If you use EmaxAIR with Maxwell
you will need to run Maxwell version 5.0 or later.
(HeliTEM or other surveys with Rx ahead of Tx should use Maxwell 6.0 or later)
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Licence

EmaxAir is a licenced software product to be used in accordance with the terms and conditions of your Licence Agreement with Fullagar Geophysics Pty Ltd.

Running EmaxAir

EmaxAir runs on IBM compatible machines. Two modes of operation are possible;

The simplest mode is stand-alone which runs from a Command Window command line and requires the field data to be in a text file with free-format columns.

The second mode accesses EmaxAir through the Maxwell™ e/m modelling software interface developed by ElectroMagnetic Imaging Technology (EMIT) in Perth, Western Australia. Maxwell will read a wide variety of data formats, and provides a graphical display of the conductivity-depth output data.

System Requirements

Windows 7 or later.

(Windows 2000, XP, Vista : may run, but are no longer supported)

The program is a 32-bit executable which will run on either 32-bit or 64-bit machines.

If you use EmaxAIR through Maxwell™ then you will require Maxwell v5.0 or later.

If you want use Maxwell to process HeliTEM or other surveys with Rx ahead of Tx then it is recommended to use Maxwell v6.0 or later; this will avoid the need to set up the processing using “reciprocity” (i.e. by treating Tx as Rx, and Rx as Tx).

See also the Maxwell system requirements on the EMIT web site.
1. Introduction

1.1 Description

EmaxAir calculates conductivity versus depth pseudosections from the transient electromagnetic (TEM) data of various airborne EM systems. Conductivity-depth pseudosections are a convenient form of presentation of EM profiles for first-pass interpretation. A number of schemes have been devised for conductivity-depth imaging (CDI) of airborne EM data. EmaxAir uses an adaptation of a maximum current (Emax) algorithm originally developed for coincident loop and in-loop ground TEM by Fullagar (1989), and later extended to fixed loop and Slingram TEM by Fullagar & Reid (1992) and Reid & Fullagar (1998).

The Emax transformation proceeds in two stages: off-time data are first converted to apparent conductivity, and the depth assigned to each delay time is the depth of the induced current maximum in a half-space with conductivity equal to the apparent conductivity at that time.

In the context of depth conversion methods it is easy to confuse physical currents and image currents. A physical current (“smoke ring”) is the real flow of charge carriers in the ground; an image current (“current filament”) is a mathematical abstraction which replicates the magnetic field on the surface. The physical current maximum, $|E|_{\text{max}}$, travels down into a half-space along a straight line path at an angle of approximately 30°, whereas the image current filament travels in a similar manner but more steeply at about 47°. This is so because the “equivalent current filament” which has an infinite current density must always be deeper than the maximum of the actual distributed current system. The consequence of this is that depth conversion methods based on image currents will inherently overestimate penetration depths. The depth conversion method used in EmaxAir pertains to physical currents.

The advantage of the Emax transformation is that, given its reliance on apparent conductivity, it is readily adaptable to a wide variety of TEM data. The disadvantage is that apparent conductivity is not unique, nor always defined. In practice the non-uniqueness rarely poses difficulties for transformation of airborne EM because the alternative apparent conductivity is usually too extreme to be considered geologically plausible.

The purpose of EmaxAir’s conductivity-depth processing is to quickly and reliably transform raw data into a useful form for presentation of conductivity at a true depth scale, and to allow for a fast initial interpretation of the data.

![Figure 1 - Secondary physical currents](image)

(a) evolution with time  
(b) numerical example

Figure 1 - Secondary physical currents
1.2 Survey Geometry

EmaxAir is able to process TEM voltage response data of various airborne e/m systems.

<table>
<thead>
<tr>
<th>System</th>
<th>X-comp</th>
<th>Z-comp</th>
<th>B-field</th>
<th>dB/dt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerotem</td>
<td>-</td>
<td>yes</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Geotem</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
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<td>Helitem</td>
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<td>yes</td>
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<td>-</td>
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<td>yes</td>
</tr>
<tr>
<td>Questem</td>
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<tr>
<td>VTEM</td>
<td>-</td>
<td>yes</td>
<td>yes</td>
<td>-</td>
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<tr>
<td>XTEM</td>
<td>-</td>
<td>yes</td>
<td>-</td>
<td>yes</td>
</tr>
</tbody>
</table>

*Figure 2 – Generalised survey geometry.*

(note: "X0" is set to the effective loop radius of the Tx coil for central loop systems like Hoistem & VTEM)

1.3 References

Fullagar, P.K., 1989,
*Generation of conductivity-depth pseudo-sections from coincident loop and in-loop TEM data.*

Fullagar, P.K., and Reid, J.E., 1992,
*Conductivity-depth transformation of fixed loop TEM data.*

Reid, J.E., and Fullagar, P.K., 1998,
*Conductivity-depth transformation of Slingram transient electromagnetic data.*

Fullagar, P.K., and Reid, J.E., 2001,
*Emax conductivity-depth transformation of airborne TEM data.*
ASEG 15th Geophysical Conference and Exhibition, August 2001, Brisbane.

Fullagar Geophysics Pty Ltd
*Emax User Guide*
2. Installation

2.1 Software

There are two licence types available.

- A **registry-key** licence. These licences are locked to a single computer and can be issued immediately through an exchange of e-mails. To enable a licence key to be generated you will need to send us your computer’s MAC address (also known as the physical address). This can be found by running the command “ipconfig/all” in a Command Window and noting the physical address of the Ethernet or WiFi adapter Local Area Connection. Often multiple physical addresses will be listed; if unsure which one to send, you can download the licence utilities tool “GET_Ethernet_Physical_Address.zip” from www.fullagargeophysics.com and send us the output file it produces.

- A **dongle** licence. We have to ship you the dongle before you can start to use EmaxAIR. These licences are more convenient if you want to install EmaxAIR on more than one computer. EmaxAIR will then only run on a computer with a dongle inserted.

Installation is via a setup executable file which can be downloaded from www.fullagargeophysics.com.

You will need to download the setup file that matches your licence type (registry or dongle).

When you run the EmaxAIR software setup file you will need to enter a setup password. Please contact us to get the current setup password.

*If you are installing the dongle version of Emax for the first time, before inserting the dongle: download the “run-time setup for dongles – zip” file, unzip and install.*

A typical install commences like this;

![Figure 3 – Installation of EmaxAir software](image)

Files are installed into the following directory (which is created if necessary):
- **32-bit operating system** C:\Program Files\Fullagar\EmaxAIR
- **64-bit operating system** C:\Program Files (x86)\Fullagar\EmaxAIR

To uninstall, either run the executable (usually named `unins000.exe`) that is stored in the program directory, or use Windows Control Panel (under Programs and Features, or Add/Remove Programs on older systems).
2.2 Operating system environment

For convenient stand-alone operation a batch file (emaxair.bat) is included in the program folder

32-bit operating system  C:\Program Files\Fullagar\EmaxAIR
64-bit operating system  C:\Program Files (x86)\Fullagar\EmaxAIR

and this program folder is automatically added to the operating environment PATH during installation.

To start EmaxAIR simply open a Command Window in your working folder and run the command **emaxair** at the prompt. If the operating system environment has been set correctly then EmaxAIR should begin running.

2.3 Licence Key

Your licence is set up separately to the installation of EmaxAIR.

