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A Geophysicist's Guide to the Fairfield Nodes

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ABSTRACT

This report details how to successfully use the Fairfield Nodal ZLand seismic instruments to collect data, including preparation steps prior to deploying the instruments, how to record data during a field campaign, and how to retrieve recorded data from the instruments after their deployment. This guide will walk through each step for the novice user, as well as provide a checklist of critical steps for the advanced user to ensure successful, efficient field campaigns and seismic data collection. Currently, use of the seismic nodal instruments is highly limited due to the detailed nature and prior knowledge required to successfully set up, use, and retrieve data from these instruments. With this guide, all interested users will have the knowledge required to perform a seismic deployment and collect data with the Fairfield Nodal instruments.

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ACRONYMS AND DEFINITIONS

Abbreviation	Definition
FCNT	Custom file format of raw seismic data for Fairfield Industries
FDSN	Federation of Digital Seismograph Networks
HHT	Handheld Trimble
MSEED	Miniseed – subset of SEED file format containing time-series of seismic data (not metadata)
Node	Fairfield Seismic Nodal Instrument
PI	Principal Investigator
SEED	Standard Exchange of Earthquake Data
StationXML	XML representation of metadata information associated with miniseed formatted files of seismic data
XML	Extensible Markup Language

1. INTRODUCTION, APPLICATIONS, AND BENEFITS OF FAIRFIELD NODE DEPLOYMENTS

A Fairfield ZLand node is a sealed, independent field acquisition unit with all elements contained internally, including the battery, sensor, electronics, timing circuitry and memory necessary for fully autonomous operation, including to sense, acquire, digitize, filter and store seismic data for up to approximately 30 days, depending on temperature and sampling rate. These nodes are commonly used in exploration industry applications and have also been adopted by academic communities for continuous recording of seismic data. While scientific communities each have methods and information on setting up, deploying, and extracting data from these instruments, this report aims to provide a common set of instructions and best practices to create a deployment plan, deploy instruments in the field, and download data from the nodes for the Fairfield Generation 2 ZLand Nodes and Fairfield Software Version 2.1.0.2.

This report also covers how to convert data from the Fairfield file format to miniSEED and StationXML formatted files, accepted file formats for the seismological community at large. The Federation of Digital Seismograph Networks (FDSN) maintains SEED, the Standard Exchange of Earthquake Data, formatted files that contain both seismological time-series and metadata information. In this report, we review how to convert data from the Fairfield file format to the miniSEED file format, a subset of the SEED standard containing only the time-series data. We also review how to store seismological metadata from a nodal deployment in the FDSN's StationXML format and provide examples on how to remove the node's instrument response, provided from the Nominal Response Library, to transform the raw data to scientific units (e.g., velocity in m/s).

Over the last decade, the compact and portable nature of these sensors have enabled an increase in deployments to collect seismic data in rapid response to on-going seismic events (e.g., Catchings et al., 2019; Farrell et al., 2018; Wu et al., 2020), as well as recording in remote, difficult to access locations (e.g., Chaput et al., 2022; Veitch et al., 2021; Ward & Lin, 2017; Ward et al., 2020; Wu et al., 2017). This report aims to further increase the utility of these instruments to obtain seismic data including with large-N deployments (e.g., Farrell et al., 2018; Ward et al., 2020).

2. PREPARATION FOR DEPLOYMENT

In this section I describe the steps required to set up the nodes and other necessary equipment prior to going into the field. This includes a quick overview of materials that should be provided before going into the field, general equipment preparation, planning the deployment station locations, and setting up the Fairfield software for the HHT (Handheld Terminal).

2.1. Required Notes for all New Field Campaigns

For each new field campaign, fill out and provide the project PI and field crew with: the 'Before going into the field' section below, the 'Deployment Schematic' (see Sect 3.1), 'In The Field material' (see Sect 3.2), and 'Ongoing Succinct Field Notes' (see Sect 3.2) in either printed or digital form. Appendix A contains a condensed copy of all required information for the PI.

Before going into the field

1. Dates & Equipment Used: _________________

2. Principal Investigator: __________________

3. HHT(s) used from inventory :

4. Directory on computer running Fairfield software with rec.txt and Fairfield-generated files: ____

5. Job Name within Fairfield software: ___________________

6. Fairfield Software settings for this job:
   a. UTM Zone: _______
   b. Sampling Rate: _________
   c. Other settings. *Unless requested differently, settings will be set to:*
      Pre-amp gain: 18dB　　Nyquist filter: Linear phase
      Low-cut filter: none　　DC offset removal: yes

7. Suggested magnetic declination for this area (from NOAA): ________
8. Required materials for the field:
   a. Field Notebook
   b. Compass (1 per team)
   c. Level (1 per team minimum)
   d. Shovel or Post-Hole Digger (if burying nodes)
   e. Connector for the Handheld Trimble to Node Connector
   f. Handheld Trimble Wall Charger
   g. Handheld Trimble Stylus
   h. Survey flags to mark buried node locations

2.2. Equipment Preparation

Take the following steps:

- Coordinate with the PI for a station list (see Sect 2.3.1).
- Charge the HHT(s) that will be used in the deployment.
- Charge the nodes that will be used in the deployment.
- Work through the Fairfield software setup and fill out the 'Before going into the field' in Sect 2.1
- Organize all auxiliary equipment needed for each team (see Item 8 of the 'Before going into the field' notes in Section 2.1).

