. OPERATOR'S MANUAL APPLICABILITY

As of this writing, this manual is applicable to HuntMaster Express and Net Editions Version 5.1.24. Reference to 'RDF Products' Remote DF Control Program DefCon2b Version 1.2.5,and DF Processors DFP-1000B/DFP-1010B and made throughout the manual.

G. ACKNOWLEDGMENTS

There have been also a great deal colegues, customers and friends who help us in getting this project running from scratch. But there has been a person in particular that made possible the conception of the MLPR algorithm. We would like to thank Osvaldo Bacchino from Sussex University who opened our minds in regards some analytical models that we where trying to materialize.

We wish to thanks also to all those beta testers that gave us all their impressions of HuntMaster. Thanks for their feedback about our software. From our beta testing team we have to thank in particular to Mr. David Shmueli for testing with such an incredible degree of detail dozens of releases of the product. We also want to thank all our friends and family that understanded our crazy dream and encouraged us, although we have been working many nights till 05:00AM!

And of course, we would like to be very thankful to Mr. Alexander Burwasser, Propietor of 'RDF Products', Vancouver, USA who pushed us to make this software international available to the Global RDF Markets. It is in our hope that you like our software as much as we liked to develop it!

SECTION II - PROGRAM INSTALLATION

A. INSTALLING SOFTWARE

HuntMaster can be easily Downloaded from HuntMaster's On-Line FTP Server. To receive a URL Link to the latest release version available of the product, please contact us. A Downloadable Distribution Package in ZIP format is available for you to Install/Upgrade your computer.

For successful installation, follow the following Installation Instructions:

- Unzip the downloaded file in a temporary folder.
- The required installation files for HuntMaster installation files are "HuntMaster.CAB", "setup.exe", and "SETUP.LST". The executable installation file for this program is "setup.exe".
- Setup.exe can be run directly from the temporary folder.
- All 3 files contained in this folder must be present for a successful installation.
- Uninstall any earlier versions of HuntMaster is not necessary to upgrade the product to a new release. Nevertheless, exit HuntMaster before attempting to upgrade the software.
- To begin the installation, click on "setup.exe" in Windows Explorer.
- Select a suitable main program folder (e.g., "C:\Program Files\HuntMaster"). If this folder does not already exist, it will be automatically created.
- Select the default program group (HuntMaster).
- During the installation process, an advisory message may appear warning that files being copied to the computer are not newer (i.e., that are less current) than existing files of the same name already on the system. When this occurs, select the option to keep the existing files.
- The executable program file is "HuntMaster.exe". This file can be used to create a shortcut on your Windows desktop.

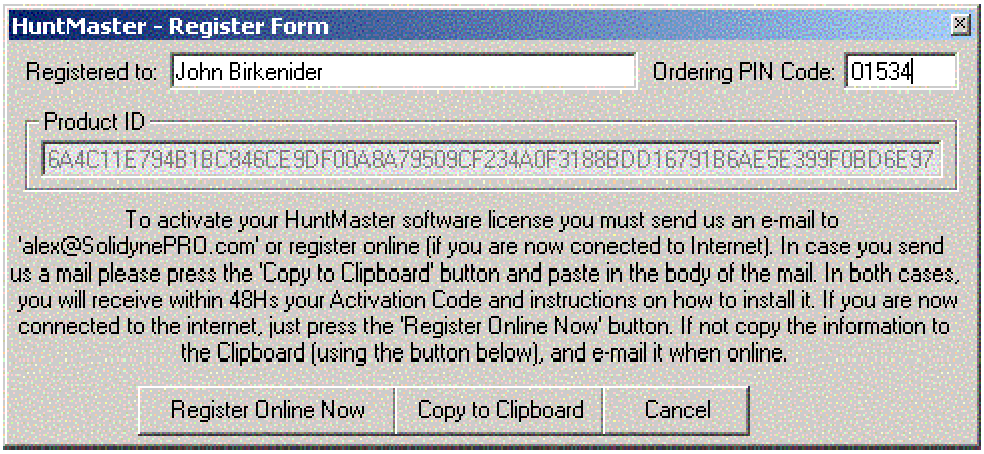
Note I: It is not necessary to restart your computer following HuntMaster installation.

Note II:If a USB serial hub is to be connected to the computer to provide the required two serial ports, then follow the hardware and software installation instructions accompanying that product.

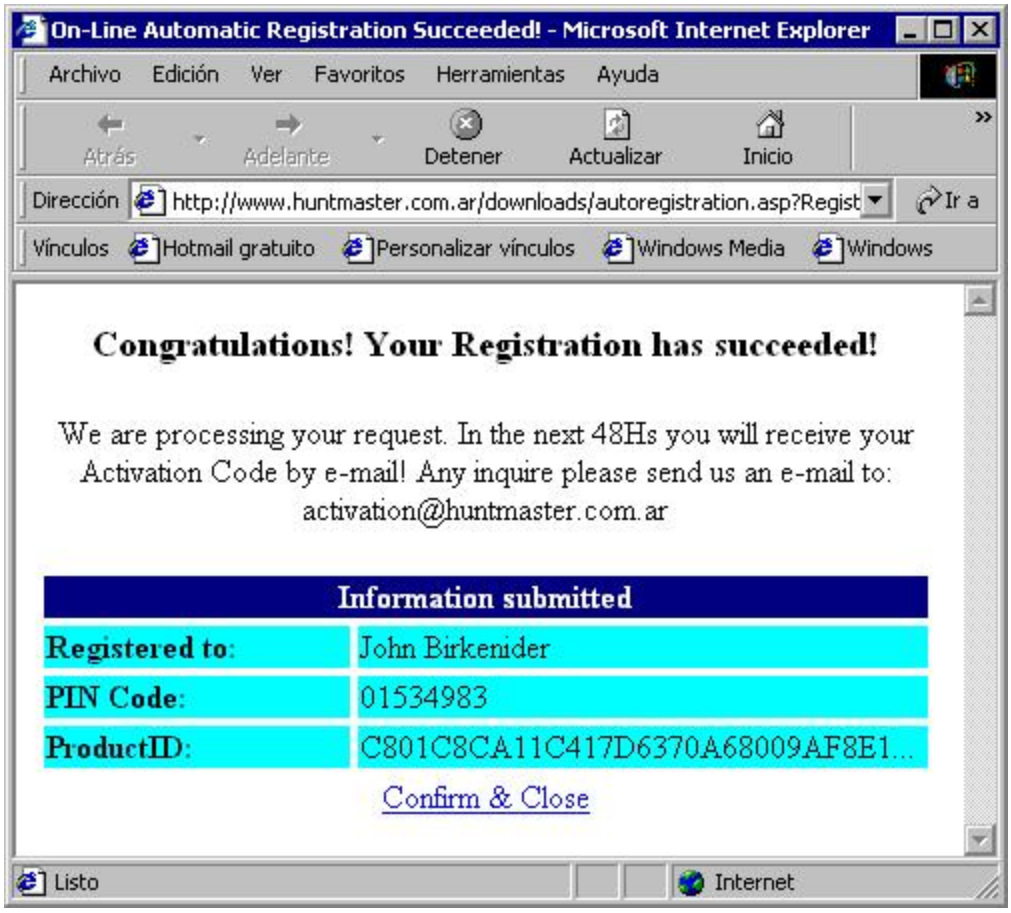
B. REGISTERING SOFTWARE

Once you buy a license of HuntMaster software you should then register it. Until you do not complete the registration process you won't be able to use HuntMaster. To be able to run this software you must first activate it. To do so, you must enter an appropriate User Activation Key. This key will be e-mailed to you and will make your purchased license valid ONLY on the PC computer you are activating the product. The activation process is very easy, please proceed as indicated below.

To start the registration process, run the program, and press the 'Registration' button (located in the right bottom corner of the form) on the Splash Window seen above. You will have only 4 seconds to do so before the application closes. You will then see the Registration Form:



Fill the first two fields. 'Register to' field should include your complete name and any extra information (such as license number). While in the 'PIN Code' field the PIN Code provided in HuntMaster purchase should be typed in. If you bought more than one HuntMaster license then proceed in the same way with each of the licensees (in each PC computer). After entering the information press the button for your preferred registration method (on-line or paste to clipboard to send it via mail). If you select the on-line activation method then you will see the following window if your information has been successfully submitted:



Remember to always have a hard copy of your 'Registered to' and 'PIN Code' information, asyou may be asked this information when requiring technical support or when needing to migrate your Activation Key to a different hardware (PC computer). In the event of any change in the OS, HD, hardware upgrades, etc you will need to run again the whole Registration Process (as you will need a new User Activation Key). You are therefore advised not to undertake computer changes before a planned radiogoneometry job.

If you want to change your Activation Key from one computer to another, you should first de-register your actual license. To do so please contact HuntMaster by e-mail at: alex@HuntMaster.com.ar.

NOTES

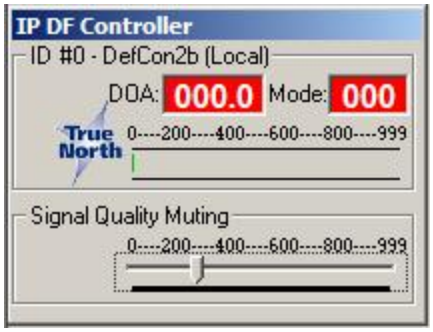
SECTION III - 'IP DF Controller' Module

A. OPERATION

The 'IP DF Controller' Module is mainly a display readout window, having just one control available to the user. Nevertheless it's simplicity, this window integrates the whole RDF Bearing information available from a single RDF unit or from an RDF Network (where various radio direction units are integrated into a multi-site tracking configuration network).

B. SINGLE RDF CONFIGURATION

The 'IP DF Controller' Window when operating with only one RDF Unit attached, displayes one pair of digital DOA & Mode indicators. The Direction-of-Arrival (DOA) Bearing Angle is the one HuntMaster receives from the DFP Unit rounded to the nearest tenth of a degree. The Mode indication, is the same one displayed graphically by the Radar Module. The Mode indication is rounded to 1, 2, 3, 4, or 5 degrees using the Radar rounding configuration.



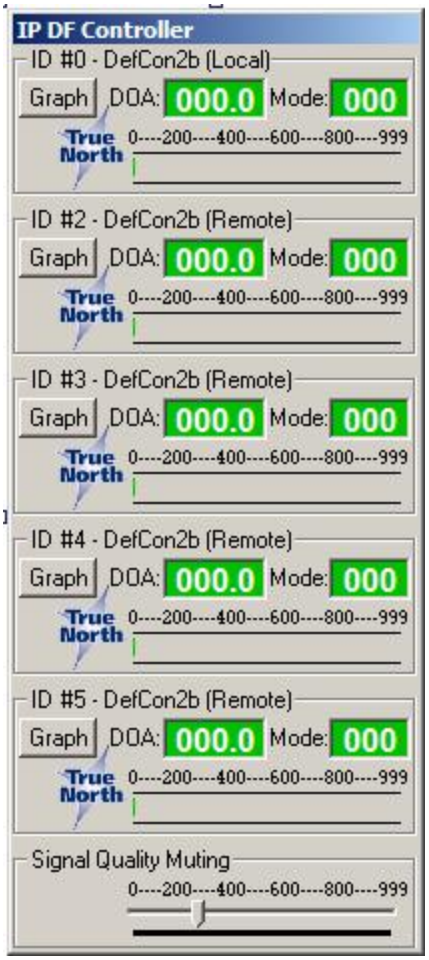
A Signal Level Meter is continuously reporting the DF Bearing's Signal Quality. This is a very important piece of information for any DF Operator to know if the data been received from the RDF Unit is good enough to perform computations with it. As a rule of thumb, poor quality measurements don't tend to give good Mode Indications that can then be used for plotting on the map to perform MLPR, Triangulations with it.

To automatically discard any poor measurements, the 'IP DF Controller' Module has a 'Signal Quality Muting' Feature. This slider control has a squelch-like behavior. When any given DF Measurement has a DF Signal Quality which is below the preset threshold of the Signal Quality Muting Slider, then this information will be discarded. It neither be displayed in the 'IP DF Controller' Module, nor it will be used by the Radar Module to compute the Mode Angle. For the user to be aware of this situation, the background of both, DOA & Mode displays becomes red, instead of green.

C. RDF NETWORK CONFIGURATION (Only available in HuntMaster Net Edition)

When the 'IP DF Controller' Window operates with several DFP data feeds configured, it becomes a truly multi-site radiolocalization network. Except from a local DFP Unit that may be connected thru a COM/USB Adapter Cable, all other DFP Units are generally located at remote sites. The interconnection is done using high-speed VPN or Internet connections.

HuntMaster Net will display a set of DOA & Mode indicators per each RDF Unit available (it doesn't matter if they are locally or remotely units). For the user information, when more than one RDF Units are available in the network, HuntMaster indicates the local unit with the legend '(local)' next to the RDF Station's Name and ID Number. The Name is always configured to be something easy for the operator to recognize. It can be the name of the Street where a fixed-site DF Unit is located. It can be the name of a squadron if it's a mobile DF Unit, or any other easy to recognize caption. The ID Number is the unique identification code of the RDF Station in the Network. Each RDF Unit must have a different number that identifies it.



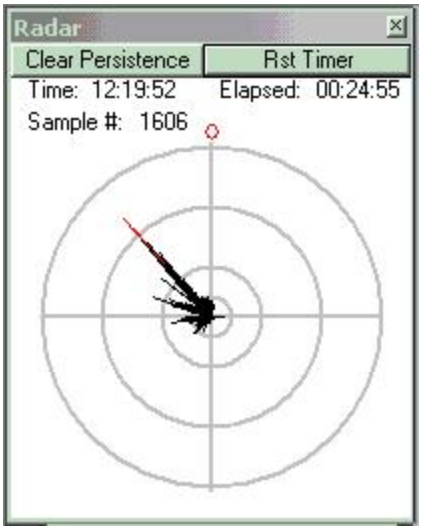
D. BEARING ANGLE REFERENCE CONVENTION

Throughout the 'IP DF Controller' Module all the DF Bearing Angles are relative to True North. Both in DOA & Mode Digital Readouts. To calculate the True North Angles, Digital Compass information is used (if no Digital Compass available, then GPS Heading is used instead).

SECTION IV - RADAR MODULE

A. OVERVIEW

This software module is the graphical display readout for RDF Measurements, including also bearings post-processing & filtering. By giving an easily readout of dozens of RDF measurements at a glance, the DF Operator can now take a much better decision based on a much larger dataset. The Radar display has also a Timer, which can be used to display elapsed time, or pauses between periodic transmissions.



The Radar works in the following way: A 360 degree radar like display shows the last measured value with a small red dot on the outer side of the main circle. At the same time, each new measurements (above the Minimum Signal Quality Muting Level) is displayed as a small line starting from the center of the Radar display, and in the direction of the measured bearing. The measured angle received from the DF Processor is rounded off to 1, 2, 3, 4 or 5 degrees (depending on the Radar Configuration) before displaying this lines. In the event of two or more bearings in the same direction, those lines became longer and longer. The longest of those lines is called Mode. This line is displayed in red color, and showed together with the DF's Bearing Angle. The Mode Angle is the statistic mode of all the measurements taken by the RDF Unit in a certain period of time. In serious radiogonemerty applications the Mode Angle (and not the plain RDF Bearing Angle) is used to workout the triangulation process over the map and into the MLPR (Maximum Likelihood Probability Region) Model.