If you installed the version of EmaxAIR that uses a **registry licence** then we will email you a ".reg" licence file. This attachment will usually arrive with a different filename extension (.txt for example) to prevent internet security software from automatically quarantining the attachment. The attachment should be saved to a temporary folder on disk, unzipped if necessary, renamed to ".reg" and double-clicked. This adds the licence information to your computer’s registry; you will be prompted for permission to modify the registry. **You cannot move a registry licence to another computer; the licence remains locked to a specific computer.**

If you have installed the version of EmaxAIR that uses a **dongle** then we will need to ship a dongle to you. **You can install the dongle version of EmaxAIR on multiple computers. The dongle can be moved between computers as required, however EmaxAIR will only run on the computer which has the dongle attached.**
3. Running EmaxAIR under Maxwell

3.1 Installation issues

Access to “EMAX_AIR.DLL” is required for Maxwell to process data. Maxwell will normally search for it in the following sequence;
1. In the Maxwell program files folder.
2. In the EmaxAIR program files folder.
3. Somewhere in the PATH.

The first version of the DLL found is the one that Maxwell will use. Be aware that if you have some old versions of this DLL on your computer there is a possibility that Maxwell will find the wrong one first and use it instead of the latest one. To guard against this possibility you should do one of the following;
(a) Install or re-install EmaxAIR after installing Maxwell. The EmaxAIR setup looks for a Maxwell program files folder and, if found, places a copy of the DLL in there.
(b) Manually copy the latest DLL from the EmaxAIR program files folder into the Maxwell program files folder.

3.2 Processing your data

Load your data into Maxwell as you would normally do.
Display the Line Editor window by doing one of the following;
Either select Edit and Process Lines under the Data/Preferences pull-down menu (Figure 4),
or click the Line Editing icon on the toolbar.

In the Line Editor window (Figure 5) select the line or lines you wish to process (yellow highlights).
Set the configuration to the correct survey type, and select “EMAX Air”. Set values for the parameters: those with **red** titles are mandatory, while **orange** are optional and **black** are not relevant.

Set the Waveform parameters and Timing Mark. The **Timing Mark must be set to the end of the Tx off-ramp, except for 100% duty cycle systems (see section 4.1 parameter file, record 14 description)**.

You should also check the parameters under the “**Units / Normalisations / Receiver Field Type**” tab.

If required you can set an arbitrary waveform in Maxwell if you are processing data from certain systems (see Maxwell documentation for additional information on arbitrary waveforms). **Figure 6** to **Figure 12** illustrate an example of how to set up a Maxwell arbitrary waveform.

**Figure 5** - Line Editor window.

**Figure 6** – An example of a standard Maxwell “periodic rectangle” waveform.
Figure 7 – Prepare your arbitrary waveform in Excel or a text editor.

Normalise your waveform to have a maximum amplitude of 1.0. This example replicates the standard waveform in Figure 6, but the amplitude at 1.75ms has been reduced. Select and copy either Excel or text editor records to the Windows clipboard.

<table>
<thead>
<tr>
<th>Time (ms)</th>
<th>Amplitude (0-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1.75</td>
<td>0.8</td>
</tr>
<tr>
<td>6.312</td>
<td>1</td>
</tr>
<tr>
<td>7.349</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 8 – Right-click over the waveform window and paste your arbitrary waveform.

Figure 9 – Select the time units used in your arbitrary waveform.

Figure 10 – Select the nearest type of standard waveform.

The parameters displayed should have been automatically calculated from the arbitrary waveform. Click OK.
Figure 11 – Reset the TimingMark to the correct value.

For the examples shown above, this parameter is the same as shown in Figure 5, Figure 6, Figure 7.

The waveform graph will now show the arbitrary waveform in grey, on top of the standard waveform plotted in red that it replaces (Figure 12).

Figure 12 – The grey line now shows your arbitrary waveform.

Once you have finished setting parameters in the Line Editor window, click Process (see Figure 5).

A Line Processing window should now appear. In the left panel, open the Electromagnetics branch of the navigation tree structure and click on the EmaxAIR option (Figure 13).

To output EmaxAIR conductivity data to file, tick the Save To File checkbox. The default filename for each line has the line coordinate {LINE} embedded in it. If you are processing multiple lines but remove {LINE} from the filename then all lines will be given the same filename so each successive line processed will overwrite the data from the previously processed line. There are other “Character Conversion Strings” apart from {LINE} which can also be used. Click the Help button on the EMAXAir parameter area for more information.

Choose the preferred Output Units for conductivity.

If the Create Grid checkbox is ticked then a grid file will be created internally within Maxwell for each selected line. These grids can subsequently be displayed as images in Maxwell’s Section Panels of the Profile Window. The default grid name is specified in the same manner as the filename mentioned in the previous paragraph.

It is possible to use Geosoft gridding in Maxwell providing that you have a version of Oasis Montaj that includes a licence for gridding. See the Maxwell Help and Documentation for more information.
If the **Sharpen** checkbox is ticked then the calculated apparent conductivity curve for each station is internally reprocessed to enhance features prior to output. While sharpening will better define good quality anomalies, for poor or noisy data the sharpening process may accentuate unwanted features. So that users are familiar with the effect of sharpening on their data, some trials with and without sharpening are advised before embarking on routine processing of data using this option.

Choose the data **Component** you want to process from the component(s) you have in your data.

Set **Contract Survey Altitude** to the nominal survey Tx loop altitude specified in the flying contract.

Set **Starting Conductivity** to an estimate of the average ground conductivity (S/m) for the area.

Select the **Waveform Type**. Maxwell will attempt to select the best option automatically based on the existing waveform parameters, but it cannot automatically distinguish between all of the asymmetric bipolar options.

![Figure 13](image)

**Figure 13** – Selecting the processing options for EmaxAir.

Click the **OK** button to begin processing the data.  
**The program may remain unresponsive for some time while processing is in progress.**

If you ticked the **Create Grid** checkbox then once processing is complete, a Grid Setup window (Figure 14) is displayed. Unless you need to change parameters, simply click the **OK** button.
Once processing is completed the Line Editor window (Figure 5) is once again active. This window can now be closed and the grid(s) displayed in Maxwell’s Section Panels.

### 3.3 Displaying the EmaxAIR conductivity data

Near the top of the **Profile Window**’s scrollable Preferences area (if not visible, right-click over the window and select Show Preferences) select **Section Panels** and tick the **Display This Panel** checkbox (Figure 15).

![Figure 15 - Profile Window's Preferences area (top part).](image)
Then scroll to the bottom of the Preferences area (Figure 16) and click on the Image button. A new Profile Image Select window pops up. Select the image to display. Click OK.

![Image selection window](image1.png)

**Figure 16** - Profile Window’s Preferences area (bottom part), overlain by image selection window.

The displayed image (Figure 17) is not necessarily for the same line of data as the displayed profiles. You should check that the image which you selected for display corresponds to the line for which the profiles are displayed.

To automatically insert the correct grid for multiple line plotting select Individual from the list (see Figure 16) and type the grid name in the Or edit box using the [LINE] keyword. (In Figure 16 for example, the images have an “EmaxAir” prefix before the line name so if you want these individual images to automatically display with their correct profiles as you scroll through different lines, insert EmaxAir[LINEX] in the Or edit box).

The flight line number is shown at the top-left corner of the Profile Window. To change the flight line displayed use the << or >> button at the top of the window to go to previous or next flight line. Moving the mouse cursor over the image will display position, depth, and conductivity values in the bottom left corner of the Profile Window.