The HHT may take several hours to charge if the battery is completely drained, and the deployment plan cannot be loaded to the HHT if it has too low of charge. The light above the screen will be yellow if the HHT is charging and will turn green when fully charged. The HHT needs to be turned on to see the light, but the screen can be shut off by tapping the power button for the HHT to enter standby mode. Note that the HHT charger cable has a 5V – 4A output, and if the light(s) are not glowing while the HHT is powered on and plugged in to charge, including when in standby mode, then the wrong charger is likely plugged into the HHT.

The nodes can also take several hours to charge, and the node rack can only hold a maximum of 16 nodes, so **plan ahead to ensure all nodes are charged**. Specifically, it can take up to 6 hours to charge a full rack of nodes whose batteries are drained and contain data. However, most instruments will not contain data and will likely take a maximum of 3 hours to charge. See Section 2.4 for information on charging the nodes and usage of the Fairfield software to view charging status and troubleshooting.

The auxiliary equipment may need to be ordered online or procured through other means, so ensure that the required equipment is available well in advance. The PI should sign out the equipment that they have taken and the date range of use. After returning the equipment, the PI should also sign the equipment back in with the nodal instrument coordinator. All PIs who misplace or lose equipment will be held liable to replace that equipment from their associated project.

2.3. Deployment Planning

Work with the PI on the line numbers, station numbers, and coordinates for each station. Multiple line numbers may better enable navigating between different locations or groups of stations within the HHT software in the field. Note that, even if the line number changes, it is best practice to not repeat station numbers. For example, if using Line 1 and Line 2, set stations associated with Line 1 to be 101, 102, etc. and stations associated with Line 2 to be 201, 202, etc.

The coordinates for all stations need to be within 100 m of the planned location. The station elevation can be approximated across multiple stations after generally estimating from Google Earth coordinates. If significant elevation change is expected across the deployment, please see Section 2.3.2 for information on extracting elevation for multiple latitude and longitude coordinates.

If the PI is not entirely certain where they will be placing their stations, have the PI determine coordinates at the 4 corners of a box defining the maximum area over the entire field campaign site that they may decide to place stations. This ensures that the full field location area will be uploaded onto the HHT to allow adding non-preplanned stations. However, this should only be used in rare cases as the nodes and nodal software are not currently designed to work this way, so there is a higher chance of data corruption or data loss.

2.3.1. Station Lists

Two sets of station lists will be required, including:

1. List with latitude / longitude coordinates as required for field navigation on mobile devices. An updated version with the final field as-deployed station coordinates and node instrument numbers obtained during the campaign will also be required for correct metadata association following the deployment.

Note: A station list, with name, latitude, and longitude can be imported into Google Earth and then exported as a kml or kmz file to be compatible with Google's MyMaps, Backcountry Navigator, or another in-field site navigation mobile application.

Example Format (note, elevation not necessary, see Sect. 2.3.2 for details on extracting elevation):

Line Station Latitude Longitude ElevMeters
1 101 48.6330 -93.9667 341

Field Deployment Format (note elevation likely not needed):

Line Station Node# Latitude(Deployed) Longitude(Deployed) Elevation(Deployed)
1 101 4567 48.6330 -93.9667 341

2. List with UTM coordinates for the Fairfield Software setup. *Note UTM zone assuming WGS1984 also required, with one UTM Zone per deployment plan or per HHT. If crossing zones, choose the zone that contains most of the coordinates and set up the UTM using that zone, which can be used to obtain coordinates via Python Scripts in Section 6.2.*

Example Format (Elevation IS required; see Sect 2.3.4 for details):

sta UTMEast UTMNorth elev_meters
101 428775.513 5387110.394 341
102 381121.737 5399036.147 329
103 474416.946 5004631.064 263
104 478360.619 5004783.023 273

2.3.2. Determining Elevation from Lat/Lon Station Coordinates

If the deployment area is over a significant change in topography, it may be prudent to have more accurate elevation measurements for the Fairfield software's station list. Note that the GPS location of each station is used for timing purposes, and incorrect station coordinates may result in errors. If the station is approximately in the right location (within 100 meters), the nodal software during a deployment should adjust the stations coordinates to the new location if the HHT GPS is turned on when deploying. In most instances, a single approximated elevation from

Google Earth can be used for all stations. Section 6.1 contains the python code to estimate the elevation from a set of latitude/longitude coordinates and pertinent details.