Notice that by using the Mode Angle the precision of the plotted line of bearing is increases drastically. As the more measurements used to calculate the Mode Angle, the more accurate the result is. On the contrary, if working with just plain (or even averaged) bearings the plotted angles accuracy could be reduced by heavy multipath, noise, or other types of random errors. This happens because the average function is NOT an unbiased minimum variance estimator of the actual bearing. While the mode function IS an unbiased estimator. A simple example is when you have most of the bearings to the front of the car (0 degree angle), but occasionally there are some

reflections from the back (180 degree). Then the simple average between those measurements is always a number higher than zero (probably in the region between 10-30 degrees), while intuitively the best bet is to go right straight forward! In this particular case, the mode would have been just zero. Therefore, the Mode Angle gives the same kind of results that one would expect from a highly skilled DF Operator. At the same time is the theoretically correct method of filtering DF measurements.

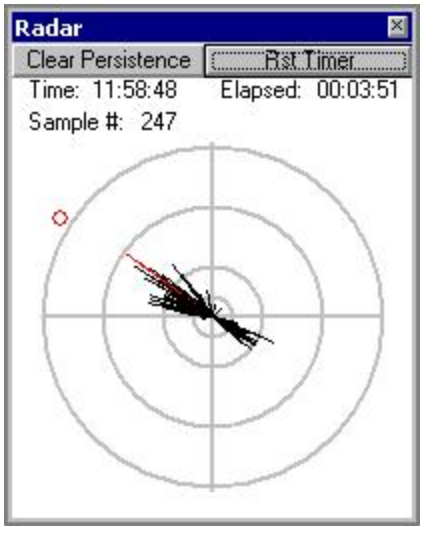
B. OPERATION

The Radar Module has very few command, as it is mainly a display readout unit. Nevertheless, it has a 'Clear Persistence' option, with can be activated by pressing the corresponding button, or by using the Ctrl-C shortcut. This command clears all lines that have been drawn in the Radar, while at the same time resetting the Mode Angle calculations. Therefore, the Mode Angle will hold the last correct Mode Angle, and it will change to the first bearing readout generated by the DF Unit. It will then start calculating the mode function all over again.

The Clear Persistence command is used when multiple transmissions are taking place in the same frequency (or when the DF Operator has tuned the DF Radio Receiver to another frequency). In all other cases, the Clear Persistence option is rarely used, except when very closed to the RF Source (a few hundred foot or less). In this cases the user could even take the decision of using just the raw bearing data from the DF Unit to triangulate the unknown signal source instead of the mode. Keep in mind that the mode is very accurate filtering tool, but it has a very important time lag to any bearing changes (produced both by a varying bearing angle, or by a heading changing vehicle).

The addition of a Timer to the Radar is sometimes used to measure the elapsed time, or to calculate intermittent transmission schedules. To reset the Timer press the corresponding button, or the Ctrl-T shortcut.

The main use of the Radar display is to filter by using a graphical tool any multipath induced bearing errors. As it can be seen in the following situation where very high multipath is present, the Radar display was a vital tool to resolve a bearing ambiguity problem.



BEARING ANGLE REFERENCE CONVENTION

The Radar Display has two modes of operation: True North / Relative (depending on the selection done on: Tools > Options > Radar > "Bearing Display Format"). When the True North option is selected, then the True North Icon is displayed in the Radar Window. If the True North icon is not visible, then the relative angles to the vehicles heading is displayed. The Radar display Window True North readings are usefull for Fixed DF Setups, while Relative readings are usefull for Mobile DF Operation.

The Radar Module does all it's internal math in True North Mode. When operating in Relative Mode the Radar Display image is rotated 0-360 based on the Digital Compass data. This will give a relative indiaction, while correctly calculating the Mode at all times. Therefore, a vehicle can be making turns while the Radar is calculating the Mode. This is a very important feature not to ruin the measurement due to the constant heading changes of the vehicle. As true north measurements are used to feed the Radar Mode Calculator, then the angles remain constant, as the direction (relative to the north) of the signal source remains constant. As the reader can infere, this kind of Mode computation is a very consistent and reliable bearing estimator even when heading changes are taking place.

NOTE: The "IP DF Controller" Window digital DOA & Mode indicators are still True North indications, even though the Radar is set for Relative Mode.

C. CONFIGURATION

It is important to understand how the Radar display works to learn how to set it's configuration parameters. Probably the default values will give acceptable results, nevertheless there are circumstances where you may want to modify this configuration.

It should be clear that the following configuration will not only affect the displayed information but also the calculation of the Mode Angle. As it was stated before, the Mode Angle is the statistic mode of all the DF measurements received in a certain period of time. That period of time is modified when changing the configuration of the Radar Module. The Mode value is recalculated each time the radar like display is overloaded, and redrawn smaller, thus allowing to accommodate new measurements.

Lets now take a look at the three configuration parameters of the Radar Module:

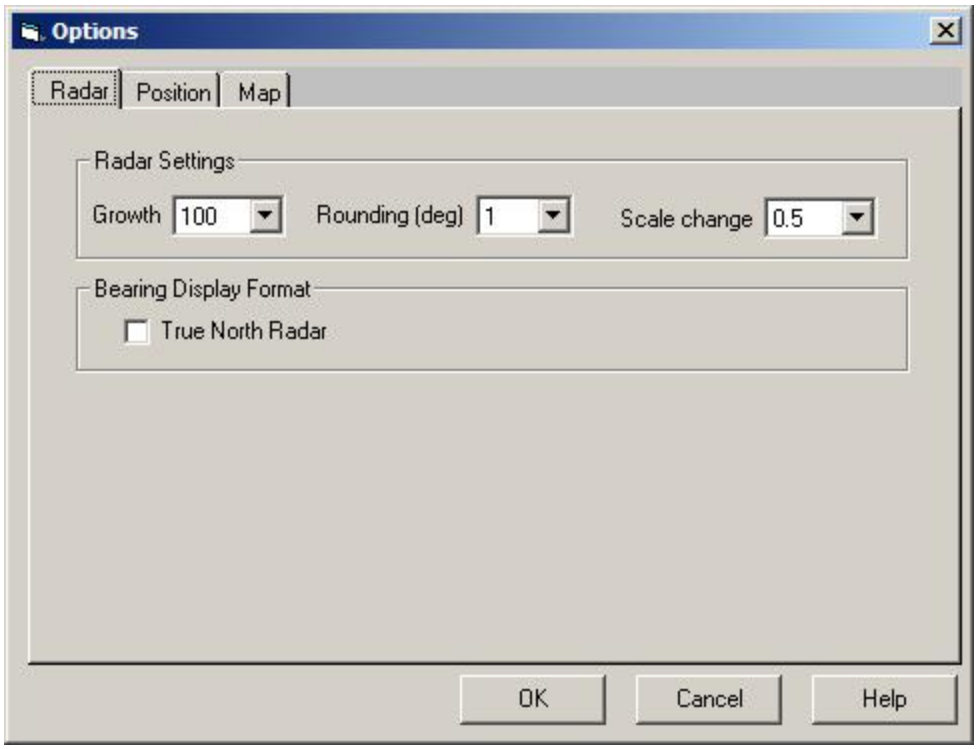
As you can see from the 'Radar' tab of the 'Options' form (located in the 'Tools' menu), this parameters can only be changed from a set of preselected values.

- **Growth:** Sets the increase in the corresponding radial line when a measurement in that direction is recorded. The value is set in the same units as the 'Radius'. Therefore a growth value of 100 (default) implies that 22 measurements in the same direction are necessary (assuming a 'Radius' value of 2150) before the whole radar runs into an

overload condition (and is automatically resized). The time between two consecutive radar resizes is the period used by the Mode algorithm to calculate the Mode Angle.

- **Rounding:** The 'Rounding' parameter is the last of the configurable options of this software module. This value sets the measured angle rounding used when reading the bearing information from DF Unit. If Rounding is set to 5 degrees, then all angles will be rounded to the nearer 5 degree value (for Mode Calculation purposes only). For example a 96 degree bearing will be rounded off to 95 degrees. This rounding is necessary, because if not, there won't be almost any direction in which several measurements accumulate (and therefore make the line in that direction growth in length). So when this parameter is set to a higher value (lower accuracy resolution) the user will quicker and easier see the correct bearing direction. But at the same time, the Mode angle will be more inaccurate (because it would be round off to 5 degree steps). As before, a certain tradeoff would be necessary. Usually a value of 2 to 3 degrees could give the best results for mobile operation.

- **Scale Change:** The 'Scale Change' parameter sets the reduction in scale that the Radar module will undertake when it has to resize the display. A value of 0.5 means that when resizing the original radar image will be reduced to half its size. A value of 0.25 will reduce the original image to a 25% of its original size, thus increasing the time between resizes. Nevertheless, the resized image may probably be too small for the user to visually keep track of the bearing direction.



SELECTABLE RADAR DISPLAY BEARING MODE (True North / Relative)

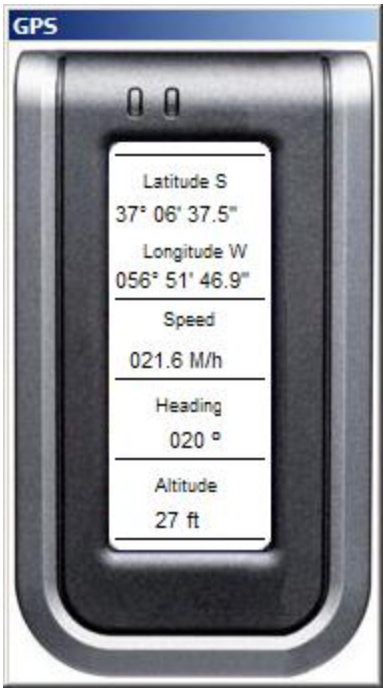
The Radar Display has two modes of operation: True North / Relative. The user can choose between any of these two modes, from the: Tools > Options > Radar > "Bearing Display Format". When the True North option is selected, then the True North Icon is displayed in the Radar Window. If the True North icon is not visible, then the relative angles to the vehicles heading is displayed.

NOTE: The "IP DF Controller" Window digital DOA & Mode indicators are still True North indications, even though the Radar is set for Relative Mode.

SECTION V - GPS MODULE

A. OVERVIEW

This software module is mainly a display repeater of the information generated by the GPS receiver. If the user is using a OEM GPS module (with no display), then this will be his primary GPS information display.



For the GPS Module to communicate properly with the GPS unit, the later should be configured for NMEA 4800bps.

It is recommended to use an external GPS antenna (if possible an active one), with a 12 channel GPS receiver unit. This is the desired configuration, for crowded city environments. If the vehicle is going to be used on rural areas, then a standard (passive) external antenna may be enough. Nevertheless it is not recommended under any circumstance to use a GPS receiver with it's built-in antenna inside the car. At least use a low loss cable extension, and locate the antenna on a roof top mounting bracket.

Keep in mind that for a proper GPS reading 5 satellites should be locked by the GPS receiver at all times (the absolute minimum for a reading are just 3 satellites).

HuntMaster can interface to the GPS in two different ways:

- By connecting the GPS receiver directly to one of the PC's COM Ports.
- By connecting the GPS receiver to a 'RDF Products' DF Processor Unit, which will

forward the Latitude and Longitude information from the GPS.

When using the more convenient way of connecting the GPS to the DF Processor, please take into account that only Latitude and Longitude information from the GPS will be available. For a complete RDF setup under this scenario, you would need a Digital Compass (connected to the DF Processor). If you intend to use the GPS Speed, Hearing , or Altitude Information, then you must connect the GPS receiver to a PC COM Port directly.

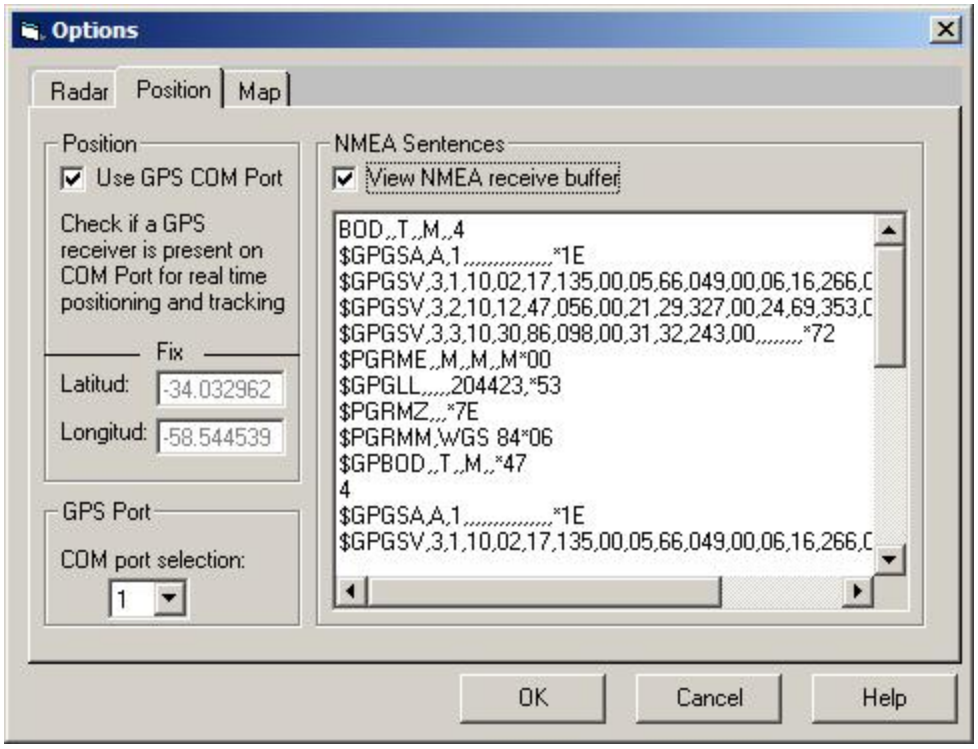
B. OPERATION

The GPS module is mainly used to setup the GPS receiver. To open the Virtual GPS window select the 'GPS Form' from the 'View' menu. This toggle option will show/hide the module for the users convenience. As stated above, the main use of this module is to setup the GPS receiver antenna. Making sure that the unit is properly receiving the necessary amount of satellites to work properly. So it is a very useful tool when testing different GPS antennas, or when setting up the RS-232 Serial connection and even for checking that the unit is responding properly to vehicle motion. It is suggested to close the GPS module once in normal DF operation to maximize the screen area used for the Map module.

GPS CONNECTED DIRECTLY TO COM PORT

If the GPS unit seams not to communicate with the GPS module, then there may be a problem in the configuration of the serial port used by the GPS. To modify HuntMaster serial port, you should enter the 'Tools' menu, and from the 'Options' form select the 'Position' tab. Check that the correct COM port is selected. You should now receive data from the GPS receiver. The user may enable the NMEA serial port dump to see if the communication between the GPS and the computer is taking place correctly.

In the GPS configuration tab, the user can also choose to enable the real time GPS tracking (on the map). To enable this option just click the 'Use GPS COM Port' ' option. If a GPS receiver is not available, then this option should not be checked, as HuntMaster opens the designated COM port and will be constantly looking for a GPS receiver there.



Tips: If the GPS position abruptly varies more than a whole degree (in latitude or longitude) then HuntMaster will mute any GPS information from that moment onwards. Therefore, if you see that the GPS Module updates it's coordinates, but the Cursor on the Map remains always in the same position, you should toggle the AUTOPAN button located in the Main Window. Doing this, will reset the GPS mute feature.