![Profile Window display](image2.png)

**Figure 17** - Profile Window display of EmaxAir conductivity data.
3.4 The conductivity output files

If the **Save To File** checkbox was ticked ([Figure 13](#)) then for each line selected for processing ([Figure 5](#)) there will be a separate “XYZ” output file written. An example of this *Maxwell output format* is shown in [Figure 18](#).

If for some reason EmaxAIR does not compute a valid apparent conductivity then the values output (running through *Maxwell*) are; depth = -999.25 and conductivity = 999.25. Output data with this depth should be treated as dummies.

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<th>East Coordinate</th>
<th>North Coordinate</th>
<th>Active Conductivity</th>
<th>Depth (m)</th>
<th>Time (ns)</th>
<th>Resistivity</th>
</tr>
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</tr>
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<td>1449.2399</td>
<td>17.5273</td>
<td>0.5733</td>
</tr>
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<td>1097.2513</td>
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<td>0.6620</td>
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<td>3843202.4000</td>
<td>991.2512</td>
<td>21.4533</td>
<td>0.3180</td>
</tr>
</tbody>
</table>

**Figure 18** – Maxwell’s conductivity output file (*column headers have been manually added for clarity*).

Note that these Maxwell output files write DEPTH as POSITIVE DOWN.
4. Running EmaxAir in “stand-alone” mode

EmaxAir can be run as a stand-alone application from the command line. The only limitation is that the input data must be available in a free-format type file as described below in Section 4.6.

4.1 Parameters

Parameters are read, record by record, from the parameter file in free format as described in Table 1 below. The user is prompted to enter the parameter file name when the program executes. The actual input data file name is read from the parameter file.

For convenience a parameter file may contain comments appended to the ends of records containing numeric input parameters; i.e. all records except the first three. The only requirement is that a comment is separated from the last numeric parameter by at least one space. The convention used in example files is to begin comments with an exclamation mark (refer to the supplied sample files).

The parameter file format changed slightly with EmaxAIR v3 and the updated format is detailed in Table 1. The main change was the ability to optionally read the transmitter waveform from an ASCII file which can be specified at the end of the parameter file. The channel time zero-reference point was also changed for most waveform types. To enable backward compatibility with older v2 format parameter files, the v3 parameter files have the special identifier #v3# on the first record.

<table>
<thead>
<tr>
<th>PAR file record</th>
<th>Parameters and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parameters new in EmaxAIR version 5.39 are highlighted in green</td>
</tr>
<tr>
<td>#v3#</td>
<td>The first record contains just the four characters as shown above. This is an identifier to indicate that the PAR file is in version 3 format. If this record is absent then EmaxAIR treats the PAR file as an older version 2 format which allows for backward compatibility with previous versions of EmaxAIR.</td>
</tr>
<tr>
<td>2</td>
<td>TITLE Text to describe the data being processed.</td>
</tr>
<tr>
<td>3</td>
<td>DATA FILENAME An ASCII column or GEOSOFT “Line header” XYZ format is assumed (see Section 4.6). An arbitrary number of header or comment records are allowed, but only at the beginning of the file. These records are identified by a slash (/) in the first column.</td>
</tr>
<tr>
<td>4</td>
<td>NVAR Total number of data columns in the data file. A negative value indicates input data will be read from a Hoistem binary BDB file.</td>
</tr>
<tr>
<td>5</td>
<td>iLINE, IX, IY, iTxALT, iDATi, iDATf, iTDXRL, iOFFX, iOFFZ, iTxCnt, iDEM, iRALT, iDATi2, iDATf2, iDATi3, iDATf3 Note that the parameters shown above should appear on one record in the PAR file, not separated onto three records – they are only shown separated here for illustration purposes while reading the following comments; Parameters 1-6 are mandatory</td>
</tr>
</tbody>
</table>

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iLINE   column number containing flightline number.
iX      column number containing eastings.
iY      column number containing northings.
iTxALT  column number containing transmitter altitude
        (metres above ground surface).
iDATi   column number of first TEM data window to be processed.
iDATf   column number of last TEM data window to be processed.
        (data is either X or Z component, depending on the value of MODE).

Parameters 7-16 are optional. They are described in three groups below. If any parameter in a
group is defined then all parameters in that same group, plus parameters in all preceding groups,
must also be defined. While not mandatory, for clarity it is recommended to enter a value for all of
the 16 parameters. Use a dummy value of 0 (zero) for a parameter that is not relevant or is not
used.

Parameters 7-10;

iTXRL   column number containing RL of the transmitter (m ASL)*.
iOFFX   column number containing horizontal Tx-Rx offset (m).
iOFFZ   column number containing vertical Tx-Rx offset (m).
iTxCrnt column number containing Tx current (amps).

Parameters 11-12;

iDEM    not used; enter 0.
iRALT   not used; enter 0.

Parameters 13-16;

These parameters define the component data columns when Total Field values are to be
calculated by EmaxAIR using either sqrt(x^2 + z^2) or sqrt(x^2 + y^2 + z^2). In this case the
columns for one of the components are defined by parameters iDATi and iDATf (see parameters
5 and 6 above), and the remaining one or two components by the following four parameters.
All components defined should each have the same number of data columns.

iDATi2   Only required for MODE=0; otherwise leave iDATi2 blank or set to 0.
        If processing total field computed from the X & Z components, iDATi2 is the column
        number containing the first TEM window for the vertical (Z) component.
        If processing total field computed from the X, Y, & Z components, iDATi2 is the column
        number containing the first TEM window for the transverse (Y) component.

iDATi3   Only required for MODE=0; otherwise leave iDATi3 blank or set to 0.
        If processing total field computed from the X, Y, & Z components, iDATi3 is column
        number containing the first TEM window for the vertical (Z) component.

iDATf2   Same as iDATi2, but specify the column for the last TEM window.

iDATf3   Same as iDATi3, but specify the column for the last TEM window.

The TEM data columns are assumed to be sorted in order of increasing delay time, and the
columns for any single component must be in contiguous columns.
Data files with up to 200 columns can be read.

*For Hoistem data, TXRL must be calculated prior to running EmaxAIR:
  TXRL = GPS_Z - ( radaralt / 3.281 ) + laseralt (with radaralt in feet)

Some systems include on-time channel data (eg. MegaTEM, Aerotem).
These channels should not be included when defining the channels for processing.

6

LMIN,  LMAX

LMIN = the minimum survey line number to be processed.
LMAX = the maximum survey line number to be processed.

The data is assumed to be sorted in order of increasing survey line number.
The program terminates as soon as a line number greater than LMAX is encountered.

7 XMIN, XMAX, YMIN, YMAX

XMIN, XMAX are the min, max eastings of the area to be processed.
YMIN, YMAX are the min, max northings of the area to be processed.

8 IDAT, ConversionFactor

IDAT = 1 for normalised dB/dt data
IDAT = -1 for dimensional dB/dt
IDAT = 2 for normalised B data
IDAT = -2 for dimensional B data

(refer to Table 2 or Table 3 for data units)

ConversionFactor is used to convert the input data into the units required by EmaxAIR. Channel data are multiplied by ConversionFactor prior to processing. If the data units in the input file are not as defined in Table 2 or Table 3 then ConversionFactor should be set to the appropriate factor necessary to achieve this. For example, if for some reason SkyTEM is supplied as nV, then ConversionFactor should be set to 0.001 so that after conversion the unit is μV.

Default value is 1.

For some systems both IDAT and an appropriate non-default value of ConversionFactor must be specified. You will also need to account for any normalisations like Tx area and Rx area that may have been applied to the data by setting appropriate values for TXMOM and RXAREA.