2.3.3. Converting a Lat/Lon Station List to UTM Coordinates

If only a handful of stations are to be deployed, Google Earth can be used to obtain both latitude/longitude and UTM coordinates. Create the station at the designated location and then use ‘Get Info’ to view the station coordinates. Switch from decimal degrees (latitude/longitude) to UTM via Google Earth Preferences (Mac) or Settings (Windows). This also allows visualization of the UTM zone, which is also shown in map view for the WGS UTM 1984 coordinate system in Figure 2-1. Note that a ‘13N’ zone indicates being north of the equator, while a ‘13S’ zone denotes being south of the equator; Google Earth does not necessarily follow this convention, but the Fairfield software does.

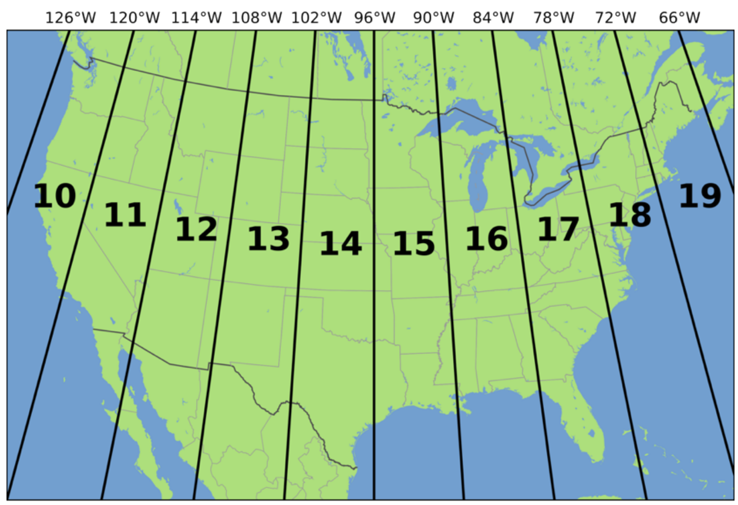


Figure 2-1 UTM Zones across the contiguous United States

To convert from latitude and longitude coordinates to UTM coordinates for many stations, see python code in the Section 6.2 detailing how to determine a UTM zone (or hardcode if already known), and estimate the UTM coordinates (assuming WGS UTM 1984) from an input station file with latitude and longitude. These codes are also available via GitLab under the SetupExtractionNodeData page as part of the SeismoAcousticDeploymentStandards group.

2.3.4. Final Station List for Fairfield Software

Set up a station list with UTM coordinates in meters to be uploaded to the Windows machine containing the Fairfield software. If the PI provided a station list that is in latitude and longitude coordinates, please see Section 6.2 for instructions on converting to UTM.

The final station list should be formatted, with UTM coordinates in meters, as:

Line Station UTMEast UTMNorth ElevMeters
R1 101 524889.0 4567891.0 1412

R1 102 524889.0 4567892.0 1412
R1 103 524889.0 4567894.0 1412

The R in the Line number denotes that this is a receiver stations locations file.

The station list file is space-delimited, but all columns of the station file below the header should be aligned. So, if using a station list with variable station numbers, more spaces may be required as each entire column will be highlighted in the Fairfield software. This can be edited in Notepad on the Windows machine containing the Fairfield software. For example,

```
Line Station UTMEast UTMNorth ElevMeters
R1    11 524889.0 4567891.0 1412
R11  102 524889.0 4567892.0 1412
R21 2001 524889.0 4567894.0 1412
```

You will also need a source shot file. Exact source coordinates are not required, as you can simply use the first line of content in the receiver file but using an S instead of an R for the first character of the Line name to differentiate the content of each file later in the software.

2.4. Software Setup

Generally, for all software setup you will need a receiver text file containing station information in UTM. See previous sections for information on creating this file. You should also take note of the settings within the Fairfield software for each specific field campaign as described in Section 2.1, 'Before going into the field,' items 3-6. This is critical as the setup information is required to obtain the correct instrument response file from the Nominal Response Library (Templeton, 2017) and remove the instrument response from the raw data to convert to physical units (e.g., m/s).

Below includes a detailed overview of the Fairfield Software. If you are already familiar with using the Fairfield software, please see Appendix B for a Quick Guide.

2.4.1. Charging Nodes

Steps:

1. Turn on Windows machine and start the HarvestManagementConsole program. Figure 2-2 shows the initial page of the HarvestManagementConsole program.

2. Turn on the node rack via the large switch; there should be around 210 V displayed if functioning properly. On the Windows machine, open the 'Rack View' in the HarvestManagementConsole program (access via double-clicking *Rack* in *Racks Overview* from the *System Dashboard*).