ALTITUDE DISPLAYING

HuntMaster has provision for GPS Altitude Displaying. For this feature to be available the following two conditions should be meet:

1- The user is operating with a Local DF Unit

2- The GPS is connected directly to HuntMaster via a second COM Port (So that full GPS NMEA data is available to HuntMaster)

When the above conditions are meet, then GPS information will be available in the Map Window (next to the GPS Coordinates) and in the GPS Window. Altitude over/under sea level will be displayed both in real time and will be logged in the .hm files together with the GPS track, and bearings data.

To enable direct COM Port GPS data the: Tools > Position > "Use GPS COM Port" checkbox has to be enabled. Using this interconnection mode, HuntMaster reads the $GPGGA (Global Positioning System Fix Data) where Altitude information is reported by the GPS. When this information is available, the GPS Altitude information will be visible in HuntMaster's GPS window (Go to: View > GPS), or next to the GPS Lat / Lon on the Map Window. If no Altitude information is available, then " - - - " will appear in the Altitude Meter of the GPS Window. When a Hunt is

taking place (and Altitude information is available) it will be logged into the .hm files. This information will be retrieved when the .hm files are played back. When playing back a .hm file, the recorded GPS Coordinates are displayed in the same Lat/Lon location where the GPS info is displayed in the Map Window. But the Lat / Lon is appended with the "LOG" caption, for the user to know that this is a logged GPS Coordinate. Altitude Info (when available) is also displayed in the same location during mission playback.

GPS CONNECTED THRU 'RDF PRODUCTS' DF PROCESSOR UNIT

When connecting the GPS receiver to the DF Processor Unit, you will automatically see the GPS Cursor on the Map, and the GPS information will flow into the GPS module without any further configuration requirements. When using this configuration, it is recommended you check that the GPS COM Port is disabled. As you don't want HuntMaster to open an unused COM Port. To disable HuntMaster's GPS COM Port, you should enter the 'Tools' menu, and from the 'Options' form select the 'Position' tab. Check that the 'Use GPS COM Port' option is disabled.

ENABLING GPS TRACK LINE DISPLAY

If the 'GPS Track' option (found in the 'Map' Menu) is checked, then a GPS track line will be displayed (if GPS connection is available). HuntMaster will plot the actual GPS position of the Local DF Station (Station ID #0) on the Map. The track line will record the last 250 points received. This option is available by default at program start up.

CLEARING GPS TRACK LINE

Under certain circumstances, it is necessary to clear the GPS Track Line. For instance, when travelling from a mission location to another, the user may want to clear the route from one spotto the other. To clear the GPS track the user should select the 'Clear track' option located in the 'Map' Menu.

SECTION VI - MAP MODULE

A. OVERVIEW

This software module is the heart section of HuntMaster Suit. This form plots an actual map (or satellite image) of the region where the DF Mission is taking place. Overlaying to it a series of marks, indications and estimators to help the DF Operator in his job of locating an RF Signal Source. First we are going to take a look at the Map Module in its default state at startup.

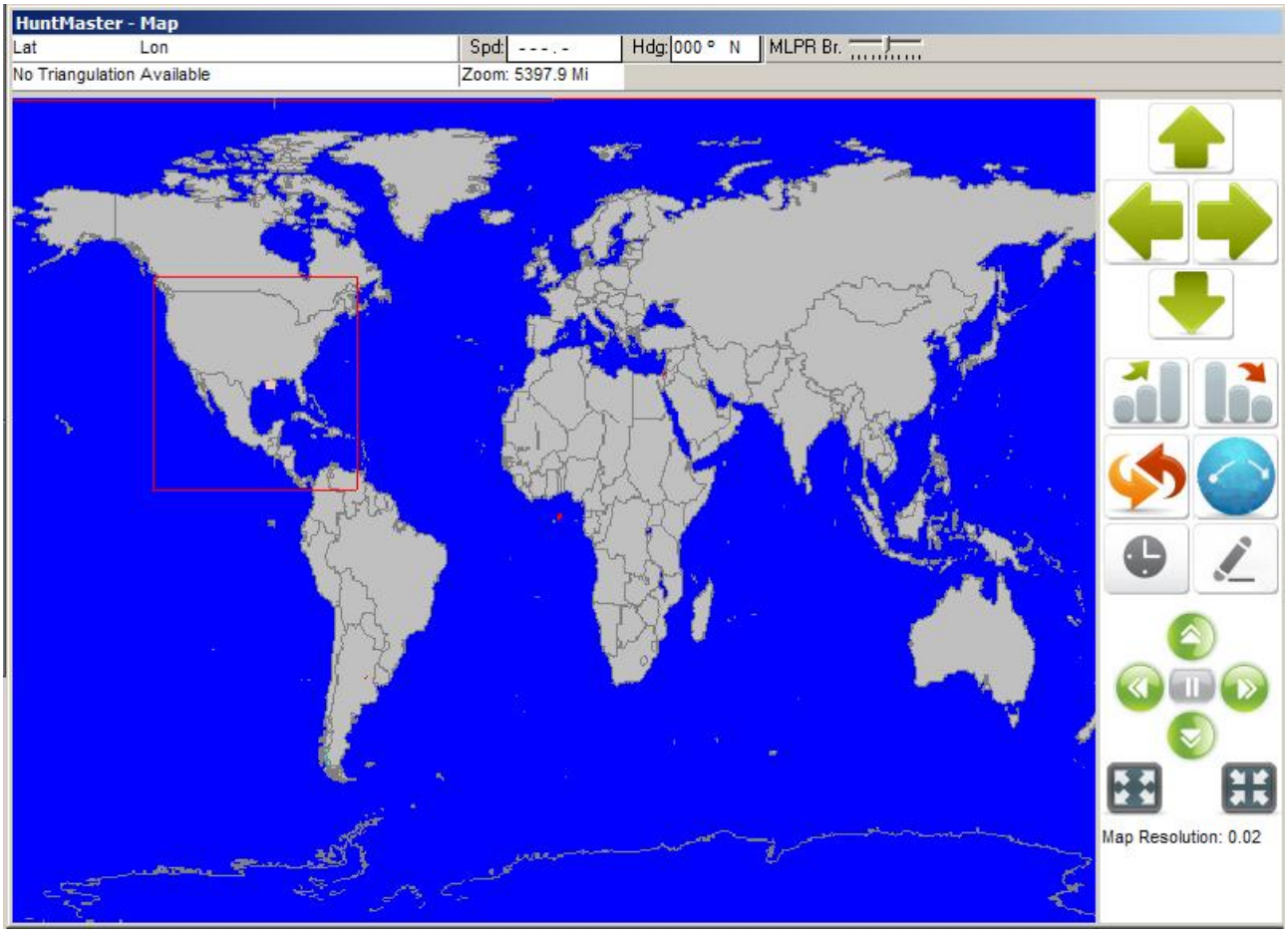
WHEN THE MAP MODULE STARTS UP

When HuntMaster starts, the Map Module will perform the following two features:

- **Auto Display of Base Map:** At startup, a Base Map will be automatically loaded into the Map Module. By default, HuntMaster automatically loads a World Map called 'TheWorld.map'. This map is a low resolution map of the entire globe that is installed together with HuntMaster. If the user considers convenient for HuntMaster to statup with a map of a specific region of the world, then this can be configured from the Tools > Options > 'Map' configuration Tab. Under 'Base Map' the user can select HuntMaster's default map to conveniently choose a map of his particular country / area of interest.

- **Coverage Area Display:** All maps found on the '\Maps' subfolder will be displayed as red boxes on the globe map. Indeed, the reason to display a map of the entire world at startup is for the user to see what maps are available to HuntMaster.

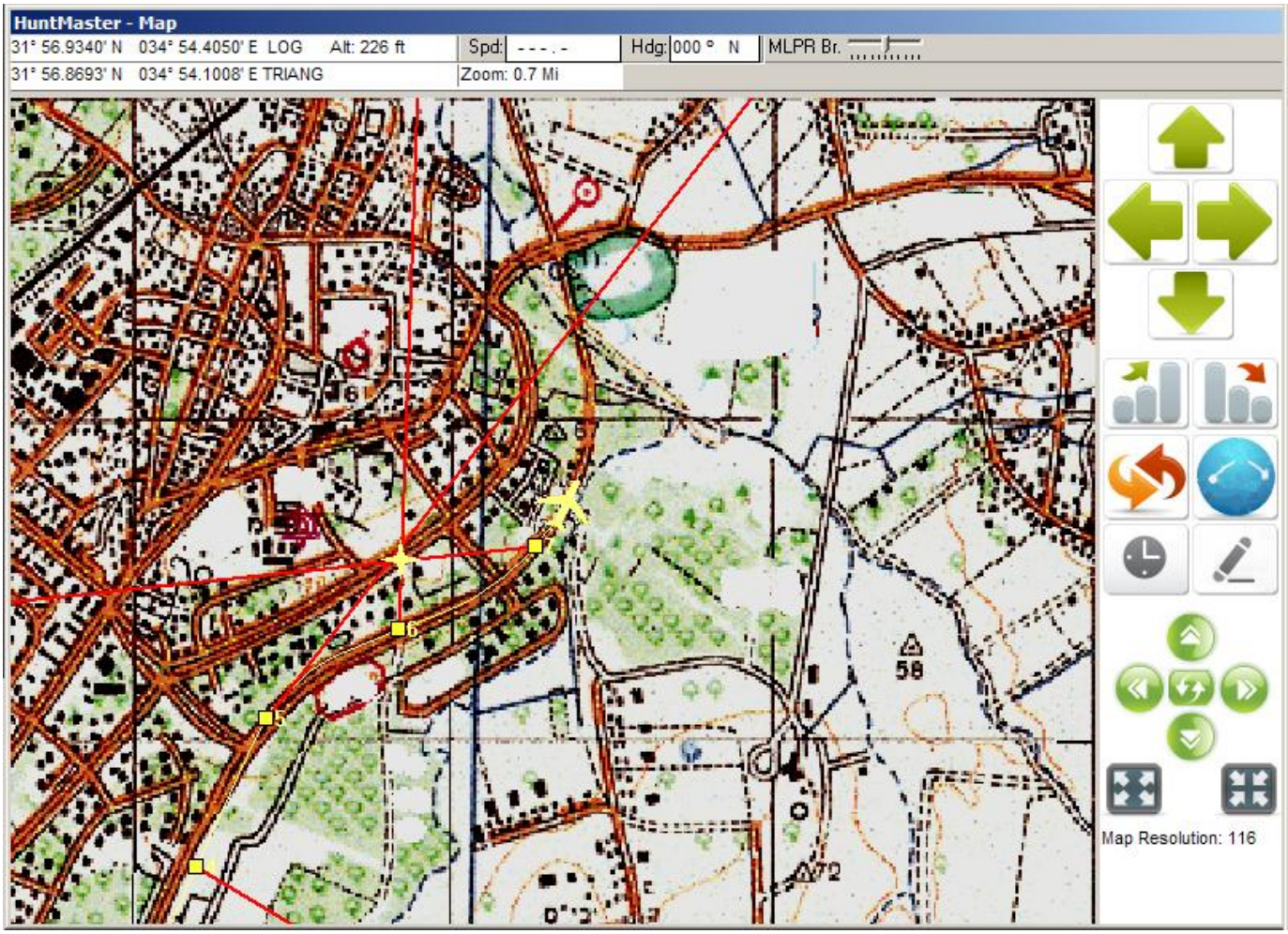
As can be seen, once HuntMaster boots up, the user can easily select the map that best fits its needs. Just by pressing "D" while clicking over their city/country of interest the user will quickly open a higher resolution map of that region. Of course, if a map is available of that particular location. This is why the Coverage Area Display is so useful at startup.
The default look of the Map Module is seen below. More and more rectangles will be visible as the user fills the '\Maps' subfolder with appropriate map files of different locations of the world.



NOTE: Although HuntMaster loads by default the above map at startup, when the first GPS Data Packet is received , HuntMaster will try to load the Highest Resolution Map available for the user's current location. So the user should take into account that when a GPS is connected to HuntMaster, the above map could probably be loaded for a second, and then replaced automatically by a higher resolution map centered in the actual location.

OBJECTS FOUND ON THE MAP DURING A MISSION

The user will have the possibility to plot and see a series of tools which are most needed in a DF Mapping Software. The most important features found on the map are seen and commented below:



- **Vehicle's Location:** A airplane icon is displayed in the current position of the vehicle (GPS Derived). The icon has the same heading of the vehicle (with respect to True North).

- **GPS track:** As the vehicle moves on the map, a GPS trail line is ploted. Displaying the route the vehicle has taken.

- **Landmarks (Fixed Waypoints):** 'Fixed' Waypoints can be loaded from a .wpt file into HuntMaster. This files could contain special interest landmarks, such as the position of known repeaters, or fixed beacons which can be used to calibrate the equipment or other usefull information for navigation or DF'ing.

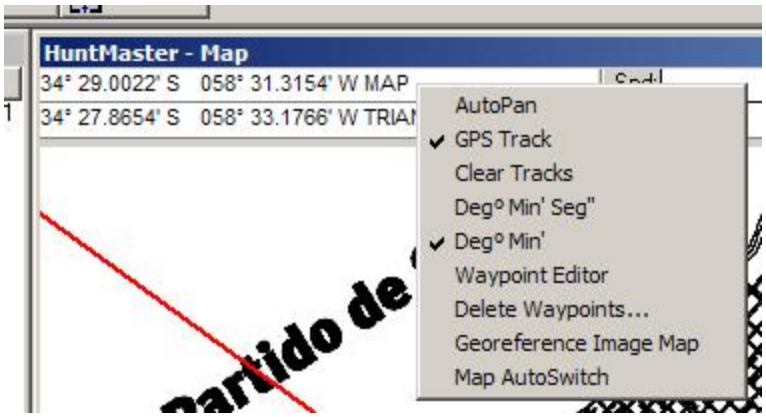
- **Bearing Lines:** The user can plot some of the measurements taken by the DF Processor. This measurements will appear as 'Mobil' Waypoints (as they are DF measurements not landmarks). This type of waypoints has the ability to display a bearing line in the angle of the DF measurement. When this lines intersect HuntMaster will indicate the intersection location with a Star Icon. This is a graphical display of the triangulation of the last two measurements ploted on the map. A more advanced triangulation tool (usefull when more than two bearing lines are present) is the MLPR Probabilistic Model.

- **Maximum Likelihood Probability Region (MLPR) Display:** This transparent layer will show a colored region where the hidden RF Source is most likely to be located.

To have more information regarding map coordinates, and how to create a map from a standard image file, please refer to the 'Maps' chapter. As the module has a Map Calibration Feature that allows the user to generate a map from an image file. Creating it's respective '.map' file.

MAP COORDINATE DISPLAY

There are several features related with the Lat / Lon Coordinates Display that's found on the Map Module. By Right Clicking the Lat/Lon Coordinates Display the user will have access to the same options as those found on the 'Map' drop-down Menu.



Depending on the context, the 'Map Coordinate Display' can have various different sources of data. It is important for the user to identify correctly which data source is been used in any given occasion. To help identify each source, the Geographoc Coordinates displayed have an appended caption indicating the source. The possible options for these captions are:

- It can have a 'MAP' legend if it is displaying the coordinates of the spot been clicked by the mouse pointer.
- It can read 'GPS' if it is displaying the GPS derived possition.
- It will read 'USER' if manual Lat / Lon coordinates where entered by the user.
- It will read 'LOG' if it is displaying the logged coordinates from a .hm Hunt File.