A VTEM example;

VTEM dB/dt is usually supplied in units of pV/(A.m^4), in which case a ConversionFactor of 10^-6 is required. VTEM B-field is usually supplied in units of (pV*ms)/(A*m^4), in which case a ConversionFactor of 0.001 is required. Since VTEM data are already normalised with respect to transmitter moment and receiver area, set TXMOM = 1 and RXAREA = 1 in both cases.

An AeroTEM example with nT/s units;

AeroTEM dB/dt is usually supplied in units of nT/s, in which case a ConversionFactor of 0.001 is required. Since units of nT/s x 0.001 are equivalent to μV normalised by RxArea, set RXAREA = 1 but keep TXMOM = actual Tx moment.

Other systems with nT/s units;

Unlike AeroTEM (ISTEP=-3), other dB/dt systems with data supplied in units of nT/s (ISTEP=0 in Table 2) only require a ConversionFactor of 1. The settings RXAREA = 1 and TXMOM = actual are also used here too.

9 NSKIP, POSLAG

NSKIP stations skipped between each station processed.
Set NSKIP = 0 to process decays at all stations.

POSLAG controls the positional lag adjustment.
POSLAG = 0 if data coordinates refer to Tx-Rx midpoint.
POSLAG = 1 if data coordinates refer to Tx.
POSLAG = -1 if data coordinates refer to Rx.

If POSLAG = 1 or -1, coords. are altered to Tx-Rx midpoint by EmaxAir.
If POSLAG = 0, coords. are not altered (assumed to refer to Tx-Rx midpoint in the data file).
TXFREQ, TXMOM, RXAREA

**TXFREQ** is the transmitter "fundamental" operating frequency (Hz).
**TXMOM** is the transmitter moment (amp.turn.m$^2$).

  True moment is required when data is dimensional (ie. when IDAT < 0), and the value specified here should take into account any normalisations in the data.

  Otherwise TXMOM is a dummy parameter (ie. when IDAT > 0).

**RXAREA** is the effective area of the receiver (turn.m$^2$):

  does not affect results, only the computed value of the primary voltage.

  The value specified here should take into account any normalisations in the data.

PULSE, ISTEP

**PULSE** is the duration of the source pulse, in micro-seconds.

  For HeliTEM / Geotem a perfect half-sine pulse is assumed.

  For bipolar square wave PULSE is the on-time duration (excluding RON and ROFF).

  For 100% duty cycle step-current waveform PULSE is a dummy value (e.g. SPECTREM).

  For other waveforms, PULSE is zero.

ISTEP = 1 for 100% duty cycle step-current Slingram (SPECTREM, TEMPEST*).
ISTEP = 0 for half-sine Tx waveform Slingram (HELITEM, GEOTEM, MEGATEM).
ISTEP = -1 for bipolar square wave central loop (HOISTEM, or similar systems without a specific ISTEP).
ISTEP = -3 for triangular waveform central loop (AEROTEM).
ISTEP = -4 for bipolar square wave central loop (SKYTEM High or Low Moment) **
ISTEP = -5 for bipolar square wave central loop (VTEM) **
ISTEP = -6 for arbitrary waveform Slingram (dB/dt data only)

* Be careful when setting up TEMPEST parameters. Data are typically supplied by the contractor as “raw” and “final” varieties. You would normally use the final data for processing. This final data has usually been normalised to 100% duty cycle and 1m$^2$ Tx area. Check your survey specifications!

** An arbitrary waveform may also be used.

MODE

**MODE** = 0 for total field data inversion.
(see the six “IDAT” parameters defined on record 5 above).

**MODE** = 1 for horizontal-axis receiver.
(normalised w.r.t. primary horizontal component if data is in ppm, ie. DAT>0)

**MODE** = -1 for horizontal-axis receiver.
(normalised w.r.t. total primary field if data is in ppm, ie. IDAT>0)

**MODE** = 2 for vertical-axis receiver.
(normalised w.r.t. primary horizontal component if data is in ppm, ie. DAT>0)

**MODE** = -2 for vertical-axis receiver.
(normalised w.r.t. total primary field if data is in ppm, ie. IDAT>0)

**MODE** = 20 for vertical-axis receiver.
(normalised w.r.t. total primary field if IDAT>0)

**MODE** = 22 for vertical-axis receiver.
(normalised w.r.t. primary vertical component if IDAT>0)

**MODE and -MODE are equivalent if data are dimensional, ie. if IDAT < 0.**
13 X0, DEL0, ALT0, ALT0_flag

X0 : depends on the type of system flown;
- For Slingram type systems it is the notional (survey specification) Tx-Rx horizontal separation (metres), and relative to the flying direction it is;
  +ve if Tx is ahead of Rx,
  or –ve if Tx is behind of Rx.
- For central loop systems (eg. VTEM, SkyTEM, Hoistem*, and similar) it is the radius of the Tx loop. (May be referred to as alternative name “R0”).

DEL0** : the notional (survey specification) Tx-Rx vertical separation (metres), and is;
  +ve if Rx is below the Tx,
  or –ve if Rx is above the Tx.

ALT0*** : the notional (survey specification) Tx altitude (metres height above ground).

ALT0_flag : a flag to force processing using ALT0 as a constant Tx altitude, instead of using the variable altitude data contained in data column iTxALT (see record 5 above in this table). This parameter was added in v5.39 to make processing of TEMPEST data easier (see Appendix 7.3).

ALT0_flag = 0 (default) uses actual altitude recorded in data column iTxALT.
ALT0_flag = 1 processes data with constant Tx altitude ALT0 instead of using the actual altitude recorded in data column iTxALT. RLs are then corrected for output by subtracting the difference (ALT - ALT0).

X0 and DEL0 govern the magnitude of the normalisation voltage, for calculation of ppm values.
The actual horizontal Tx-Rx separation for the recorded data is assumed to be X0, unless IOFFX is non-zero (see record 5 above). Likewise, the actual vertical Tx-Rx separation is assumed to be DEL0 unless IOFFZ is non-zero (see record 5 above).

*For Hoistem data recorded before early 2002, X0 = 9.79m = effective radius of 301m² Tx coil;
for Hoistem data recorded after early 2002, X0 = 10.93m = effective radius of 375m² Tx coil.

**Normally for central loop systems such as VTEM and Hoistem DEL0 = 0. However DEL0 <> 0 is still permitted has an Rx that is at a different height to the Tx.

*** The “actual” Tx altitude (from radar altimeter) at each station is read from the TEM data file.

14 T, CHW, PCERR, SDMIN

T is the midpoint* time (microseconds) for the TEM window.
CHW is the window width (microseconds).
PCERR is percent error (%) for the TEM channel (use -1 if not defined).
SDMIN is minimum allowable standard deviation (TEM data units) (use -1 if not defined).

The program will expect NCHAN = IDATF – IDATI + 1 successive records in the parameter file here (refer to record 5 above), each with a window midpoint time and width.

* From EmaxAIR v3 the zero-time reference point for window times in the EmaxAIR PAR file is the “cessation of current”, the point on the waveform after the main Tx pulse where the current has fallen to zero. The only exception is for a 100% duty cycle waveform.

Depending on the waveform the description varies slightly;
for half-sine: the end of the half-sine pulse.
for bipolar square: the end of the Tx off-ramp.
for triangular: the end of the Tx off-ramp (ie. waveform regarded as just an on- and off-ramp).
for an arbitrary waveform : the point where current first returns to zero after the waveform start.
for 100% duty cycle step-current : the start of the step.