3. Dock all nodes. There should be an audible click if correctly docked. It will take a few minutes for the rack to detect and work with the nodes. Figure 2-2 also includes what the Rack View should look like with nodes correctly docked across the top row and one on the second row of the rack.

4. View Lights on the node rack (red/green and flashing/not flashing).

5. See the 'Rack View' in the HarvestManagementConsole program for information on node status. Should be charged, data extracted, and show 'RTD' when ready-to-deploy. Note that the RTD status is not required, but nodes should be charged to ≥98% and have all data harvested (or show Data Size: 0) before a new deployment.

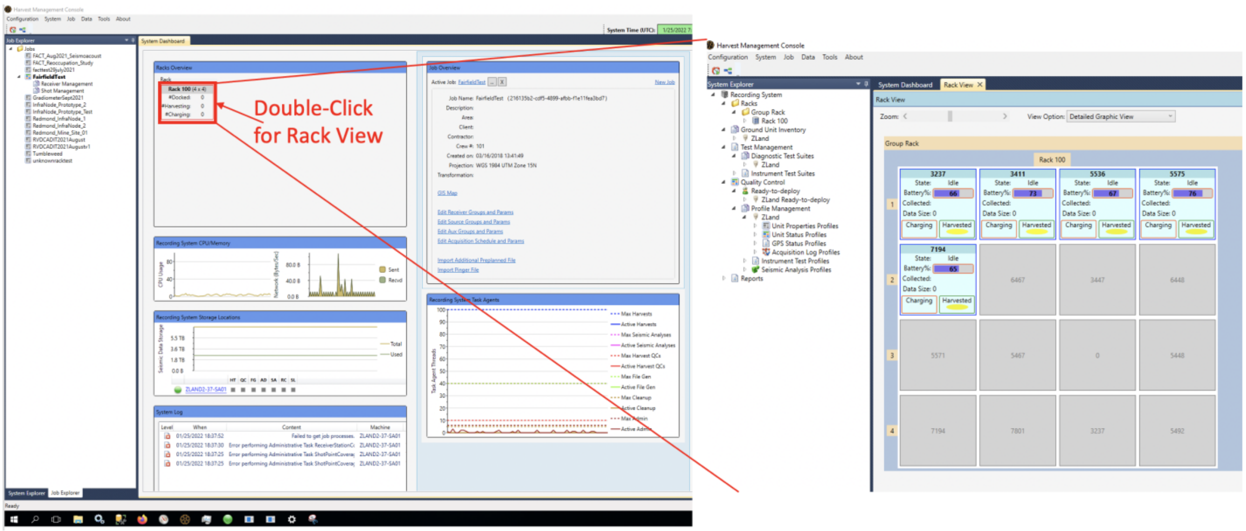


Figure 2-2 (Left) HarvestManagementConsole main screen. **(Right)** Rack View, containing node charging and data harvest status, obtained from double-clicking the 'Rack View' highlighted in red in the left panel.

If there are issues with docking the nodes, see the 4 trouble-shooting steps below:

1. From *Task Manager* [Ctrl Shift Esc] under *Services* make sure all ZLand programs are running, which is easily viewed by sorting by Name to obtain reverse-alphabetical order. If some ZLand programs are not running, right click and start them manually. It is ok if the GPS Time Client ZLand program is not functioning, but all others should be.

2. Disconnect and reconnect the node from the rack. This step may also be required after each of the steps below.

3. Soft reset in *Rack View*: Select a device with an error, right-click, *View Docking Processor*, and the page on the right side of Figure 2-3 will appear. Select 'Soft Reset' option. If the unit is not being detected, also try 'Reboot Docking Processor' from this page. Go back to Rack View (left side of Figure 2-3) to see if the problem is resolved (will take a few minutes).

3. If error persists, right click and select *View Docking Processor* (Fig 2-3), and then select 'Hard Reset.'

4. Lastly, right click the device and select *Bypass Deployment QC.*

5. If you see an error that says, *'RU attachment without USB connection'* then select the device in *Rack View*, select *View Docking Processor* (Fig 2-3) followed by 'Reboot Docking Processor.'

6. If the trouble persists, try attaching this node to another spot on the rack. Also check the pins for this location on the rack are not loose or too pushed into the rack docking port, and that the pin connection points of the node are clear of debris.