B. BASIC OPERATION

OPENING A MAP BY ITS NAME (Manual Map Loading)

To open a specific map, the user should select the 'Open Georeferenced Map (*.map)' option from the 'File' menu. We assume the user has one or more georeferenced maps in the '\Maps' subfolder. If not, please refer to 'Maps' chapter for information on how to create a georeferenced map from an image file.

Once the map is loaded, the user will see it on the Map Module. The maps are opened at FULL window size zoom (no matter what scale is the map in). The exact zoom level used is found at the top of the Map Module. Zoom distance is expressed in radius values (in the vertical axis). So the total distance from top to bottom of the viewing screen is double the zoom value. The horizontal/vertical map window ratio is 1.28. Therefore the maximum horizontal distance between the leftmost and rightmost points of the view should normaly be two times the zoom distance times 1.28.

You can now load a .wpt file containing waypoint information of the loaded map area. This additional information can be sometimes useful to identify peculiar landmarks or certain fixed beacon sites (such as repeaters or radio transmitters) that can be used to corroborate the system bearing accuracy before operating the system. This files can also include 'Mobil' waypoints (although HuntMaster reserves this waypoints to be exclusively used for radiogoneometry bearing measurements). Therefore, it is suggested to save the waypoint files after each job so that all the historical information about each measurements is recorded for further analysis (this is also automatically done by the Hunting Mode thru the .hm hunt files).

PANNING MODES

Once the map and its waypoints are loaded, it is important to be familiar with the different methods that are available of navigating through it:

- **Using the keyboard:** The user can move the map in any of the four direction with a step size of 1/6 screen size. He can also zoom in/out in 20% steps at a time. This is done by pressing Ctrl-I (up), Ctrl-K (down), Ctrl-J (left) and Ctrl-L (right). Or zooming using the Ctrl-PgUp (Zoom In 20%) or Ctrl-PgDn (Zoom Out 20%). For a complete list of shortcuts please refer to the section 'Shortcuts' of this Manual.

- **Automatically with AutoPan:** When Autopan mode is enabled the map will track the vehicles motion if a GPS data source is available (GPS connected to RDF Unit, or to PC COM Port). To enable the autopan mode press the 'Autopan' button from the toolbar (it has toggle action). To select the threshold distance to the center of the viewing area necessary to trigger the map repositioning, select 'Options' from the 'Tool' menu. Then select the 'Map' tab where the user will find the percentage radius that triggers a map redraw. The distance from the center of the viewing window to the actual position of the vehicle is divided by the radius of an imaginary circle that has exactly the height of the map window area. When this ratio is higher than the one set in the 'Map' tab, then a map redraw is triggered. A value of 100% will make the autopan redraw just when the vehicle reaches the perimeter of this imaginary circle. While a value of 0 will make the autopan to redraw at all times. Keep in mind that selecting very low values will increase unnecessarily CPU processing power, as it will require to redraw the map excessively. Each time the map is redrawn (due to movements or changes in its scale) the MLPR display is cleared, therefore if the Autopan is constantly redrawing the map you will have to constantly recalculate the MLPR display (pressing Ctrl-R), increasing even more the CPU processing needs.

C. WORKING WITH MULTIPLE MAPS

3.1 - OVERVIEW

There are several built in features to make navigating thru the available map resources as easy as touching a key. In most cases HuntMaster can auto select the proper map to use from the respoitory of maps available (that should be stored in the "\Maps" sub-folder). HuntMaster map selection can be diferentiated when you are on a mission (GPS Information comming in) or when you are at the office navigating thru maps off-line (no GPS data available). Let's examine each case next.

3.2 - MAP NAVIGATION WITH GPS CONNECTION

This scenario is normally found when the user is under a Hunt Mission. In this case, the AutoPan feature together with the Auto Map Switch feature make map selection a totally automatic task. HuntMaster will select the Lowest Resolution Map available (widest area coverage).

- **3.2.1 - Auto Map Switch Mode:** When HuntMaster is executed and it first receives GPS information, it will open the map with the SMALLEST resolution when Auto Switching between maps is enabled (default setting at startup). The zoom level at which the map is opened is to display the whole map in HuntMaster's Map Window. The Auto Map Switch, when enabled, automatically selects a map of the spot where the GPS is located. Therefore, the user does not need to open maps manually by name, as the Auto Map Switch chooses the map for you! This feature is enabled by default, nevertheless it can be disabled from: Map > "Map Auto Switch". On the Map Window there is also a shortcut to this control (located in the middle of the 4 Manual Map Loading Arrows).

  Note: When Auto Switching between maps HuntMaster selects the map with the most similar resolution, and the same zoom level than the previous map opened. This minimized operator's confusion when jumping from one map into another.

- **3.2.2 - Selecting different resolution maps of the same area:** A pair of buttons labeld 'Higher Resolution' / 'Lower Resolution' are used to select different resolution maps of a certain area. When pressing this buttons HuntMaster will locate a proper map with higher/lower resolution of the spot where the vehicle is located (if different resolutionmaps of the same region are available in the "\Maps" sub-folder). If no map is found, this will be reported in the Status Line. There is also a "Resolution" Meter that indicates the actual resolution of the loaded map. The resolution is measured in pixels per kilometer of latitude. As an example, a map with a resoution of 1000 pixels per kilometer means thatin the North-South direction the map has one pixel per meter.

- **3.2.3 - Manual Contigous Map Switching:** If the user want's to select a map from a different location, then he can use the 'Manual Map Switch' feature. This is something that the user may want to do if the triangulation region is located outside the loaded map. This can happen when the vehicle is far away from the target been tracked. By pressing one of the North/South/West/East Arrows, a contiguous map can be loaded. Each time the user

uses the 'Manual Map Switch' feature HuntMaster will automatically disable the 'Auto Map Switch'. The new map been loaded, is zoomed at the level of the previous map to make the transition as smooth as possible to the operator.

- **3.2.4 - Loading the highest resolution map of any place clicked:** To open a map of a currently blank area, or to display the HIGHEST Resolution Map of a certain spot on the loaded map, the user can press the "D" key while pressing this key clicking left clicking on the location of interest. A cross is drawn at this location, and HuntMaster asumes this is the simulated GPS derived vehicle location where the user wants to focus his maps from now on. .

  Note: When you open a new map using this feature, the Auto Map Switch feature is disabled. As GPS information could make the new loaded map to unload, and get back to the previous map been displayed.

3.3 - MAP NAVIGATION WITHOUT GPS CONNECTION

This scenario is normally found when navigating thru maps at the office with no GPS connection. In this case, HuntMaster does not know the exact location where the user is willing to focus his attention. Basically there are three ways in which the user can let HuntMaster know what location he wants to concentrate in:

- **Default:** If no information is provided to HuntMaster, then it asumes the user want's to focus in the center of the viewed map.

- **Pointing on the map:** If the user selects a spot on the map (by pressing the "D" key while he clicks on a certain location on the map), then a cross is drawn at this location, and HuntMaster asumes this is the simulated GPS derived vehicle location where the user wants to focus his maps from now on.

- **Geographic Coordinates:** By left clicking the Lat/Lon Coordinates in the Map Window, the user can have access to the 'Manual Coordinates Entry' Window. This popup gives the user the possiblity of entering a location (based on Lat / Lon Coordinates). HuntMaster will process this coordinates as if it was GPS information. It will first try opening the maximum resolution map of that location. The new geographic coordinates will be displayed in the Map Window, followed by the legend 'USER'.

Once the location is determined, then there are differents ways to operate HuntMaster to select different maps of a certain spot while no GPS is present:

- **3.3.1 - Loading the highest resolution map of any place clicked:** To open a map of a currently blank area, or to display the HIGHEST Resolution Map of a certain spot on the loaded map, the user can press the "D" key and while pressing this key clicking left clicking on the location of interest. A cross is drawn at this location, and HuntMaster asumes this is the simulated GPS derived vehicle location where the user wants to focus his maps from now on. .

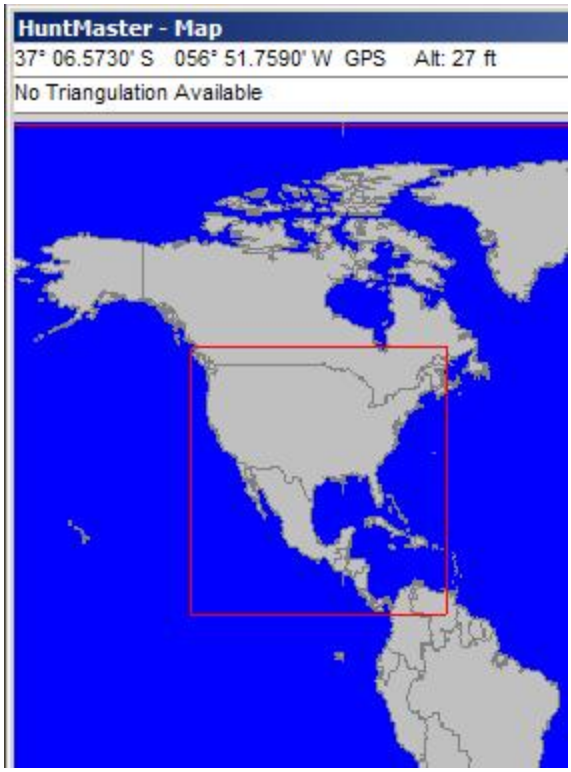
Note: When you open a new map using this feature, the Auto Map Switch feature is disabled. As GPS information could make the new loaded map to unload, and get back to the previous map been displayed.

- **3.3.2 - Selecting different resolution maps of the same area:** A pair of buttons labeld 'Higher Resolution' / 'Lower Resolution' are used to select different resolution maps of a certain area. When pressing this buttons HuntMaster will locate a proper map with higher/lower resolution of the spot where the user has positioned the cross (thru pressing "D" plus left mouse clicking). If not, the center of the screen is used as the spot to focus on. If different resolution maps of the same region are available in the "\Maps" sub-folder, HuntMaster selects the proper one. If no maching map is found, this will be reported in the Status Line. There is also a "Resolution" Meter that indicates the actual resolution of the loaded map. The resolution is measured in pixels per kilometer of latitude. As an example, a map with a resoution of 1000 pixels per kilometer means that in the North-South direction the map has one pixel per meter.

- **3.3.3 - Manual Contigous Map Switching:** If the user want's to select a map from a different location, then he can use the 'Manual Map Switch' feature. This is something that the user may want to do if the triangulation region is located outside the loaded map. This can happen when the vehicle is far away from the target been tracked. By pressing one of the North/South/West/East Arrows, a contiguous map can be loaded. Each time the user uses the 'Manual Map Switch' feature HuntMaster will automatically disable the 'Auto Map Switch'. The new map been loaded, is zoomed at the level of the previous map to make the transition as smooth as possible to the operator.

3.4 - MAPS COVERAGE DISPLAY

HuntMaster can plot map coverage of each of all available maps found in "\Maps" sub-folder. To display this information the user should press the Ctrl + "M" shortcut. By doing this, he will see a series of rectangles each of them indicating the coverage area of each map. To open a particular map, just proceed as in 3.2.4 or 3.3.1. Doing that procedure will open the highest resolution map of the area. If the operator prefers a smaller (less resolution map, the Lower Resolution Button should be used).



3.5 - INTELIZOOM

HuntMaster has context sensitive map opening zoom levels. To make operation as smooth as possible, each time HuntMaster opens the Base Map at startup, it does it at FULL window size zoom. If the user opens a map manually (from the 'Open' option found in the 'File Menu'), then the map is also opened at full window size zoom. Nevertheless, when a new map is loaded thru the Auto Map Switch, or the Contigous Map Switch options, then maps are opened at the same zoom level than the previous loaded map to make the transition as smooth as possible to the operator.

D. WORKING WITH WAYPOINTS & BEARING LINES ON THE MAP

Now that we have learned how to load and pan the map, we need to be able to show bearing measurements. Both from the DF Unit or from manually taken bearings (using directional antennas). To do so, the Map module has a special tool to create what are called 'Mobile' waypoints. This waypoints have the special feature of displaying a bearing line on the map. The user can also manipulate them easily, modifying, hiddening, or even deleting them. The user has various ways to create one of this waypoints, depending on the source of the information.

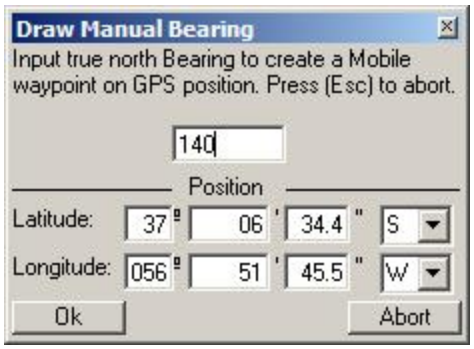
The standard method for plotting a measurement on the map is to press the Ctrl+F3 shortcut, or press the "World Icon Image with two DF Bearing Lines on it" found in the Touch Screen Buttons Panel. Using this method, HuntMaster uses the Mode angle information generate the corresponding bearing line on the GPS derived location. This method also has an Auto Persistence Clearing Feature of the Radar Display, which is necessary to prepare the Radar

Mode calcuations for the next measurements to plot.

ADVANCED PLOTTING OF BEARING MEASUREMENTS

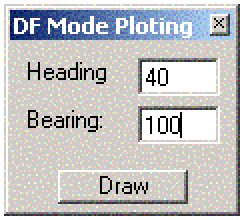
For advanced users who may need to operate HuntMaster under different scenarios, additional options are availalble to efficiently plot bearing lines on the map.

- **Manual/External DF Entry Window:** If going to display a manual bearing Ctrl-F1 should be pressed. The following form will pop-up:



- This feature enables the DF Operator to enter the exact coordinates of a remote SIGINT (Signal Inteligence) DF Station. The user will have to enter the bearing angle referred to the North of the remote DF Station. This angle is what's measured on a magnetic compass mounted to the mast of a directional antenna (and has been compensated for magnetic declination). Notice if the Quick MLPR actualization is enabled, then if a MLPR is been displayed this measurement will be added to the previous probability computations. To change this configuration select 'Option' from the 'Tool' menu. Then select the Map tab, there you will find the default setting of the Quick MLPR Display actualization. This entry mode has no touch-screen button, as the DF Operator will have to use the keyboard to select the coordinates and bearing angles.

- **DF Mode Angle Entry Window:** If the user wants to create a Mobile waypoint with the Mode Angle calculated by the Radar Module (based on local DF Station bearings), then the Ctrl-F2 shortcut should be pressed. The following form will appear:



- It is very similar to the previous one, except for the fact that the bearing information is already loaded with the Mode angle calculated by the Radar module. It can be seen that this bearing is not in absolute degrees North, but it is measured from the vehicles heading. Therefore, the travelling direction of the vehicle is needed to correctly display the measurement on the map. This information is obtained from the Digital Compass connected to the DF Unit, or if not available from the GPS receiver's data. Keep in mind

that if using GPS derived Heading then the the vehicle should be in motion (and in an aproximately straight line) for the GPS Heading to be accurate. As stated before, the Quick MLPR setting of the 'Options' form will dictate the way the MLPR display will be updated (or not). .