PCERR and SDMIN values for individual channels defined here take precedence. Where an
Individual channel's error parameters are not defined (PCERR = -1), the default values are used, viz. PCERR0 and SDMIN0 defined on record 16+ NCHAN. (see below)

A channel width of 0 (meaning instantaneous recorded voltage) is not valid in this version.

Times may need to have PULSE subtracted from them if the contractor measures times from the start of the pulse (e.g. GeoTEM, MegaTEM).

Some systems include on-time channel data (e.g. MegaTEM). These channels should not be included when defining the channels for processing.

<table>
<thead>
<tr>
<th>14+ NCHAN</th>
<th>ITMAX, PERT, TOL, IPRINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITMAX</td>
<td>is the maximum number of iterations allowed for determination of apparent conductivity for one time window. Usually 10.</td>
</tr>
<tr>
<td>PERT</td>
<td>is the maximum fractional change in the conductivity at each iteration. Usually 0.5.</td>
</tr>
<tr>
<td>TOL</td>
<td>controls the convergence condition for cases when the data are not consistent with a homogeneous half-space response; iterations cease if the ratio of perturbation to current conductivity value is less than TOL. Usually 0.01.</td>
</tr>
<tr>
<td>IPRINT</td>
<td>controls the written output. If IPRINT = 0, the written output is minimal. Recommended setting is 0. If IPRINT = 1, voluminous details of the run are written to &quot;*.OUT&quot; file.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15+ NCHAN</th>
<th>IINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>IINT</td>
<td>governs the time sampling interval, DELTA, used for convolution in the half-sine waveform cases (ISTEP=0). DELTA is defined as PULSE/IINT, in microseconds. DELTA need not correspond to the acquisition time sampling interval. A typical value for IINT is 30.</td>
</tr>
<tr>
<td>IINT</td>
<td>is a dummy parameter for step-current systems (ISTEP = 1, -1).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>16+ NCHAN</th>
<th>SIG1, SIG1MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIG1</td>
<td>is the initial conductivity estimate (S/m) for the first channel at the first station. For other stations, the starting conductivity for the first channel at a station = the apparent conductivity solution for the first channel at the previous station. The starting conductivity for the second and successive channels = the apparent conductivity solution for the previous channel. However, the starting value at a new station is not allowed to exceed SIG1MAX. If ISHARP = 2, SIG1 is the surface conductivity (see record 17+ below).</td>
</tr>
<tr>
<td>SIG1MAX</td>
<td>(S/m) is the maximum permitted starting conductivity at any station. This provides a degree of immunity against non-uniqueness: low signals can be due to extremely high conductivity as well as to low conductivity. If all apparent conductivities appear to be unrealistically high then try a re-run with a much smaller SIG1MAX. Conversely, if all apparent conductivities appear to be too low, re-run with a much larger SIG1MAX.</td>
</tr>
<tr>
<td>SIG1MAX</td>
<td>If ISHARP = 2, SIG1MAX is the maximum conductivity (see record 18+ below). Normally set SIG1MAX = SIG1.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>17+ NCHAN</th>
<th>PCERR0, SDMIN0, IEDIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCERR0</td>
<td>is the percentage error assumed for each recorded decay value. The error is regarded as the standard deviation of a Normal random variable. Convergence is presumed when the normalised squared misfit between the calculated and observed data value for a delay window is less than or equal to unity, this being the expected value for the corresponding chi-squared random variable.</td>
</tr>
</tbody>
</table>
SDMIN0 is the minimum allowable standard deviation (TEM data units). Express as ppm or dimensional units according to the value of IDAT. Percentage error can become unreasonably small at late times, as the signals decay. SDMIN is an absolute error, which can be regarded as the noise floor. Also see Section 7.1 for more comments.

IEDIT controls editing of depth reversals in the output data. If the Rx decay signal is not monotonically decreasing with time then it will cause depths to reverse and get shallower, instead of deeper, with later delay times. Typically these reversals occur at late times when noise becomes significant, so the default is to reject remaining data in the decay once a reversal is detected. However there can occasionally be a reversal at very early times resulting in most or all of the decay being rejected. The cause of such an early time reversal may be a dubious instrumentation signal, or it may be due to an otherwise unknown cause. In this situation you will likely want to disable the depth reversal editing in order to prevent the removal of the intermediate and later channels’ data.

- IEDIT = 0 for no removal
- IEDIT = 1 for depth reversals removal (default)

PCERR0 and SDMIN0 are used as default values when individual channel PCERR and SDMIN are not defined at record 14 above.

<table>
<thead>
<tr>
<th>18+</th>
<th>NCHAN</th>
<th>ISHARP, ITSHEET, OutputFmt</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISHARP = 0 : no “sharpening” is applied.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISHARP = 1 : the original apparent conductivities are treated like conductances, and are differentiated to produce a final “sharpened” apparent conductivity versus depth profile.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISHARP = 2 : the original apparent conductivities are treated like inner products of the true conductivity with the linear sensitivity functions of Christensen (2002)*. A simple inversion yields a &quot;C-sharpened&quot; estimate of the true conductivity versus depth. SIG1 and SIG1MAX (see record 16+ above) assume special roles when ISHARP=2; SIG1 is the surface conductivity, and SIG1MAX is the maximum conductivity allowed after sharpening. This is a more aggressive sharpening option than ISHARP=1.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| ITSHEET = 0 : homogeneous halfspace model for conductivity calculation (value of 0 is for normal usage). |
| ITSHEET = 1 : thin sheet model for conductivity calculation (use this value only for Hoistem, if desired). |

OutputFmt is used to control which of multiple possible output formats are created. There are four options, and each option has a numeric flag associated with it; option A, flag = 1 : standard “CDI” format. option B, flag = 2 : Geosoft XYZ format – with Line headers; one output file per flightline. option C, flag = 4 : Geosoft XYZ format – with flightline column but no Line headers. option D, flag = 8 : Geosoft XYZ format – suitable for array channel import to Oasis Montaj. Set OutputFmt equal to the sum of the flags that correspond to the output formats you require. For example to output three files in formats A,C,D set OutputFmt to a value of 1 + 4 + 8 = 13. To output all formats set OutputFmt to 15.

A maximum value of 10 S/m is enforced if sharpening is applied, i.e. if ISHARP = 1 or 2.

### 19+ NCHAN

<table>
<thead>
<tr>
<th>IHC</th>
</tr>
</thead>
</table>
| **IHC** is a switch for height-corrected output data. Adjusted data values are computed at a uniform ground clearance, with the Tx at the notional survey altitude, ALT0. Height-corrected data are written to a separate output file.  
IHC = 0: no height-corrected data output.  
IHC = 1: yes, height-corrected data output.  
IHC = -1: yes, height-corrected data output: written in Hoistem binary BDB format. |

*Output data units are always those defined by IDAT. Where a value of ConversionFactor (see parameter record 8) was used to convert the units during data import, the original input data units will be different to the output data units.*

The height correction is intended to suppress the effect of altitude variation as a preparatory step for generation of "time channel maps", i.e. it is purely intended to improve the interpretability of "raw" data display. *EmaxAIR accounts for the survey height variation explicitly when computing the apparent conductivity, whether or not the height-correction option is turned on.*

### 20+ NCHAN

<table>
<thead>
<tr>
<th>RON, ROFF</th>
</tr>
</thead>
</table>
| **RON** = turn-on ramp time (microseconds).  
**ROFF** = turn-off ramp time (microseconds).  
These parameters are only relevant for systems using a bipolar square or a triangular waveform; they are treated as dummy parameters for other systems. For Aerotem, RON = ROFF is half the duration of the triangular pulse. |