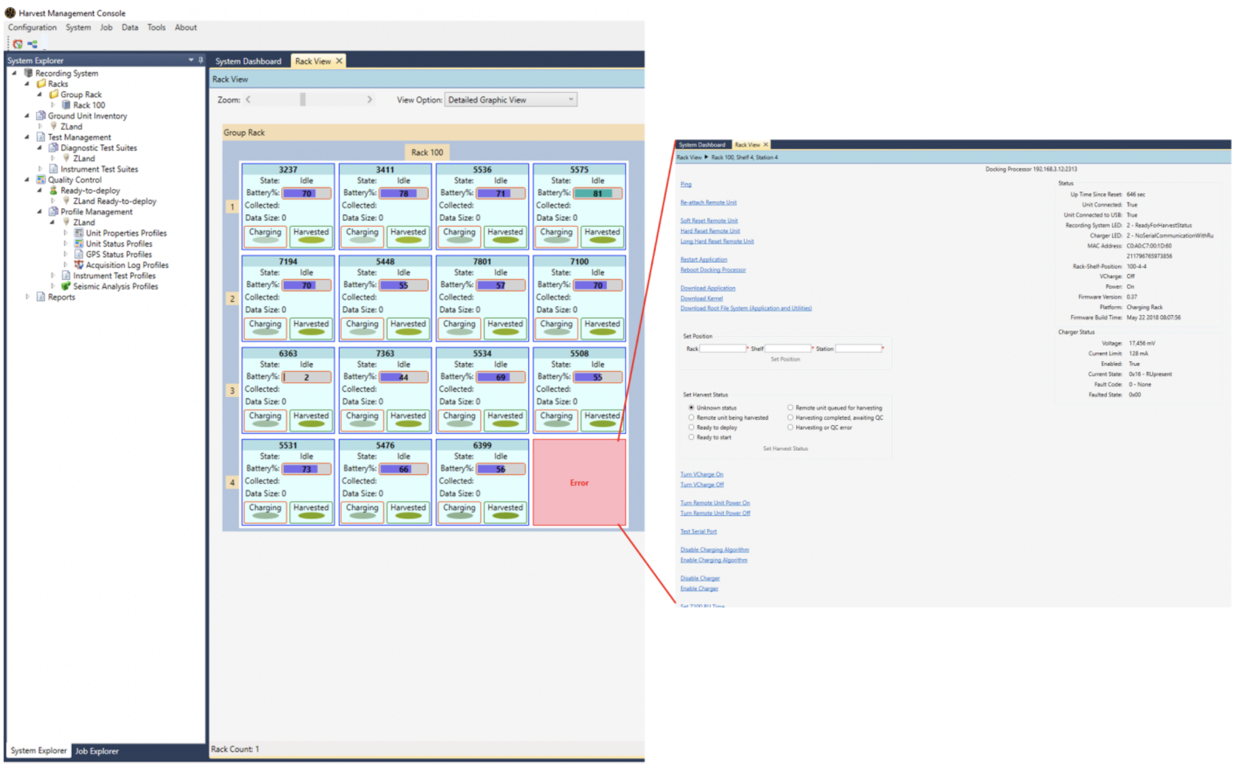


Figure 2-3 (Left) Rack View with an error at a node port station, selecting and right-clicking the station, and then choosing 'View Docking Processor' will pull up the **(Right)** page with a variety of Trouble-shooting options.

2.4.2. Receiver and Shot Files

Make a folder to contain the deployment information on the computer running Fairfield software. This should be located on the Windows machine in *System (C): Jobs > YourJobDirectoryName*. An example path to the *ExDeploy_25Jan2022* job is shown in Figure 2-4.

Note the name of the directory for this job in the 'Before going into the field' notes under Item 4 in Section 2.1.

Place the previously created receiver (and shot / source, if previously created) file (rec.txt) into this directory. The contents of the example *ExDeploy_25Jan2022* job are shown in Figure 2-4. The content of the rec.txt file for this job is shown in Figure 2-7, but feel free to open the rec.txt in the example job directory for reference. Use the Notepad program to ensure the spacing and line separations are consistent with the original station file, as often there is a discrepancy between Windows and Mac/Linux operating systems.

If a source file is not already available, create one (src.txt) in the same directory. Note that the first line from the receiver file can be used to create the source file. See the example job's src.txt file for reference.

Example Receiver file, rec.txt:

Line Station UTMEast UTMNorth ElevMeters
R1 101 524889.0 4567891.0 1412
R1 102 524889.0 4567892.0 1412
R1 103 524889.0 4567894.0 1412

Example Source file (contains only the header and first line of the Receiver file), *src.txt*:

Line Station UTMEast UTMNorth ElevMeters
S1 101 524889.0 4567891.0 1412

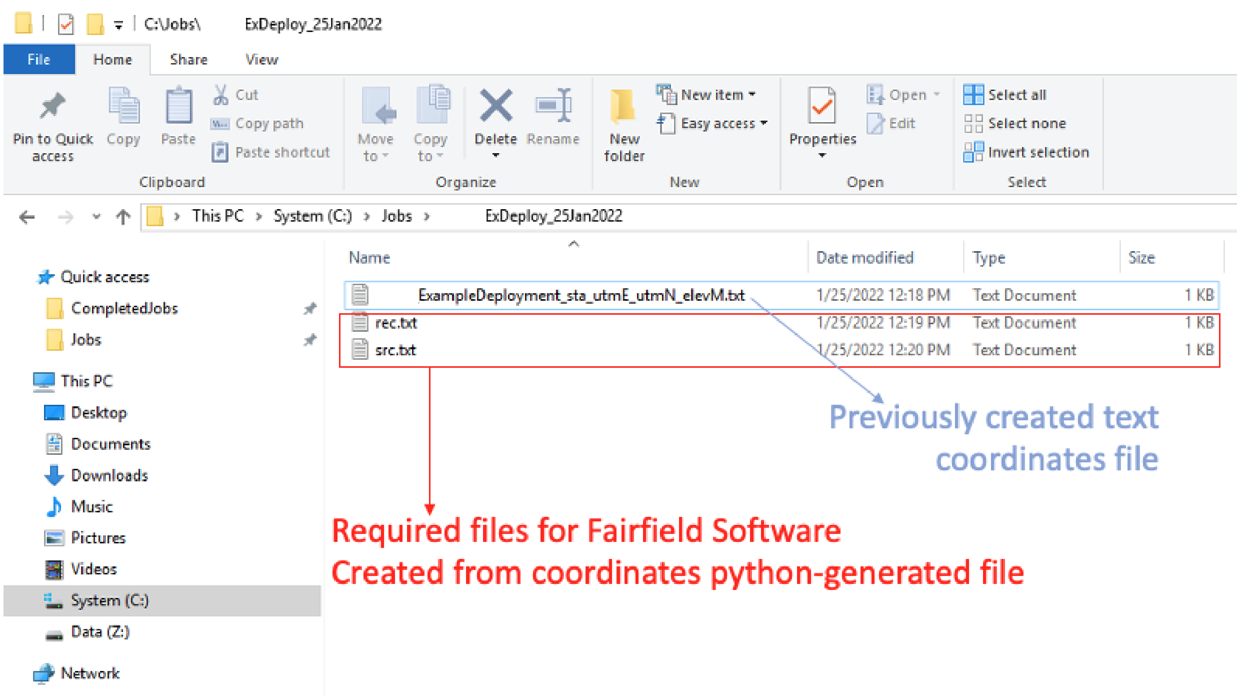


Figure 2-4 Content, including receiver and source text files, in the subdirectory specific for this project under the System(C:) > Jobs folder.

2.4.3. *Creating a Job*

Open HarvestManagementConsole.

From the *System Dashboard,* select 'Job Overview' on the right, close all Active Jobs via the X (see Fig 2-5).

1. Set the Job Folder (should be located within *System (C): Jobs*)

If a folder for this job DOES exist:
Select *New Job* → *Jobs* → Select previously created folder for this job

If folder for job does NOT yet exist:
Select *New Job* → *Jobs* → Create a folder for this job

Make sure the Directory of the job is listed in the 'Before going into the field' notes (see Section 2.1) under Item 4.