This input method is very similar to the Ctrl+F3. The difference is that this mode allows the DF Operator to trim the Mode Value, and Vehicle's Heading. It does not Clear the Persistence of the Radar display. Except for special purposes, the user is suggested to use Ctrl-F3 instead of this entry method.

- **Visual DF Bearing Plotting:** The last method is usefull when the user is using the Map Module with no GPS receiver or DF Unit attached. Under this circumstances, the user should press the 'Insert WP' toggle button located at the toolbar. When this option is enabled, a waypoint can be created by double clicking on any place on the map. A pop-up window will prompt to enter the manual bearing measurement. The user should once again keep in mind that he should first compensate the measurement for magnetic declination before entering the angle.

CREATING FIXED WAYPOINTS

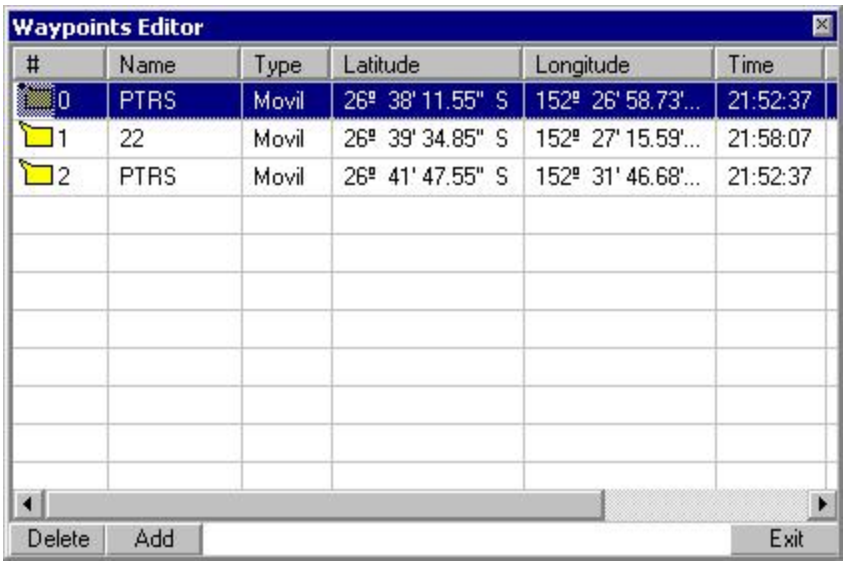
The main difference between a Fixed Waypoint and a Mobile one is that the first one has no bearing angle asociated with it. There are two ways to create a Fixed Waypoint. The most convenient method depends on what information the user has available about the landmark to locate:

- **If geographic coordinates are known:** If the latitude and longitude of the landmark is known, then the best way to create a fixed waypoint with this information is by opening the 'Waypoint Editor' located in the 'Map' menu. The user will find there an 'Add' button that allows add a new waypoint by entering its coordinates. The Name and Description of the fixed waypoint can also be entered in a similar way.

- **If geographic coordinates are not known:** If the coordinates of the landmark are unknown, but its location can be visualy determined on the map, then proceed as follows: press the 'Insert WP' toggle button located at the toolbar. When this option is enabled, a double click of the mouse on any place of the map will create a waypoint. A pop-up window will prompt to enter the manual bearing measurement. If you leave it blank and confirm (by pressing the 'Ok' button or by pressing the Enter key) a Fixed waypoint will be created. To change its Name or Description you may disable the 'Insert WP' mode, and double click the new waypoint. You will have an option to edit it.

MANIPULATING WAYPOINTS

The Map module has a list of loaded waypoints, which can be viewed by selecting the 'Waypoints Editor' option from the 'Map' Menu:



As you can see, all the information of any given waypoint can be browsed, and a given waypoint can be edited. From this form it is also possible to delete a selected waypoint, and manually add new waypoints. This last option is mainly used to create 'Fixed' landmarks waypoints (which can be saved, and then loaded at hunt time). To add a new waypoint using this option the user must know the exact coordinates of the landmark he is going to highlight. If this information is not available, then first look at its coordinates by locating the mouse cursor over the landmark while pressing the left mouse button (or proceed to an alternative method as suggested above). The coordinates will appear on the top of the Map module window. Then from the Waypoints Editor add a new waypoint with this coordinates.

DELETING WAYPOINTS

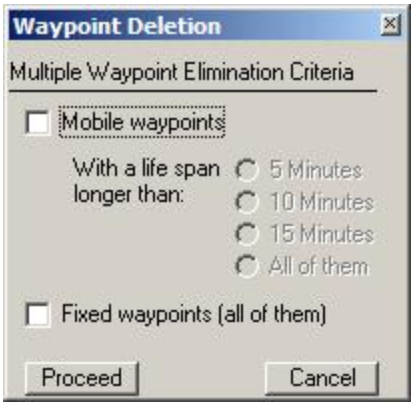
There are several ways to delete a Waypoint (both Mobile or Fixed). Options are:

- **Single Waypoint deletion by clicking the Object on the Map:** When double-clicking a Waypoint, the Information Window will pop-up. This window has a 'Delete' button whichwill erase the object.

- **Single Waypoint deletion by selecting the Object in the Waypoint Editor:** Selecting the 'Waypoints Editor' option from the 'Map' Menu the user will see the complete list of Waypoints loaded. The user can select any of these objects based on its Name, Description, Date & Time Stamp, or any other additional field. After selecting which waypoint to erase, the user should press the 'Delete' button to erase it.

- **Batch Waypoint deletion by type/age:** HuntMaster has a powerfull Waypoint deletion tool that's found in the 'Map' Menu under 'Delete Waypoints...'. A pop-up window will be

displayed prompting which rule to use to erase Waypoints. Options are: To delete Mobile Waypointes (Plotted Bearing Lines) or Fixed (Landmarks). When doing a mission it is sometimes usefull to delete older waypoints based on age. If the vehicle is approaching the target transmission, then it is important to hide (erase) the older Bearing Lines, not to confuse the DF Operator. To do this, simply choose 'Mobile Waypoints' and select the maximum age allowed to keep the Bearing Lines. .



There is also a keyboard shortcut feature to selectively erase all Mobile Waypoints (Bearing Lines) which are older than a certain amount of minutes. A set of 3 different keyboard shortcuts erase all bearing lines older than 5/10/15 minutes. Using shortcut Ctrl+F8 all Mobile Waypoints older than 5 minutes are erased. In a smiliar way, pressing Ctrl+F9 erases all Bearing Lines older than 10 minutes. Finally, by pressing Ctrl+F10 all Mobile Waypoints older than 15 minutes are deleted.

- **Bearing AutoErase Feature:** This feature automatically erases older Bearing Lines keeping just a certain number of measurements visible at all times. The AutoErase Wpt operates while the Hunting mode is enabled AND while playing back a .hm file. If a Hunt is underway, then the AutoErase feature will be active. If the Hunt is Paused or Stopped, then the AutoErase feature will be disabled. In a similar way, the AutoErase feature will be active while playing back a mission file. Therefore, if you are playing back a mission the user will see ONLY the amount of Mobile Waypoints that you have configured to show. During mission playback if you move the slider back (to a previous moment in time) the user will see all waypoints in the .hm file for an instant. The waypoints in excess will be then erased a moment later. To configure the maximum amount of Mobile Waypoints the user wants to keep, please refer to Tools > Options > Map > "AutoErase Mobile Waypoints" section. .

  NOTE: Please remember that this feature is only active while Hunting.

WAYPOINT NAVIGATION INFORMATION WINDOW

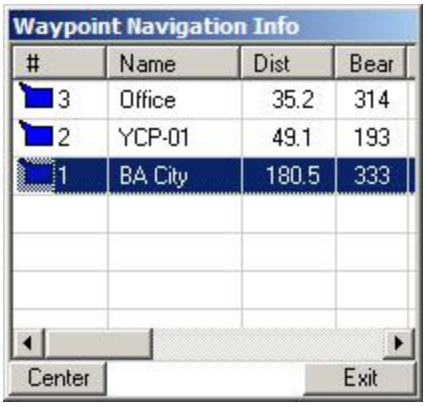
This feature allows the user to have specific information related to the Fixed Waypoints plotted on the Map. When the WpyNav toggle button (located on the top ToolBar) is activated, it will pop-up the Waypoint Navigation Information Window, which will:

a- Displays the NAMES of all landmarks (FIXED waypoints) located on the map, next to the icon indicating their location.

b- The Waypoint Navigation Information Window will become active. All landmark (FIXED waypoint) will be displayed there ordered by shortest distance from the actual location (GPS derived). The bearing the vehicle should take to go to that landmark location, and the distance to reach destination are also displayed for each landmark.

c- If the user left clicks on a certain location of the map, then the above custom window will give the distance and bearing angle from each landmark to that specific location clicked by the operator. Once the operator depresses the mouse button, the window will use the GPS location to recalcualte all Bearings and Distances.

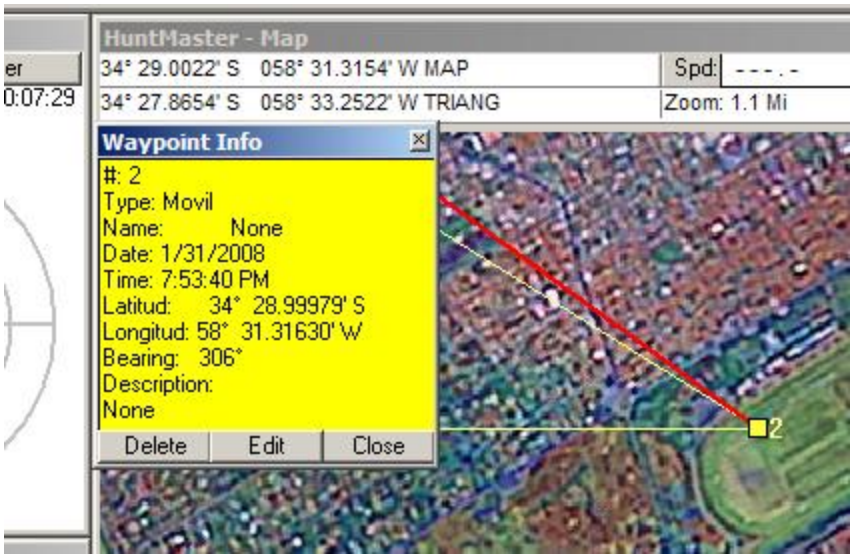
d- If the WptNav button is disabled, all the above information will be hidden. The WptNav button has toggle action.



This WptNav feature helps navigation using the Landmarks (FIXED Waypoints) loaded on the map. The Waypoint Navigation Information Window is updated with each GPS data reception.

OBTAINING INFORMATION FROM ANY WAYPOINT SEEN ON THE MAP

HuntMaster has a 'Waypoint Info' window that shows all the information available of a certain Waypoint. This window will look similar to this one:



There are two ways in which the user can prompt for information of specific waypoints seen on the screen. Both methods, will make the 'Waypoint Info' window to pop-up:

- **For an Individual Waypoint:** By double clicking with the mouse on a waypoint will make the 'Waypoint Info' window to pop-up displaying all available information of that Waypoint.

- **Browsing Multiple Waypoints:** By pressing the Left Mouse Button while moving the mouse cursor on the map, the user can select any Waypoint he is interested in. Each time the cursor goes over a Waypoint, the 'Waypoint Info' window will be updated with the particular information for that Waypoint. The 'Waypoint Info' window closes automatically when the user depressed the Left Mouse Button.

E. HUNTING MODE & LOGGER

The usefulness of a Hunting mode in a DF Mapping application are multiple. First if HuntMaster is awared of what the user is doing, he can reconfigure itself best to help the DF Operator efficiently. Second, the Hunt Log generates valuable information for later analisys, as an entire DF Mission could be latter on reviewed. Searching for procedural mistakes, erroneous or misleading pieces of information, and so on. A Hunt Log is an incredible tool to improve your staff DF skills, and share experiences with other DF Operators. Sharing Hunt Files with other DF teams proves to be very useful to learn from each others experiences.

When the Hunt mode is active the following functionality is available:

- The Maps been used by the user are logged.

- If a GPS receiver signal source is available, then HuntMaster will log the GPS track trail on the Hunt file every 5 seconds. While it keeps the last 250 track points visible. If altitude information is available, this will also be stored in the file.

- All bearings plotted by the DF Operator (both user ploted measurements and AutoPloted measurements) will be logged into the hunt log file, together with DF Bearing Quality information.

- If 'Bearing AutoPlot' mode is configured (Tools > Options > 'Map' tab), then automatic measurements will be plotted on the map while the Hunting mode is enabled.

- If the 'AutoErase Mobile Waypoints' mode is configured (Tools > Options > 'Map' tab), then only the last bearing lines will be visible on the map, as older Bearing Lines will be automatically erased.

The user may also be interested in activating the 'AutoPan' feature. As this will automatically pan the map so that the vehicle will remain near the center of the map

HUNT FILES (.HM) NAME OPTIONS

There are two operating modes for the selection of the file name of the (.hm) Hunt Log File. Let's see the logic behind each option:

- **Fixed File Name:** If the user clears the 'Append Data Stamp to Log File Name' checkbox (found in the Tools > Options > 'Map' tab) then, the Hunt File will have the name defined in the 'Hunt Log File (.hm)' field, located in the same configuration tab. If the user sets a fixed name for a Hunt File, then HuntMaster will save all Hunt information in the same file. If the file already exists, you can choose to overwrite the previous file.

- **File Name with Date & Time Suffix:** By checking the 'Append Data Stamp to Log File Name' checkbox (found in the Tools > Options > 'Map' tab) the Hunt File will have the name defined in the 'Hunt Log File (.hm)' field plus a suffix formed by the Date and Time Stamp. So each time you trigger a Start Hunt a new file is generated automatically, and with a different name. This is the suggested method of operation.

Note: All (.hm) Hunt Files are stored by default in a subfolder called '\Hunt'. This makes it very simple to find them in the event the user wants to copy this files to share them with other DF Users. To learn more about the logger file format, please refer to 'Advanced User Information' section of this Manual.

STARTING / PAUSING / ENDING A DF MISSION FILE

A Hunt Button is conveniently located in HuntMaster's Toolbar. By pressing this toggle button a new Hunt can be Started, a Hunt can be Paused, and latter on Resumed. To End the Hunt (which is something the user does just once, and when the mission has ended) the DF Operator should go to the Menu: Hunting > "End Hunt". Note that if the user does not end the hunt before closing HuntMaster, the program does end the hunt automatically before closing.

When the Hunt Button is in the Paused mode, it is indicated by a 'Rec Icon' which blinks in Yellow/Red, while the button changes its caption from 'Hunting' to 'Paused' every 500mS. This helps the operator not to forget the Hunt Paused when action is taking place.

Remember to exit from the Hunting mode once you finish the mission. This will stop file logging, and will properly close the Hunt File. In this file you will have the complete history of operation, with periodical measures (every 5 seconds) of GPS Latitude, Longitude, Code, Altitude, Time&Date Stamp, DF Bearing, Radar Mode Angle, DF Hold Status, Mute, DF Bearing Quality, GPS Speed, Digital Compass (or GPS Heading if no Digital Compass is available).

Please take into account that to have GPS Altitude, Speed and Heading information the GPS receiver has to be directly connected to one of the computer's COM Ports. When the GPS receiver is connected to the DF Unit, only Latitude and Longitude information is retrieved.