### anywhere after the “RON ROFF” record

<table>
<thead>
<tr>
<th>#WAVEFORM# &lt;filename&gt;</th>
</tr>
</thead>
</table>
| **<filename>** is the name of a file containing the points on an arbitrarily defined waveform.  
**THIS RECORD IS OPTIONAL.**  
*If it is present then the standard waveform defined above by ISTEP, RON, ROFF will be ignored and the arbitrary waveform used instead.*  
The file should contain two columns separated by spaces or a comma; Time (seconds) and Current (normalised to a maximum value of 1).  
For example |

```
0.000000 0  
0.000500 0.4  
0.000900 0.38  
0.001350 0.69  
0.001700 0.66  
0.002150 0.83  
0.002550 0.80  
0.003000 0.88  
0.003350 0.85  
0.003850 0.92  
0.004200 0.89  
0.004700 0.96  
0.005000 0.93  
0.005500 1.00  
0.005900 0.96  
0.006050 0.99  
0.007349 0  
```

A Maxwell ".mcg" configuration file can also be specified (although EMIT discourage this as they do not guarantee that the .mcg file format will remain unchanged). If specified then EmaxAIR will attempt to extract an arbitrary waveform from the data in the .mcg file.
anywhere after the “RON ROFF” record

#ROTATE# DEC, XREF, YREF, IADD_LOC

Rotate input coordinates from survey grid to local grid prior to processing and output.

**THIS RECORD IS OPTIONAL.**

- **DEC** = flight line bearing (declination) clockwise from survey grid north.
- **XREF** = survey grid reference point Easting about which to rotate.
- **YREF** = survey grid reference point Northing about which to rotate.
- **IADD_LOC** = add XREF,YREF back onto local coordinates after rotation. 0 = no, 1 = yes

| Table 1 – Parameters used in .PAR file for stand-alone processing. |
4.2 Data Units

EmaxAIR expects sensor data to be supplied in specific data units. These are generally the data units native to the airborne system used. In most cases the required ConversionFactor is 1, however in some situations the ConversionFactor is not 1 for native data units as shown in the table below.

If your data units are not as shown in the table below then you should vary the ConversionFactor accordingly. (refer to record 8 in table in Section 4.1 for explanation of ConversionFactor).

The Table 2 and Table 3 show expected data units for dB/dt and B-field systems respectively, as well as the parameter settings that are generally needed.

<table>
<thead>
<tr>
<th>dB/dt system</th>
<th>supplied data units</th>
<th>IDAT</th>
<th>ConversionFactor</th>
<th>ISTEP</th>
<th>Tx Moment (Am²)</th>
<th>RxArea (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerotem</td>
<td>nT/s</td>
<td>-1</td>
<td>0.001</td>
<td>-3</td>
<td>actual</td>
<td>1</td>
</tr>
<tr>
<td>Geotem</td>
<td>nT/s</td>
<td>-1</td>
<td>1</td>
<td>0</td>
<td>actual</td>
<td>1</td>
</tr>
<tr>
<td>Geotem</td>
<td>pV/m²</td>
<td>-1</td>
<td>0.001</td>
<td>0</td>
<td>actual</td>
<td>1</td>
</tr>
<tr>
<td>Geotem</td>
<td>ppm</td>
<td>+1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Helitem</td>
<td>nT/s</td>
<td>-1</td>
<td>1</td>
<td>0</td>
<td>actual</td>
<td>1</td>
</tr>
<tr>
<td>Hoistem</td>
<td>μV</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>actual</td>
<td>actual</td>
</tr>
<tr>
<td>Questem</td>
<td>nT/s</td>
<td>-1</td>
<td>1</td>
<td>0</td>
<td>actual</td>
<td>1</td>
</tr>
<tr>
<td>Questem</td>
<td>ppm</td>
<td>+1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Reptem</td>
<td>μV</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>actual</td>
<td>actual</td>
</tr>
<tr>
<td>SkyTEM Lo Mom</td>
<td>μV</td>
<td>-1</td>
<td>1</td>
<td>-4</td>
<td>actual</td>
<td>actual</td>
</tr>
<tr>
<td>SkyTEM Hi mom</td>
<td>μV</td>
<td>-1</td>
<td>1</td>
<td>-4</td>
<td>actual</td>
<td>actual</td>
</tr>
<tr>
<td>SkyTEM Lo mom</td>
<td>pV/(A.m³)</td>
<td>-1</td>
<td>0.000 001</td>
<td>-4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SkyTEM Hi mom</td>
<td>pV/(A.m³)</td>
<td>-1</td>
<td>0.000 001</td>
<td>-4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VTEM</td>
<td>pV/(A.m³)</td>
<td>-1</td>
<td>0.000 001</td>
<td>-5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>XTEM</td>
<td>μV</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>actual</td>
<td>actual</td>
</tr>
<tr>
<td>Slingram systems</td>
<td>μV</td>
<td>-1</td>
<td>1</td>
<td>-6</td>
<td>actual</td>
<td>actual</td>
</tr>
</tbody>
</table>

Table 2 – Data units for dB/dt systems.

<table>
<thead>
<tr>
<th>B-field system</th>
<th>supplied data units</th>
<th>IDAT</th>
<th>ConversionFactor</th>
<th>ISTEP</th>
<th>Tx Moment (Am²)</th>
<th>RxArea (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geotem</td>
<td>pT</td>
<td>-2</td>
<td>1</td>
<td>0</td>
<td>actual</td>
<td>1</td>
</tr>
<tr>
<td>Helitem</td>
<td>pT</td>
<td>-2</td>
<td>1</td>
<td>0</td>
<td>actual</td>
<td>1</td>
</tr>
<tr>
<td>Spectrem</td>
<td>ppm</td>
<td>+2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Tempest</td>
<td>fT/(A.m²)</td>
<td>-2</td>
<td>0.001</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VTEM</td>
<td>pV.ms/(A.m⁴)</td>
<td>-2</td>
<td>0.001</td>
<td>-5</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3 - Data units for B-field systems.
4.3 Normalisation

Knowing the normalisation convention used is critical when transforming ppm data;

- Is the "primary" used for normalisation of the B-field or dB/dt?
- Is the primary field amplitude proportional to maximum Tx current or to current range [max-min]?
- Are the data normalised by total field or by one of the components?
- If by a component, which one?

Unfortunately, a plain English definition of the normalisation convention is not usually included in the header file. EmaxAIR will often invert quite happily, even if the assumed normalisation does not tally with actuality.

4.4 Rate-controlling factors

Speed can be increased in the following ways:

- Set the expected error, controlled by PCERR and SDMIN, high; the acceptable data fit will be relaxed accordingly.
- Increase NSKIP, to skip over more stations.
- Invert the x- or z-component, not total field.
- Reduce ITMAX, the maximum number of iterations. This may mean a more sparsely populated CDI section (i.e. fewer apparent conductivities).
- Set IPRINT to zero, to suppress non-essential output.
- For Geotem, MegaTEM, and Questem, increase the time sampling interval by reducing IINT, the number of time intervals spanning the transmitter pulse.
- Increase TOL.

4.5 Maximum conductivity

A maximum value of 10 S/m is imposed if sharpening is applied, i.e. if ISHARP = 1.

4.6 Input data format

The input data file needs to be in free-format. This means that each column of data must be separated from the next column of data either by at least one blank space, or by a comma. There must be the same number of values on every data record; asterisks are used to indicate missing or dummy channel data values.