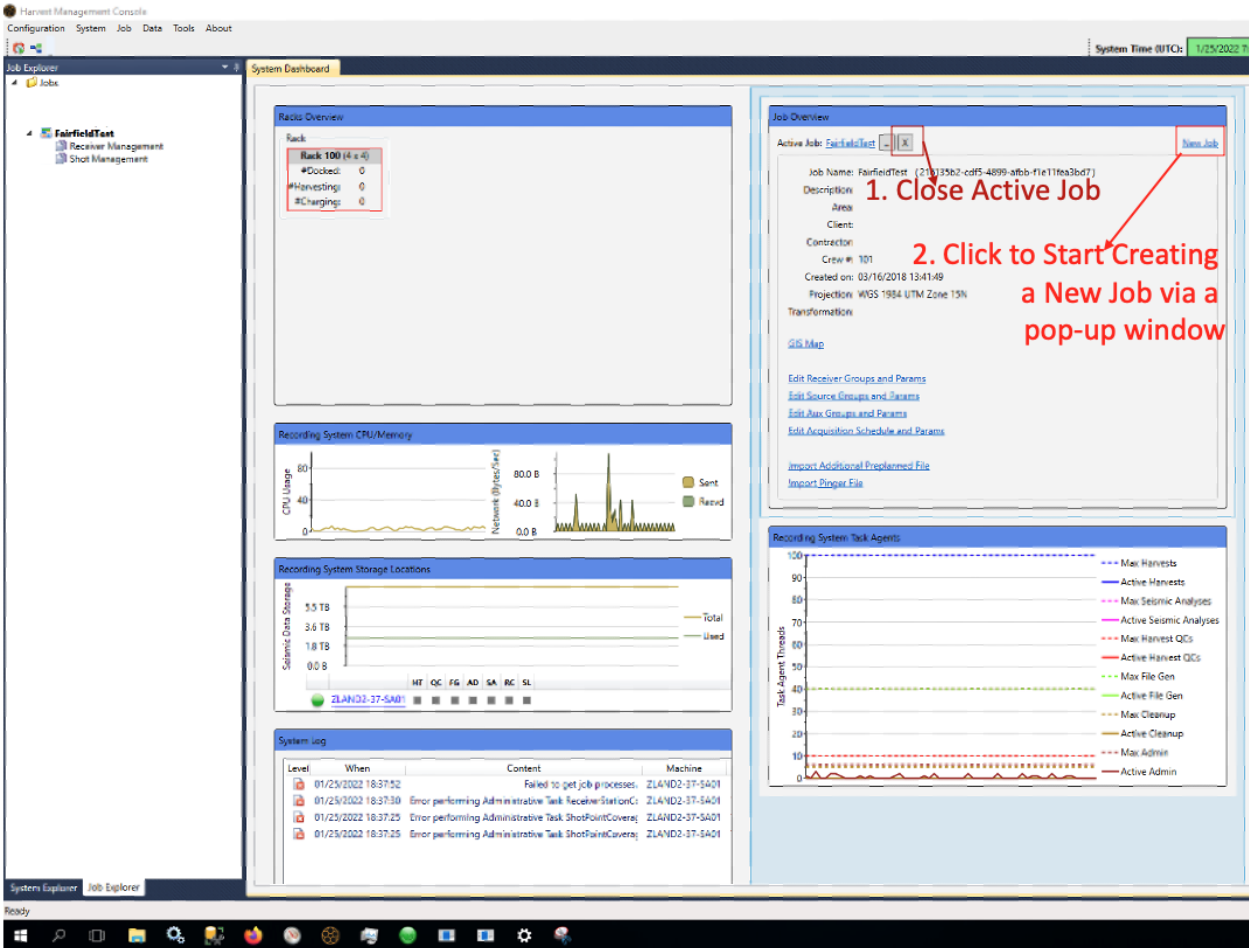


Figure 2-5 HarvestManagement Console main page with initial required steps highlighted in the Job Overview panel.

2. Check receiver and shot files

Check that rec.txt and src.txt are in this folder
(*System (C): Jobs > YourJobDirectoryName*).
If not, add them via File Explorer and edit in Notebook (see Section 2.3.4).

3. Job Settings

Create Job → Add Job Name, Job Folder and Crew #, as shown in Figure 2-6.

Note the 'Job Name' in the 'Before going into the field' notes (see Section 2.1) under item 5.

Hit 'Next' to proceed to the Preplanned Files and Map page.

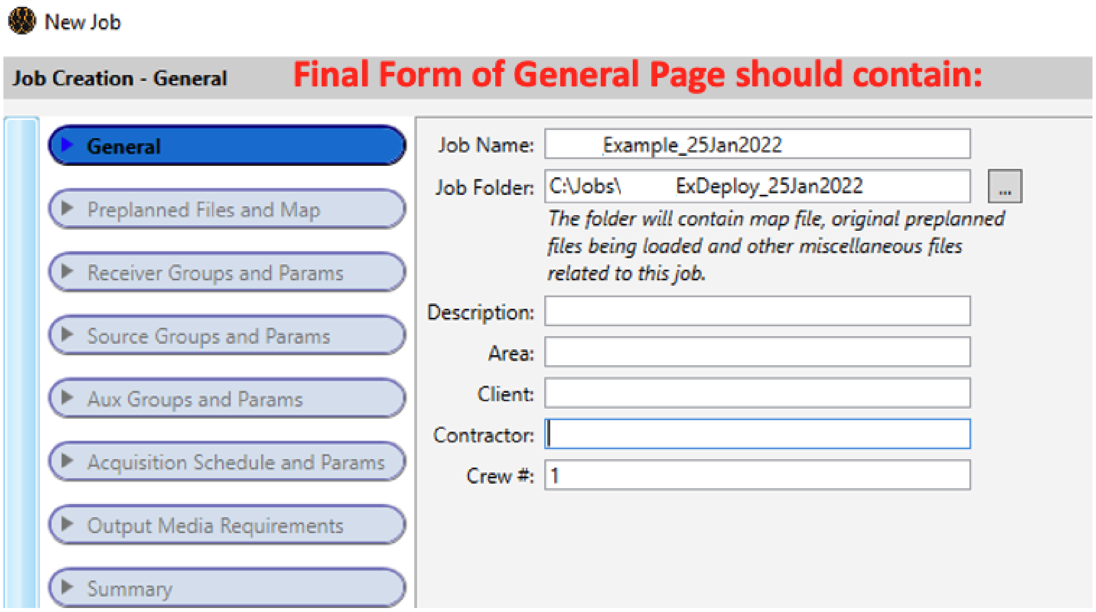


Figure 2-6 Final format of the first page from the pop-up window generated via 'New Job' (see Fig 2-5).