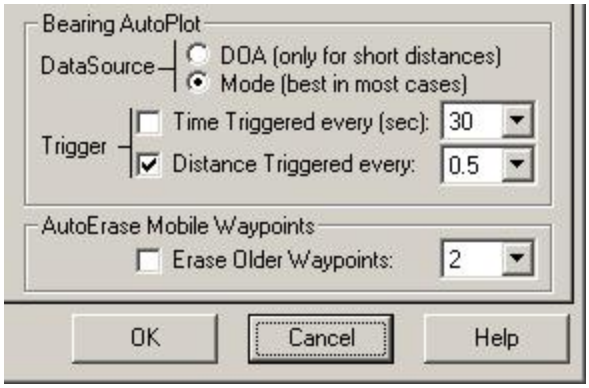
BEARING AUTOPLOT FEATURE

This automatic bearing plot mode places bearing lines on the map without user intervention when

- A certain time has elapsed (time trigger)
- A certain distance has elapsed (distance trigger)

The amount of bearing lines automatically displayed are also user configurable. So that bearing lines don't increase indefinitely. Those automatic bearings, as all bearings will be plotted on the exact GPS derived location, and will use the Digital Compass heading information for computing the true north absolute bearing to be displayed on the map. In the Description Field of the Mobile Waypoints generated automatically will read: "AutoPlot Measurement" for the user to know that this has been an automatic generated waypoint.

The new AutoPlot feature is enabled/disabled together with the Hunt Toggle button. When the Hunt is underway, then the AutoPlot feature will be active. If the Hunt is Paused or Stopped, then the AutoPlot feature will be disabled.



To configure the Time / Distance Trigger of the AutoPlot, please refer to Tools > Options > Map > "Bearing AutoPlot" section. The Data Source can be selected between plain DOA data (the raw

data received from the DFP-1000B unit), or the Statistical Mode integrated over the time period elapsed between the last measurement has taken place. I recommend you use the Mode Data Source option at al times, except when you are very near the target (signal source) and the Bearing Line Angle is not constant, but increasing/decreasing rapidly.

BEARING AUTOERASE FEATURE

This feature automatically erases older Bearing Lines keeping just a certain number of measurements visible at all times. The AutoErase Wpt operates while the Hunting mode is enabled AND while playing back a .hm file. If a Hunt is underway, then the AutoErase feature will be active. If the Hunt is Paused or Stopped, then the AutoErase feature will be disabled. In a similar way, the AutoErase feature will be active while playing back a mission file. Therefore, if you are playing back a mission the user will see ONLY the amount of Mobile Waypoints that you have configured to show. During mission playback if you move the slider back (to a previous moment in time) the user will see all waypoints in the .hm file for an instant. The waypoints in excess will be then erased a moment later. To configure the maximum amount of Mobile Waypoints the user wants to keep, please refer to Tools > Options > Map > "AutoErase Mobile Waypoints" section.

NOTE: Please remember that this feature is only active while Hunting.

AUTOPLOTTING GPS SYNCED DOA MEASUREMENT (Advanced User Information)

For users that are going to deploy a Mobile DF Station on a very high speed vehicle, it may be important to synchronize the DF measurements with the instant where the latest GPS Position is available. HuntMaster has provision of this feature. This minimizes measurements errores in the case where:

1- The user is operating with a Local DF Unit

2- The Bearing AutoPlot Mode is enabled

3- It is using DOA Source DF Data

4- The DF Station is travelling at very high speeds (> 500Km/h)

When the above circumstances happen, it is important to have GPS Synced Measurements. As a ultrasonic airplane travelling at 2000Km will travel 0.3Km in between two GPS consecutive updates. To decrease this sampling error to zero, then HuntMaster reads the DOA Bearing at the instant when the GPS Position is updated. Avoiding the localization error between the time DFP-1000B computes a bearing line and the exact place where the vehicle was at the time. Correlation between GPS position and DF bearing information has been implemented by only reading the first DFP-1000B Bearing Angle after each GPS $GPGGA Packet (Global Positioning System Fix Data Packet). This way HuntMaster can warrantee absolute correlation between both sources of information that are going to be plotted on the map. All measurements that have been plotted in GPS Sync mode have the following Waypoint Description: "AutoPlot

Meas. (GPS Sync)".

The above GPS Sync algorithm only works when the user has enabled the Bearing AutoPlot feature, with the DOA Source selected. The GPS Sync Measurements has only been implemented in the AutoPlot mode, as the other manual methods to display Bearing Lines use the Mode instead of the plain DOA data. When using the Mode, it is not important to have GPS Synced Measurements, as the Mode is computed thru a comparably long interval of time (dozens of seconds) therefore the latest GPS Position Updates is not important.

F. PLAYING BACK A HUNT FILE

OPENING A (.HM) HUNT FILE

To play back a (.hm) Hunt File, the user should select the 'Play' option found in the 'Hunting' Menu. A pop-up window for selecting the Hunt File to retrieve will appear. Once the file is selected, HuntMaster will open the necessary Map files, and will display the GPS track and show all the Bearing Lines taken during that particular DF Mission.

HUNT PLAYBACK CONTROLLER

HuntMaster Ver. 5.1.8 onwards has support for Ver. 2.0 Logger Engine Files. This enhanced recorder/playback module is much more powerfull than before. The user can now set the speed at which the .hm Hunt File is played back. Using a time line slider control the user can move back and forth in time to see the exact moment where something took place. This playback control looks similar to an MP3 audio playback window to be as user friendly as possible.

The 'Hunt Play Controller' has a checkbox to select 'Open Maps in (.hm) file'. By default this options is checked, forcing HuntMaster to open the same map files that the DF Operator used in each precise moment in the Mission. There are moments, when the user may want to select a different map, or a better map that was not available at the time the Hunt File was recorded. By unchecking this option, HuntMaster will cease to open any map files recorded in the (.hm) Hunt File. The user can then use the 'Auto Map Switch' feature, or any other option to open a different map while playing back the Hunt File.

LEGACY COMPATIBILITY WITH VERSION 1.0 LOGGER FILES

New Ver 2.0 (.hm) Hunt Files are no longer compatible with older 1.x files. Therefore, HuntMaster will play older files in the older fashion (no Playback Controller will appear), while providing improved features only when newly recorded (.hm) Hunt Files are used. The new (.hm) Hunt Files record multiple map changes, while also having provision for multi DF Station tracking. The new file format is capable to track and show DF Measurements of up to 5 different DF stations.

SECTION VII - TRACKING DOWN THE SIGNAL

A. RDF BASIS

1. INTRODUCTION TO RDF TECHNOLOGY

When a new user comes to operate a RDF System for the first time, he may feel that the unit is not operating properly. This first feel is normal, as Radio Waves are not like laser beams. Radio signals reflect in objects (mountains, buildings) in a similar way as sound reflects in objects. You probably have heard the sound of an airplane approaching and believed that it was coming one way, while the aircraft was approaching from exactly the opposite direction! Well, the same is true with radio waves; they reflect. Indeed, there are cases where you will have a bearing in the opposite direction from where the transmitter is located. In a newcomers own words:

"I have an area where I move the vehicle 40 yards and the signal comes from a different angle and the signal strength drops. I move halfway and the signal is still strong, but is off by about20 to 30 degrees"

Those scenarios are just normal, bearing direction discrepancies are always present. There are ways to mitigate this multipath generated errors, as we will discuss throughout this chapter.

2. ABOUT HOW TO INTERPRET THE DF DISPLAY'S DATA

Of course all those reflections and bearings that move +/- 45 or more degrees can be filtered. If not, DF operation would be impossible. The clues a DF Operator uses to avoided using erroneous data are:

- **2.1.** *Temporal:* Reflections tend to be displayed as short bursts in DefCon2b & DFP-1000B bearing display.
- **2.2.** *Quality:* Reflections tend to give less quality measurements (shorter vectors).
- **2.3.** *Statistical:* The correct bearing angle tend to be more recurrent than any other direction in the bearing display.

The above clues are seen both in DefCon2b's & DFP-1000B bearing displays and have to be evaluated subjectively by the operator. Once he gets used to looking at these displays, he will perform steps #2.1 thru #2.3 without even noticing it. As stated in 'RDF Products' Web Notes:

"The highly dynamic nature of mobile DF applications is such that considerable judgement is

often required to differentiate a valid bearing from erroneous ones induced by noise and reflections. Inexpensive bearing displays such as mechanical pointers and LED rings are extremely difficult to interpret under such conditions. Numeric bearing displays are almost useless. In contrast, the RDF Products Models DFP/DFR-1000B and DFR-1000B employ real-time polar bearing displays that not only indicate the azimuth, but also indicate the quality of the bearing in a highly unified, intuitive format. To explain, bearings induced by noise and reflections tend to be associated with shorter display vector lengths while valid bearings tend to be associated with longer display vector lengths. The real-time polar bearing display is thus an enormously powerful tool for helping the operator deal with the demanding requirements of mobile DF."

While in a mission, it is very important to see the quality of the DF Bearings at all times. Again an extract from 'RDF Products' Web Notes:

"As a case in point, if the operator is using the system in a tracking and homing mode, it is important that he "ride" the Video Gain control so that the vector length always be on-screen so that he can see the relative vector lengths (and rely upon bearings associated with longer vector lengths as being the most reliable). Unfortunately, most inexperienced operators are inclined to miss this subtlety and set everything to "max". (This is the reason why the bearing vector color changes when the vector exceeds full-scale). Another case in point is that in a mapping application, it is important that the vehicle be in motion so that multi-path can be averaged out."

The above quotation is a rule of thumb of DF Operation. This is the reason why HuntMaster has provision of a 'Signal Quality Muting' Control (located in the IP DF Controller window). Low quality measurements are automatically discarded. Nevertheless, this feature operates properly ONLY if the DF Operator is riding the Video Gain (as 'RDF Products' engenieers suggests). If Video Gain is set at maximum, both good and bad measurements are going to slip into the Radar Display (and will eventually be used to calculate bearing lines later on).

3. MAKING SURE YOU ARE ON THE CORRECT LEAD

3.1. Taking advantage of DFP Audio listen-thru capability

Considerable effort is dedicated in DFP designs so that users could take advantage of the DFP voice listen-thru capability. This is a very important feature that new users generally overlook. As a good case in point, tracking weak pulsed vehicle radio beacon signals would be almost impossible if the operator did not listen to the audio (in this case CW) so that he would know exactly when the signal is present. Below an extract of 'RDP Products' DFR-1200B manual:

Aside from frequency selection (which is accomplished exclusively using the Radio Receiver), the Radio Receiver and DFP-1000B are essentially parallel receivers with independent IF bandwidth and demodulation mode selection as well as independent audio outputs. This allows the user to rely on either of the two units to select reception mode and listen-through. For most applications, we recommend that reception mode selection and listen-through be done via the

DFP-1000B. This simplifies operation, both from the standpoint that the DFP-1000B is easier to operate than the Radio Receiver and that the user need pay attention to only one unit (the DFP-1000B) for all operational matters (aside from frequency selection, which must still be done at the Radio Receiver). Another benefit is that the DFP-1000B includes a special filter that attenuates the DF antenna encoding tones for most signal formats, thus improving listen-through capability.

Since most DF applications require only basic receiver feature selection (e.g., reception mode, IF bandwidth, and volume/squelch adjustment), this operating scheme is usually the best choice. If the user chooses to operate the system in this fashion, then we recommend that the Radio Receiver AGC (automatic gain control) be disabled since this results in a slight performance advantage.

3.2.Taking advantage of DFP S-Meter capability

The truth of the matter is that a dB-linear S-meter indication is much more desirable than the more typical S-Meter indication found on Radio Receivers (where high-signal levels are all compressed above S9). To explain, the S-Meter indication in a mobile DF system is the operator's best relative ranging indicator. If this indication is dB-linear, the operator has a much better indication of relative range than if the scale is compressed at the high end.

In fact, law-enforcement users (who use mobile DFs to track radio beacons planted on suspects' vehicles) rely heavily on the DFP S-Meter indication to know when they are getting very close to the tracked vehicle. This would not be easy to do using a typical communication Radio Receiver S-Meter.

Therefore, DFP-1000B S-Meter is a much more useful ranging indicator than the one on the Radio Receiver been used.

4. FINDING THE RIGHT PLACE TO DF

For all clues mentioned in #2 to held true, the DF vehicle has to be in motion while using the DF System. If the vehicle is not moving, then the user will loose the temporal cue, the statistical cue, and if facing a poor quality measurement there is no way the user can fight aginst it! Therefore, for the above 3 cues to be 'visible', the DF vehicle has to be in motion while DF'ing. Nevertheless, the vehicle is not required to travel at high speeds. With a speed of 5-10 miles an hour the user will see these cues just fine.

Another important issue is about obstacles between the unknown transmitter and the DF Antenna Array on the cars roof. If the DF Operator know that the unknown RF Source is (for instance) located at mountain top. Then it is much more easy to have very good DF measurements to track them down. Just move to a nearby mountain top, and do your measurements from there. Bearings taken from hill tops are really trustworthy. Very few measurements but taken from two different mountain tops are much more useful than hundreds of poor quality measurements taken at a valley (which add no useful information at all).

5. HOW HUNTMASTER FITS IN?

HuntMaster has a novel approach to treating cues #2.1 thru #2.3. For temporal and statistical cues, it uses the Radar Module's Mode filtering. While for the Quality cue, it uses a muting when the measurements have a quality factor below a certain threshold. This threshold can be modified from the 'IP DF Controller' window. For this quality muting to operate properly it is important that the user 'rides' the Video Gain of DF Processor at all times.

For instance, if the DF Operator faces an unknown location transmission of 50 seconds in length, he should: Drive his DF vehicle in a straight line (at a hill top, or at any other wide open location). Meanwhile, during that period of time he lets the Radar Display accumulate measurements. Once the transmission ends and only if he feels comfortable with the overall quality of the measurements (based on the above 3 cues) he now proceeds to plot the bearing on the map (Ctrl+F3 shortcut). If the user does not trust the overall quality of the 50 seconds of measurements taken, then he should try to move the DF vehicle to a better spot. A better spot would be a location where he could receive the signal with less reflections due to nearby objects obstructing the 'line-of sight' between the DF Antenna Array and the transmitter.

6. USING HUNTMASTER'S RADAR AND PLOTTING CAPABILITIES EFFICIENTLY

HuntMaster has some very powerfull tools not found on other DF Mapping aplications. Therefore, it is important for any DF Operator to take some time to learn how to efficiently use the available resource toolbox. Some poorly conceived DF Mapping programs rely on very simple algorithms to plot bearing lines on the map. Indeed, some DF Users belive that a Mapping application is just an algorithm that at the press of a button start shooting directional lines at the target while moving, displaying a cross in the intersection region of these lines. Been able to stop the shooting and or clear the lines at any time.

Although the above implementation is an actually way to go (indeed most commercial DF Software operate that way) our engenieers found that it is not the best way to go for efficient signal localization. After several years of joint development efforts with econometricians from the University of Sussex (UK) we jointly developed a very sophisticated mathematical aiding tool to track down a RF Signal. The first breakthrough in DF operation was finding an appropriate unskewed statistical filter to clean spurious DF data. This was the statistical mode operator. Indeed, the Radar display does just that: to calculate the statistical mode in an easy to read graphical display. By doing so, it is possible to accurately estimate the real bearing angle. Discarding as much noise, interference and multipath induced errors as possible.