Geosoft XYZ format files with embedded "Line" headers are allowed. If a data column containing the flight line number is also present then specify that column number using the parameter iLINE (see record 5 in table in Section 4.1), but if a flight line data column does not exist set iLINE to 1. Note that if the file contains both Line headers and a flight line data column, the Line headers take precedence.

Header records are permitted at the start of the data file (before any data records). The first character on a header record must be a forward (/) or back (\) slash.

Data is assumed to be in order of increasing flightline number.

Two examples of input data files are shown in Figure 19 and Figure 20.
4.7 Note concerning the VTEM waveform

Since about 2013 Geotech have been deconvolving their VTEM data. This means that the effective waveform is some "ideal" construct, not the real waveform actually transmitted. The delay times are also different to what they had been previously. The effective waveform and times should all be documented in the relevant survey report. Take care that you use the correct waveform for the data being processed.
4.8 Running

From a Command Window run the EmaxAir executable (Figure 21).

![Figure 21 – EmaxAir run as stand-alone.](image)

Give the name of your parameter file. A default name is shown in square brackets and can be accepted by just hitting the enter key. Alternatively you can enter the parameter filename on the command line, eg:

```
D:\data> emaxair example.par
```

The program begins without further user input: the name of the data file is read from the parameter file, and this name is used to automatically generate the output filenames.

4.9 The output files

The output from EmaxAir stand-alone is in multiple formats, and is selectable by the user.

If for some reason EmaxAIR does not compute a valid apparent conductivity then the values output (running stand-alone) are; depth = 999.25 and conductivity = 999.25. Output data with this depth should be treated as dummies.

Note that these stand-alone output files write DEPTH as NEGATIVE DOWN.

Option A

The “CDI” output file contains all conductivity-depth results written to a single file in the same manner as earlier versions of EmaxAir. An example is shown in Figure 22.

LINE : is the flightline number
X : is the easting.
Y : is the northing.
DIST : is the distance from the start of the flightline.
DEPTH : is the depth below surface, -ve down.
CONDUCT : is the conductivity in mS/m.
RL : is the depth relative to the RL datum (eg. sea level), -ve down.
TIME : is the channel delay time in microseconds of the processed point.
ALT : is the Tx altitude above the ground surface.
TXRL : is the Tx height relative to the RL datum (eg. sea level), -ve down.

<table>
<thead>
<tr>
<th>LINE</th>
<th>X</th>
<th>Y</th>
<th>DIST</th>
<th>DEPTH</th>
<th>Conduct</th>
<th>RL</th>
<th>TIME</th>
<th>ALT</th>
<th>TXRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1001</td>
<td>258728.00</td>
<td>3643201.40</td>
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<td>-16.05</td>
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<td>64.94</td>
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<td>258728.00</td>
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<td>-46.29</td>
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<td>-16.91</td>
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<td>55.00</td>
<td>64.94</td>
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<td>1001</td>
<td>258728.00</td>
<td>3643201.40</td>
<td>0.00</td>
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<td>600.49</td>
<td>-20.98</td>
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<td>64.94</td>
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<tr>
<td>1001</td>
<td>258728.00</td>
<td>3643201.40</td>
<td>0.00</td>
<td>-35.20</td>
<td>479.10</td>
<td>-25.26</td>
<td>195300</td>
<td>55.00</td>
<td>64.94</td>
</tr>
</tbody>
</table>

Figure 22 – EmaxAir stand-alone CDI output file; format option A

Option B

There is one XYZ file written for each flightline in the data. The format is consistent with Geosoft “Line XYZ” so that the data can quickly be gridded using spline gridding and viewed using Geosoft software. The Line Header records have a line number that is a composite of the actual flightline number and the station being processed, so for example “Line 10000_00002” corresponds to flightline 10000 station 2.

An example of this format is shown in Figure 23.

X : is the distance from the start of the flightline.
Y : is the depth below surface, -ve down.
Conduct _mS_per_m : is the conductivity in mS/m.
RL : is the depth relative to the RL datum (eg. sea level), -ve down.
East : is the easting.
North : is the northing.
Time_usec : is the channel delay time in microseconds of the processed point.
TxAlt : is the Tx altitude above the ground surface.
TxRL : is the Tx height relative to the RL datum (eg. sea level), -ve down.

Option C

This is a variant of option B, and is essentially identical except that:
- an additional column containing the flightline number has been added.
- the Line Header records are commented out.
- all flightlines are written to a single file.

An example of this format is shown in Figure 23.

The columns are identical to Option B, but with the addition of a “Line” column in the first position.

Option D

This option is intended for users who want output as Geosoft “array channel” format.
All flightlines are written to a single file.
An example of this format is shown in Figure 23.
Line : is the flightline number
Distance : is the distance from the start of the flightline.
X : is the easting.
Y : is the northing.
TxAlt : is the Tx altitude above the ground surface.
TxRL : is the Tx height relative to the RL datum (eg. sea level), -ve down.
then followed by grouped columns;
Depth1, Depth2, ... : depth below surface, -ve down, for successive channels.
Cond1, Cond2, ... : conductivity (mS/m) for successive channels.
Time1, Time2, ... : delay time for successive channels.
RL1, RL2, ... : depth relative to the RL datum (eg. sea level), -ve down, for successive channels.

Comments on the output files

Coordinates East, North (X,Y columns in Options A & D) will differ from the input coordinates if POSLAG is set to +1 or -1.

Distance is the along-line distance. Distance is measured from the first station recorded in the input file for each flightline. For this reason it is recommended that the input file is pre-sorted on flightline and active coordinate (E or N) so that the distance is always measured from same end of all flightlines. If the input file is in the original order as supplied by the contractor (typically sorted on flightline and fiducial, the order in which the aircraft flew the survey) then the Distance will typically be measured from alternating ends of flightlines.

RL is the inferred elevation of the conductivity: RL = TXRL – ALT + DEPTH
Note that values for DEPTH (below surface) used in this formula are negative downwards.

RL is output as zero if the transmitter elevation (TXRL) is not included in the data file.

Output file names are derived from the rootname of the parameter file.
For example if the parameter file specifies is MySurvey.PAR then the output files will be named;

MySurvey.OUT general program output.
MySurvey.CDI output data, format option A : results for the whole survey.
MySurvey_1010.XYZ output data, format option B : results for flightline 1010 only.
MySurvey_1020.XYZ output data, format option B : results for flightline 1020 only.
…etc… for all flightlines.
MySurvey_line_channel.DAT output data, format option C : results for the whole survey.
MySurvey_array.DAT output data, format option D : results for the whole survey.
Figure 23 – EmaxAir stand-alone XYZ output files; format options B, C, D.
5. Sample Data

5.1 Sample Data – one example

Some sample data for various airborne systems is provided for checking and testing EmaxAir operation and output results. See subdirectories under:

(32-bit operating systems) C:\Program Files\Fullagar\EmaxAIR\
(64-bit operating systems) C:\Program Files (x86)\Fullagar\EmaxAIR\

Since EmaxAIR v3 parameter files have been slightly different to those used previously in v2, however the newer versions of EmaxAIR are backward compatible with these older v2 format *.par files.

For illustration these are the Tempest sample files generated using the v3 *.par file; The CDI section is shown in Figure 24.