To take the best advantage from the Radar Mode filtering, the DF Operator should acumulate as much measurements in the Radar Module as possible before plotting a bearing line with it. Of course, the DF Measurements have to belong to the same RF Signal Source, and the DF Incidence Angle should remain constant through the vehicle displacement. Once the DF Operator considers that a proper estimation has been achieved (seen as a very consistent reading in the

Radar Screen) then he should press Ctrl-F3. This shortcut will generate a new measurement bearing line (Mobile Waypoint), while then Clearing the Persistence of the Radar Screen. Preparing the Radar to accumulate new measurements to estimate a new bearing line. The Ctrl+F3 shortcut is equivalent to pressing the "World Image with two DF Bearing Lines on it" button from the Touch Screen Buttons Panel.

If the DF Operator has modified, the DF Radio Receiver's frecuency, or a different RF Source is now been received, then he has to start a new measurment estimation by Clearing the Persistence of the Radar Display. He should then press the 'Clear Persistence' button (of the Radar Screen). It can also use Ctrl-C as a shortcut. The Radar will start a new Mode estimation with the measurements decoded from now on.

As you can see it is an easy two step process on each measurement the DF Operator wants to perform. One step to Start the data recollection in the Mode Econometric Model, and the second step to End the process and display the result on the map.

The DF Operator should try to wait as much time as possible between plotting sucessive bearing lines. DFP-1000B generates some 40 measurements per second, then, as more time elapses, more information will be available to accuratelly calculate a Mode Bearing Angle. As a practical rule, at least some 1000 / 2000 samples are required for a good Bearing Angle estimation. This are approximately 30 to 60 seconds of data integration. Of course it is best if the DF Operator can wait even longer. The practical limit to the time the DF Operator can wait between starting the computation, and plotting the result is a matter of how much time the RF Singal Source is present, and the Incidence Angle of that singal remains constant from the vehicles point of view.

After a couple of minutes of work, the DF Operator will have a few measurements (instead of dozens of them if automatic plotting every 5 seconds was used in poorly conceived software applications). But these few measurements take into account thousands of measurements that have been processed to generate those few bearing lines. Now it is possible to triangulate using this VERY reliable Bearing Lines. We developed for this triangulation task a Homosedastic Maximum Likelihood Probabilistic Model (MLPR) which is a very advanced tool to determine the most probable region to find the origin of the RF source. Even multiple sources on the same radio channel can be tracked at the same time! The display for the MLPR is a colored overlay on the map. This areas are colored from a light yellow (minimum probability) to a dark red (maximum probability). There are 1280 rainbow like colors to depict probability values. To activate the MLPR (once you have two or more Bearing Lines on the map) the DF Operator has to press Ctrl-R. Just as easy!

7. CONCLUSION

Any new user should get introduced into RDF Technology in a step by step approach. The milestones one would suggest to any new DF Operator are:

- **7.1.** Use a known beacon (e.g. leave a transmitter at the office) and track it down using the DF vehicle. While driving thru the city the user should take a look at DefCon2b's & DFP-1000B's Bearing Display. To learn how to understand the cues we have already talked about. We suggest to travel to a nearby mountain top (or clear area) and appreciate how

measurement overall quality improves drastically compared to measurements taken downtown. Of course, this is a quite boring exercise, as the exact location of the transmitter is known. But it is an important step to understand the equipment.

- **7.2.** Ask someone else to drive in a vehicle and park at a nearby Macy's parking lot (or similar wide open parking lot). Ask this person to transmit periodically, while you try to track him down with the DF vehicle.

- **7.3.** Once the user gets used to dealing with DF bearing issues, now go out for a real world mission. Suggestion would be to start by DF'ing a simple transmission in a fixed frequency first. Tracking down a signal with a high S-Meter inidcation would be best (start tracking down a nearby transmitter first). If not, select a transmission you feel more comfortable with. Once the object to locate is clearly indentified, go to a mountain top (or wide open parking lot) to take the first measurement. Drive the DF vehicle at low speed and take some measurements from there. Plot on HuntMaster's map only one bearing at the end of each transmission (so that the Radar accumulates all the measurements received during the transmission). Repeat the process from another second hill top, or clear place. Now you can also start travelling in the direction indicated by the bearing lines intersection on the map. The DF Operator is encouraged to perform some additional measurements while travelling to the intersection spot, increasing the precision of the signal source localization.

8. A FINAL NOTE ON REPEATERS

Some newcomers may believe that erroneous bearings may be produced by the existance of repeaters that cause bearings to bounce back and forth. Nevertheless, once repeaters are understand, the user will understand that this is not possible to happen, as this systems have two different frequencies. One for reception of the mobile user, and one for transmitting the repeated signal. This originates what is called a 'repeater shift'. If you have a repeater frequency of461MHz with a repeater shift of +5MHz, this means that the repeater retransmits on 461MHz what it receives in 466MHz. The short notation for a 461MHz repeater with a +5MHz repeater shift would be: 461MHz +5MHz. Of course, this general comments are only for analog repeaters. Therefore, the user should understand the exact technology behind the signals he is intending to locate.

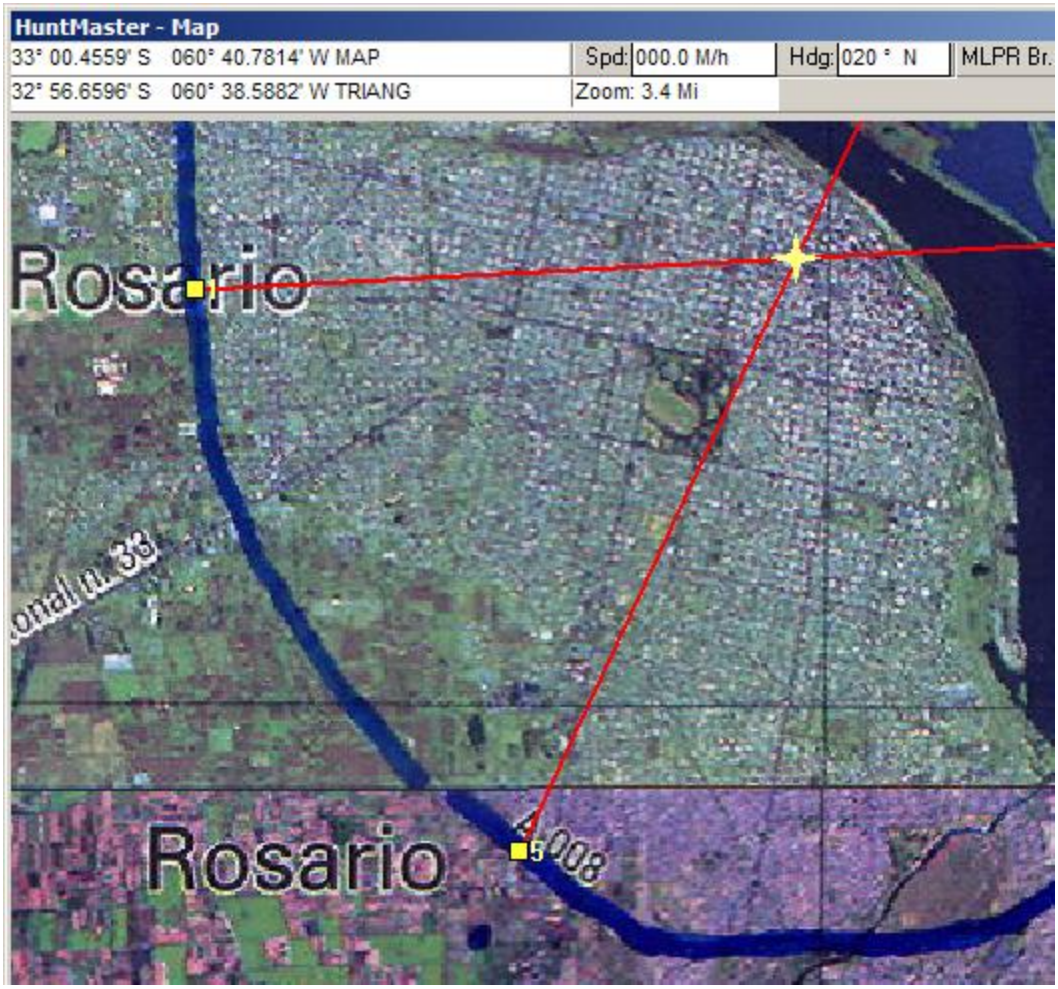
As a general rule, repeaters cannot cause DF bearing angle volatility because they have a separate input and output channels. The only DF related problem when using repeaters is that if the user tunes his DF Radio Receiver to the transmission frequency of the repeater, then all stations using the repeater will generate the same bearing angle in the DF System. This happens because he will be tracking down the localization of the repeater instead of the location of the mobile users he may be more interested in locating.

To determine an analog repeater's input frequency in the UHF Band the user should normally check +/-5MHz from the repeater's output. The output is easier to find, as all stations will be getting out of the repeater system, and the user will have a higher S-Meter Indication.

B. AUTO BEARING LINE TRIANGULATION

This is the simplest help guidence provided by HuntMaster to the DF Operator. When two or more bearing lines are avaliable, this feature activates, providing the user with:

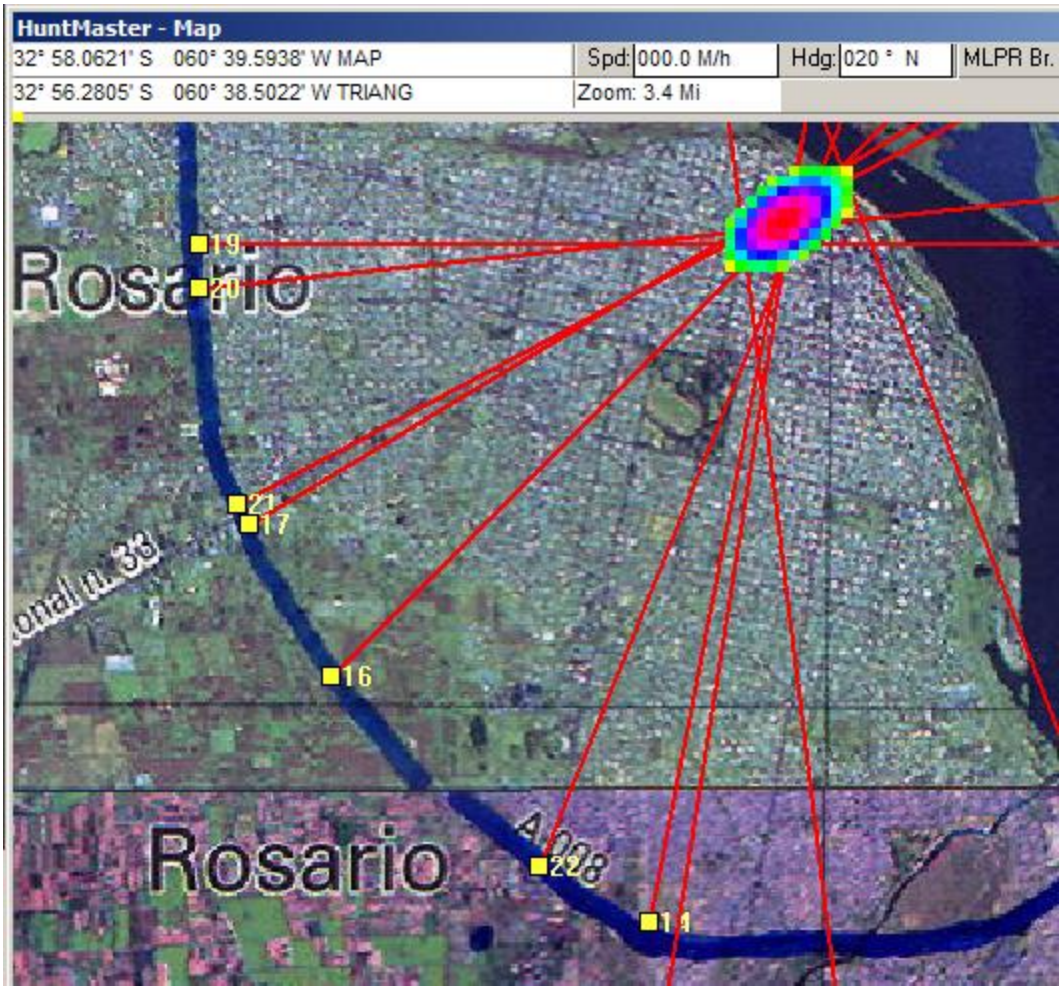
- Indicates the intersection of the last two bearing lines with a 'star' icon on the map.
- Provides the Geographical Coordinates of this intersection point in the same numeric format than the rest of the coordinates used thruought the application. These coordinates will be displayed below the GPS coordinates in the Map Window.



NOTE: If the two bearing lines don't intersect (because they have divergent angles) HuntMaster calculates the 180 degree out of bearing line, and uses it to estimate a probable "back" intersection spot. This feature has been added, as sometimes multipath makes a measurement to be 180 degree out of its course.

C. USING THE MAXIMUM LIKELIHOOD PROBABILISTIC REGION DISPLAY

Based on a map and a set of DF measurement, HuntMaster can calculate the most probable region for the RF Signal Source to be found. To do so, just press Ctrl-R shortcut, and wait until the Probabilistic Model is resolved. You will then see an ellipse colored area on the map. This is the most probable region were the Signal Source comes from based on the amount of measurements available. A usuall mission plot may have the following shape:



This colored layer is overlapped over the map showing the most probable region for the unknown RF Signal Source to be found. This areas are colored from a light yellow (minimum probability) to a dark red (maximum probability).

In this case, the region has an elliptical pattern. The exact shape depends on the localization where the measurements have been taken. In a two measurement case both of them are measured very near from one another, then a very elliptical pattern is formed (in the axis where the measurements are done). This is the consequence of error propagation probability in the mathematical model. Intuitively is also clear that if you take two measurements very near from each other, then you will probably have a good direction indication, but a very inaccurate distance indication. This is depicted by the MLPR Display with this highly elliptical pattern.

Of course there are infinite shapes that can be formed when more and more measurements are

taken into account. This also increases the precision of the region displayed as been the most probable for the unknown location of the RF Source to be. In the limit, when the amount of information (measurements) tends to infinite, this ellipse tends to be just *a point* on the map displaying the exact position of the transmitter (of course if there are no biasing errors in the DF measurements).

It is important for the DF Operator to know that each time the map is zoomed in/out, or moved in any direction the MLPR displayed overlay will be erased. He should press Ctrl-R after each map view change to Recalculate the MLPR Display.

Tip: Keep in mind that under certain circumstances (such as when 2 or more transmitters are keyed alternatively) it is possible to see two different colored regions (or more) overlapped over the map. This can also happen when some of the radiogoneometric measurements have been systematically biased. This could happen when 'night effect' or 'shore effects' are taking place. Under this circumstances, a false high probability region could be displayed together with the actual region. It is therefore always important for the DF Operator to understand the environment where he is operating the RDF System.

COLOR PROBABILITY AUTOSCALING

The MLPR color scale may change as you go through zooms, or view area changes. This is because each time the MLPR Moder is run by HuntMaster it also recalculates the color scale probability reference (sensitivity) based on the probability values of the area under display. Therefore, if you zoom into a low probability are, the algorithm will automatically increase the sensitivity (and color brightness) of that area to compensate. This automatic MLPR probability brightness control cannot be overridden manually. Nevertheless, there is a manual brightness control ('MLPR Br' Slider Control) that modifies +/- 10 log probability units the automatically selected brightness threshold. This is much like the way the Automatic Exposure Control of Digital Photo Cameras works.

The 'MLRP Br' Slider Control is seldom used. It increases/reduces the MLPR color scale sensitivity (brightness). Sometimes when the DF Operator is tracking down more than one signal at a time, or when the signal source does not appear as at a clear spot we may find usefull to increasing the MLPR sensitivity. As this will assign additional probabilities to places overlooked in first place.This control slider is not required for normal DF operation. It is only usefull for advanced operation and to learn how the MLRP Model works. Therefore, the suggestion is for the average user not to modify this control from the 0 (center) slider position during normal operation.

Advanced users may want to increase the Silder to positive values when there are lots of measurements plotted, and none of them tend to give a clear indication. When this happens, the MLPR Model may not show any overlay at all (as probabity areas are too low). Under this scenario, the user can place the 'MLRP Br' Slider at +6 or +7 to have a visible indication of the most probable regions where the RF Source may be located. Nevertheless, the user should be awared, that overall probabilities are very low. This could indicate that there are various RF Sources on the same frecuency, or that some measurements have very high accurancyproblems.

HIDING/UNHIDING THE MLPR OVERLAY

As the MLPR Overlay can hide certain map details, it is important to have some quick way to hide the Overlay to look on the map, and turn it back on again. This is the Ctrl+"S" shortcut. It shows/hides the MLPR Overlay. This shortcut responds very quick so the user can hide the MLPR, see the map below the colored area, and turn back on the MLPR in a matter of a second or so.

ABOUT MLPR VISUAL RESOLUTION

The MLPR Model works with a 128 by 100 pixel resolution. Therefore, the user will appreciate that the map has a much higher resolution (usually 500x400 pixels) than the overlaid probability layer. This will produce bigger colored pixels in the region where the probability layer is not transparent. This is normal, and is the result from a 'processing time versus pixel size' tradeoff. Nevertheless, as the user increases the zoom over a certain region of the map, the probability layer pixels remain constant in size, and therefore are relatively smaller compared with the ones from the original map image. So the overall precision of the MLPR Model is non dependant of the pixel visualization size. As each time the map is zoomed, and the MLPR Model re-run, the new smaller map view is recalculated.

The MLPR Model is calculated one measurement at a time. Therefore, the time it takes to calculate the whole area is dependant on the number of measurements. In a Pentium III 700Mhz MMX each measurement requires approximately 0.1 seconds of CPU processing. Then a 10 measurement hunt will require of 1 second to be processed by the MLPR Model.

HOW DOES THE MLPR MODEL WORKS(For Advanced and curious users only)

The software runs a Homosedastic Maximum Likelihood Probabilistic Model, based on some key assumptions of every one of the measurements. It is important to understand the logic underneath the algorithm to have a better interpretation of the results.
Model assumptions:

1- All measurements have a Normal (gaussian) distribution error which is therefore unbiased (by definition of normal distribution).

2- Therefore there are no systematic errors on DF bearing lines (this is important at high latitudes, as the Digital Compass, or GPS derived Heading should be reporting magnetic field adjusted Compass measurements for high accuracy operation).

3- Amplitude error of a certain measurement is fixed (in degrees). So the absolute error (in feet) of a measurement is proportional to the distance from where the measurement has been taken. This is the same that to say that the Standard Deviation of the normal distribution is proportional to the distance from the point where it has been taken to the point where the RF Signal Source is located (Homosedastic Function).

4- All measurements are independent from one another. This implies that a certain error of one measurement in one direction is *totally* independent from the error of the next measurement taken. This implies that (for instance) the calibration error of the DF Units involved is *zero*. If not, all measurement will have a common non Normal distributed error, that will generate non canceling errors in the algorithm. The same occurs if measurements are taken while in motion and undertaking sharp turns. For best performance of the Probabilistic Model, and to have an accurate Maximum Likelihood region this kinds of biasing errors should be avoided.

5- It is supposed that map longitude and latitude coordinates are totally accurate. The same is true of GPS position.

CONFIGURATION OF THE STANDARD DEVIATION CONSTANT

For the MLPR model to work, a key assumption about the standard deviation of the bearing errors should be made. This value should be modified accordingly to the accuracy of the DF measurement equipment used and the environmental conditions in which it is operated (e.g. City, Country Side). For instance, for fixed site RDF measurements, then a 2 to 4 degree of standard deviation is suggested. As the RMS error of a Professional Grade RDF Unit under this circumstances can achieve this small error values. When working mobile, then this value should be increased into the 5 to 10 degree range. To modify the Standard Deviation constant select the 'Map' tab from the 'Options' form from the 'Tools' menu.

SECTION VIII - MAPS

A. WHAT IS A MAP?

A map in HuntMaster software suit is an image of a map which has been calibrated (georeferenced) so HuntMaster can use any pixel position on the map to determine the true geographic position. When you calibrate a map using HuntMaster Map Module creates a .map file which contains the calibration information and a link to the image you are using. This files are compatible with OziExplorer (www.oziexplorer.com) version 3.x or higher .map files. The user can therefore use this shareware software to georeference an image file.

If the user is going to create a map image by scanning it or using an image file, he should make sure that the image has north in the upward direction, so that latitudes become horizontal and longitudes vertical. This is one of the main differences between an image and a map. If it is a paper image then use a scanning software to save the image as a graphics file.

The other method of creating maps is to import them. There are maps and charts available in digital form which have the calibration (georeferencing) for the map included either directly in the file or provided as information in an additional file. Importing these maps reads the calibration information from the map files and creates an OziExplorer map file.

B. CREATING MAPS FOR HUNTMASTER

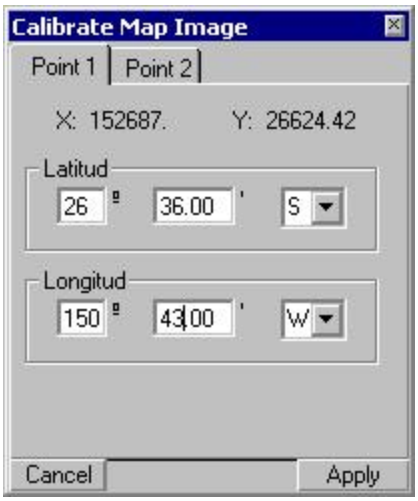
Where do a user obtain the map images from - he can obtain them from 3rd parties who have produced them in digital form as images or you can scan them for himself. The user has several ways to create map files. With HuntMaster an image can be imported and assign latitude and longitude coordinates to it (georeference the map). Then save the file (in .map format) and the user is ready to use the map in Map Module. To create a map, the user can first create a map image (using a scanner) and store it in a graphics file. Scan the maps at or about 125 to 200 dpi (dots per inch) with 16-bit color. The dpi can be modified to suit your requirements, colors settings should be at least 16-bit resolution. The amount of control you have for setting these parameters depends on your scanner and its software. Save the scanned image as a BMP file, although other image files are supported, it is very important to achieve best performance to use a non compressed file format. The reason why this is necessary is because when the Map Module has to re-draw the map windows the image file has to be read and decompressed. This decompression process is slow, and reduces the software response to users movements on the map. Alternatively a map image can be created using a commercially available map program like MapExpert (by DeLorme Mapping).

There are some things you should consider when making a HuntMaster map. If the map has many details and/or is very dark, you might find it hard to see bearings on the screen. It is advisable to use a map with fairly pale colors or with limited detail.

The next step is to georeference the image by assigning coordinates to it. To perform this task, the user has to know the latitude and longitude of at least 2 points on the map (preferably near opposite corners of the image to reduce errors to a minimum). As stated above the Latitude/Longitude lines must run parallel to the edges of the screen for the calibration to be acceptable.

C. CALIBRATING (GEOREFERENCING) AN IMAGE FILE

From the Map menu select the Calibrate Map Image option. Using commands in this form the user assign coordinates to his pixel image by specifying the latitude and longitude of two locations on the image.



Thus, the user needs to know the latitude and longitude of two points that he can identify in the image and select with the mouse. He is free to choose any two points, except that they must define a rectangle (they cannot line up). To achieve maximum precision, the user should see to it that the two points are fairly far apart, preferably along a diagonal of the image (and near opposite corners of it). The procedure to georeference the map is as follows:

1- Select First Point: Determine the location (latitude and longitude) of the first point. After selecting this tab the user should move the cursor to the right location and double click the mouse. The location you have chosen is marked with a black cross on the image. Enter the latitude and longitude in the tab location dialog box. If you are not satisfied, repeat the process to re-select the correct pixel for that location.

2- Select Second Point: Determine the location (latitude and longitude) of the first point. After selecting this tab the user should move the cursor to the right location and double click the mouse. The location you have chosen is marked with a black cross on the image. Enter the latitude and longitude in the tab location dialog box. If you are not satisfied, repeat the process to re-select the correct pixel for that location.

3- Once you successfully selected both calibration locations on the image press the Apply button. The image will now be re-scaled to the corresponding map scale.

4- The user should now save the map. From the File Menu select the Save Option, then click to save in .map format. All georeferencing information will be stored in this file and a link to the image file you are using will be stored on that file. Therefore, the path to the image must not change from this moment onwards. This .map files are compatible with OziExplorer (www.oziexplorer.com) version 3.x or higher .map files.

Once you have assigned coordinates, you can check the coordinates of any location by moving the mouse while pressing down the left button. The latitude and longitude of the cursor location are displayed at the top of the Map Module screen.

SECTION IIX - ADVANCED USER INFORMATION

A. ADVANCED CONFIGURATION

CHANGING THE DEFAULT SCREEN SIZE

By default HuntMaster is configured for 1024x768 resolution monitors. Other resolutions can be accomodated by manual configuration of the HM.INI file. For the average user, HuntMaster window can be resized by dragging it with the mouse. The Map Window can also be resized by dragging. In this case, the user should resize the Map Window to the desired vertical highth of the window. HuntMaster will automatically determine the correct width for that height. To change the default size settings to accomodate other monitor resolutions the HM.INI file has to be edited. The INI text lines to modify are the following:

- **Map Window Size:** Locate the line 'MapHeight=539' and edit the number of pixels as per the user requirements. Please note that the Map Window Width is automatically calucalted based on the Height been selected.

- **Main Window Size:** Locate the lines 'MainHeight=634' and 'MainWidth=1024'. Edit them so that the number of pixels best fit your computer's screen.

B. SHORTCUTS

Each of HuntMaster's Modules has a certain set of shortcut keys. Most of this commands require to first press the Ctrl key and then the shortucut key. When HuntMaster is running, it captures the keyboard in such a way that the shortcuts will work all the time (even if the focus is on another program). That's why almost all the shortcuts require the Ctrl key to be pressed. While in a mission, it is suggested that the DF Operator mantains the Ctrl key pressed at all times while using HuntMaster. There is no way of disabling the shortcuts except by closing the program.

Care should be taken not to leave the focus on a Slider when using certain shortcuts (such as the PgUp, PgDn or Zoom shortcuts) as this could have two effects: To change zoom scale, and to move the slider at the same time.

SoftDoppler Module shortcut table

Key	***Description***
Shift	When pressed the audio filter's bandwidth is increased by 10 (fast response)

Radar Module shortcut table

Key	***Description***
Ctrl-C	Clear Radar's Persistence (Mode Reset)
Ctrl-T	Timer Reset

Map Module shortcut table

Key	***Description***
Ctrl-PgUp	Zoom In (x1.2)
Ctrl-PgDn	Zoom Out (x1.2)
Ctrl-X	Open Next Higher Definiton Map of this area
Ctrl-Z	Open Next Lower Definiton Map of this area
Ctrl-M	Map's Coverage Display (Show/Hide)
D+Left Click	Open Highest Resolution Map available of the clicked location
Left Click	Pressing the Left Mouse Button while moving the mouse cursor to the location of a Waypoint, will pop-up a Waypoint Information Window
Ctrl-I	Move Map Up (1/6 screen)
Ctrl-K	Move Map Down (1/6 screen)
Ctrl-J	Move Map Left (1/6 screen)
Ctrl-L	Move Map Right (1/6 screen)
Ctrl-R	Recalculate MLPR Display
Ctrl-S	Hide/Unhide the MLPR Overlay
Ctrl-F1	Show Manual/External DF Entry Window
Ctrl-F2	Show DF Mode Angle Entry Window
Ctrl-F3	Plot DF Mode on Map and Clear Persistence (suggested plotting method)
Ctrl-F8	Erase all Mobile Waypoints older than 5 minutes
Ctrl-F9	Erase all Mobile Waypoints older than 10 minutes
Ctrl-F10	Erase all Mobile Waypoints older than 15 minutes

C. HUNTMASTER FILE INFORMATION

FIXED FOLDER STRUCTURE

HuntMaster has a fixed sub-folder organization structure, where the different types of files are stored. The user will find the following files in the sub-folders as per the following table:

- **Map files:** '.map' files in sub-folder: \Maps
- **Waypoint files:** '.wpt' files in sub- folder: \Wpts
- **Hunt (Mission Logging) files:** '.hm' files in sub- folder: \Hunt

The Intelligent Default Folder algorithm automatically selects the correct folder based on the type of file the user is going to open/save.

'.HM' HUNT FILES DESCRIPTION

In this file HuntMaster stores three types of events:

- **Map Changes:** If a new map is loaded, then the new map opened is logged into the file
- **Waypoint Plotting:** Any new Waypoints plotted on the map (together with all their information) is logged into the file
- **GPS Tracks:** All the GPS tracks of the different DF Stations available will be plotted on the map as separate track lines

GPS Track information is recorded every 4 seconds including the following additional fields:

Name	Value	Description
DF Station Address	DFxx-Track	Where xx indicates the Address of the DF Station been logged
GPS Latitude	xx.xxxxxx	Degrees and Fractions of Degrees
GPS Longitude	xx.xxxxxx	Degrees and Fractions of Degrees
Code	Reserved 1	-
GPS Altitude	Meters	A value of -777 means no altitude information available
Date & Time	xxxxx.xxxxxxx	IEEE Data & Time Format
Reserved 2	Reserved 2	-
Reserved 3	Reserved 3	-

RDF Bearing Angle	xxx.x	Degrees and Fracions of Degrees
Radar Mode	xxx	Degrees. Rounded to 1, 2, 3, 4, 5 degrees. Depends on Radar Configuration
RDF Hold	x	Boolean Value. 1 (True) when RDF Unit is On Hold / 0 (False) if RDF Data is flowing
Reserved 4	Reserved 4	-
RDF Bearing Quality	xxx	Using SoftDoppler: Numerical value corresponding to Signal Qlty #1 Meter. Range from [-20db, 0db]. 'RDF Products' RDF Units: Bearing Length value. Range from [0, 999]
RDF Bearing Quality 2	xxx	Using SoftDoppler: Numerical value corresponding to Signal Qlty #2 Meter. Range from [-20db, 0db]. 'RDF Products' RDF Units: not used
RDF Bearing Quality 3	xxx	Using SoftDoppler: Numerical value corresponding to Signal Qlty #3 Meter. Range from [-20db, 0db]. 'RDF Products' RDF Units: not used
GPS Speed	xxx.x	Knots (Miles per Hour)
Heading	xxx	Heading in Degrees. If no Digital Compass Information is available, then GPS Heading is used