<table>
<thead>
<tr>
<th>file name</th>
<th>file name</th>
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</thead>
<tbody>
<tr>
<td>EmaxAir input data file</td>
<td>samp_tempest.dat</td>
</tr>
<tr>
<td>EmaxAir input parameter file</td>
<td>samp_v3_tempest.par</td>
</tr>
<tr>
<td>EmaxAir output CDI data file, format option A</td>
<td>samp_v3_tempest.CDI</td>
</tr>
<tr>
<td>EmaxAir output containing general program run information</td>
<td>samp_v3_tempest.OUT</td>
</tr>
<tr>
<td>EmaxAir output XYZ data file, format option B, flightline 10022</td>
<td>samp_v3_tempest_10022.xyz</td>
</tr>
<tr>
<td>EmaxAir output XYZ data file, format option C</td>
<td>samp_v3_tempest_line_channel.DAT</td>
</tr>
<tr>
<td>EmaxAir output XYZ data file, format option D</td>
<td>samp_v3_tempest_array.DAT</td>
</tr>
<tr>
<td>plotted output for flightline 10022 (with sharpening - see Figure 24)</td>
<td>samp_v3_tempest_10022_plot.png</td>
</tr>
</tbody>
</table>

![Figure 24 – Conductivity-depth section for flightline 10022.](image)

If you want to do some test runs using the sample data, to avoid write permission problems do not try and run it in the Program Files directory. Instead copy it to a temporary folder on your data drive first and run your tests from there.
5.2 Using the “sharp” option

The effect of applying the sharpening option is illustrated in Figure 25. This example is from ground-based coincident loop data, but the effect of applying sharpening to airborne data will be similar. The colour stretch is the same in both sharpened and unsharpened images.

The sharpened data (bottom image) illustrates the effect of this option wherein the gently-west-dipping conductive feature has been better defined. Sharpening can often define conductors more tightly, especially their upper boundaries (as seen particularly in the left of Figure 25).

Sharpening also has the tendency to enhance noise where present, typically at late times where signal is poor. A small example of this effect can be seen below at 2325E and a depth of 400m. Users should be aware of these kinds of artefacts which may be produced by the sharpening process.

Figure 25 – Normal (top) and sharp (bottom) data.
6. Support

For support please contact:

<table>
<thead>
<tr>
<th>technical and installation queries:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phil Muir</td>
</tr>
<tr>
<td>(Hobart, Tasmania)</td>
</tr>
<tr>
<td>Southern Mineral Exploration Geophysics</td>
</tr>
<tr>
<td><a href="mailto:phil.muir@bigpond.com">phil.muir@bigpond.com</a></td>
</tr>
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</table>

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<tr>
<th>licensing queries:</th>
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<tbody>
<tr>
<td>Peter Fullagar</td>
</tr>
<tr>
<td>(Vancouver, Canada)</td>
</tr>
<tr>
<td>Fullagar Geophysics Pty Ltd</td>
</tr>
<tr>
<td><a href="mailto:fullagargeophysics@yahoo.com">fullagargeophysics@yahoo.com</a></td>
</tr>
<tr>
<td>Mobile/Cell:</td>
</tr>
<tr>
<td>(778) 847 3428</td>
</tr>
<tr>
<td>intl: +1 778 847 3428</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>physical address for correspondence:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fullagar Geophysics Pty Ltd,</td>
</tr>
<tr>
<td>45 Tahune Crescent</td>
</tr>
<tr>
<td>Blackmans Bay</td>
</tr>
<tr>
<td>Tasmania 7052</td>
</tr>
<tr>
<td>Australia</td>
</tr>
</tbody>
</table>
7. Appendices

7.1 Choosing SDMIN0

SDMIN0 provides a floor on the standard deviation; it only starts to have an effect if it's larger than the standard deviation computed using PCERR. Therefore a change in SDMIN0 with PCERR fixed will only affect later channels.

Your choice of SDMIN0 should be guided by what you think is the noise level in the data. It is expressed in the same units as the data read from the input file.

Choosing a value that is too high may result in EmaxAIR settling on conductivity-depth solutions that are not as good as they could be. This is the situation shown in the example on the left of Figure 26 where some decays show sharp changes in depth compared to adjacent decays. Here the conductivity-depth solutions are perfectly valid according to the SDMIN0 value specified. In addition the depth extent of the section is significantly reduced because otherwise healthy data is rejected by the high SDMIN0 value.

Choosing a value that is too low allows genuinely noisy data to be processed and results in a much greater depth extent of the section, as shown on the right of Figure 26.

The optimum SDMIN0 value for the sample data shown in Figure 26 is somewhere between the two examples plotted; a value of 0.001 removes the sharp changes in depth evident in the left section, but prevents the excess of noisy data beginning to appear at the deeper parts of the right section.

Figure 26 – Choosing a value for SDMIN0.
7.2 Reciprocity

For some systems it is possible to use the principle of “reciprocity” and interchange the Tx and Rx in order to process data. In this situation the Tx is treated as if it were the Rx, and vice versa.

This approach was needed, for example, with HeliTEM data when using EmaxAIR v5.10b or earlier, or when using Maxwell v5.16.71.25319 or earlier. In a HeliTEM survey the Rx is ahead of and above the Tx, therefore the sign convention used by EmaxAIR (Figure 2) requires the vertical separation parameter X0 to be negative. These older versions of software did not handle negative X0 values with EmaxAIR processing.

Figure 27 shows the general parameters required to define the Tx and Rx positions and separations for (left) the normal case with Tx and Rx in their actual position, and (right) when reciprocity is used to interchange the Tx and Rx definitions during processing.

The X0 and DEL0 parameters are defined as positive when the Rx is behind and below the Tx.

![Diagram showing normal and reciprocity cases for HeliTEM parameters](image)

The sign convention used above is for the EmaxAIR parameter file.

*When entering Tx-Rx separations in Maxwell, the vertical sign convention is opposite to that used above.*

When using Maxwell the vertical separation value you would use for the above two illustrations are:
- NORMAL: vertical separation +26.7
- RECIPROCITY: vertical separation -26.7

![Figure 27 - Reciprocity of Tx and Rx.](image)
7.3 Using for the correct Height for TEMPEST surveys

These comments can apply in a general sense to any system, but they apply in particular to the TEMPEST system and its final data. TEMPEST surveys usually include “HPRG corrected” e/m data which has been corrected for variations in Height, Pitch and Roll of the transmitter/receiver Geometry [corrections based on Green’s (1998) apparent dipole depth method].

EmaxAIR uses altitude in the conductivity calculations. Normally the altitude for each station is read from a column in the input data file. However HPRG data has typically been corrected to a constant 120m altitude and therefore the altitudes contained in the input data file column do not apply (those altitudes only apply to non-HPRG data). Incorrect CDI data will be generated if the incorrect height is used by EmaxAIR, and this will cause errors that are particularly noticeable in shallower parts of the CDI sections.

For HPRG data processing prior to EmaxAIR v5.39 the user needed to create an extra column in the input data file containing the HPRG constant altitude. The parameter “ALT0_flag” has been introduced so that the extra altitude column is no longer required; instead if ALT0_flag = 1 then EmaxAIR will use the nominal survey altitude set in parameter ALT0 as the constant altitude for processing the whole survey.

Figure 28 shows HPRG data processed with the incorrect altitude (ALT0_flag = 0; using actual altitudes read from the data file) illustrating some shallow and abnormally high erroneous conductivities. Figure 29 shows the same data processed with the correct altitude (ALT0_flag = 1; using constant altitude defined by parameter ALT0).

![Figure 28](image1)
Figure 28 – TEMPEST example, HPRG data processed with variable (measured) altitude.

![Figure 29](image2)
Figure 29 - TEMPEST example, processed with constant (ALT0) altitude.