4. Add source and receiver files

On the **Preplanned Files and Map** (see Figure 2-7):

- Set the File Format: *Custom File Format with fixed width*
- Set Projected Coordinate System: use the '…' button and then navigate to your UTM Zone through *Option: Projected Coordinate Systems > UTM > WGS 1984 > (Hemisphere of Choice) > (UTM Zone of choice; e.g., WGS 1984 UTM Zone 13N.prj)*.

  The UTM Zone was previously determined to create the source and receiver text files, so be consistent with these files. Note this information under Item 6a in the 'Before going into the field' notes (Section 2.1), if not already noted from the rec.txt file creation.

- Set the Receiver File: use the '…' button and navigate to the rec.txt file. From the pop-up window deselect Point Code, set the Header, and use the up/down arrows to select the columns containing Elevation values (see orange highlighted section in Figure 2-7), then use the up/down arrows to set all columns containing UTM Northing values, then Easting, then the Station, and last the Line number. Note that the column numbers may not be identical to Figure 2-7, but all fields should be highlighted as displayed in Figure 2-7. Hit 'Ok' to save this information in the pop-up menu.

- Set the Shot File as the src.txt file and set the file contents from the pop-up window in the same way as the Receiver File.
- No relation file is needed for a passive study. See Figure 2-8 for what the final view of this page should look like. The bottom half should be auto-filled and does not need to be edited.
- Hit Next (*Do NOT select Preview Map, but allow the 'Creating GIS map' to generate which may take some time*).

If Create GIS map fails, remove any files created directly by the Fairfield software in the *System (C): Jobs > YourJobDirectoryName* directory you created and try again.

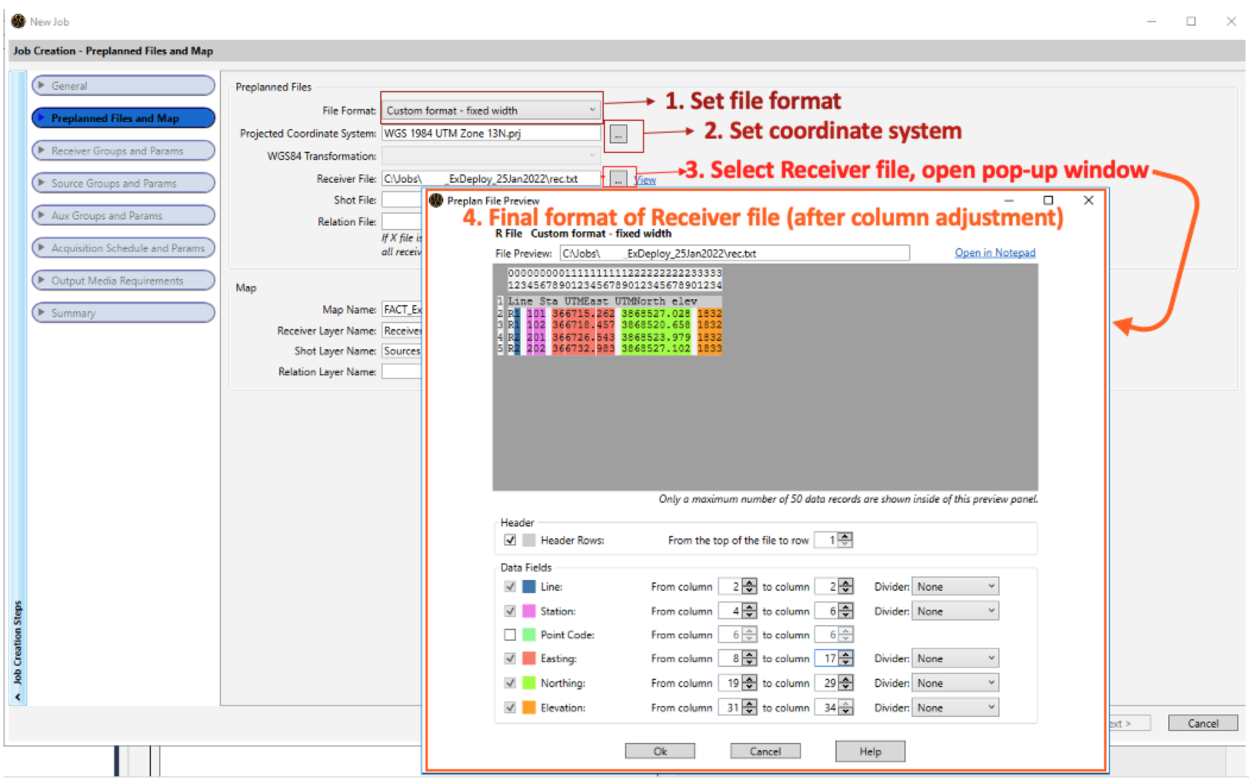


Figure 2-7 Layout of the correct settings and steps for the Preplanned Files and Map page.

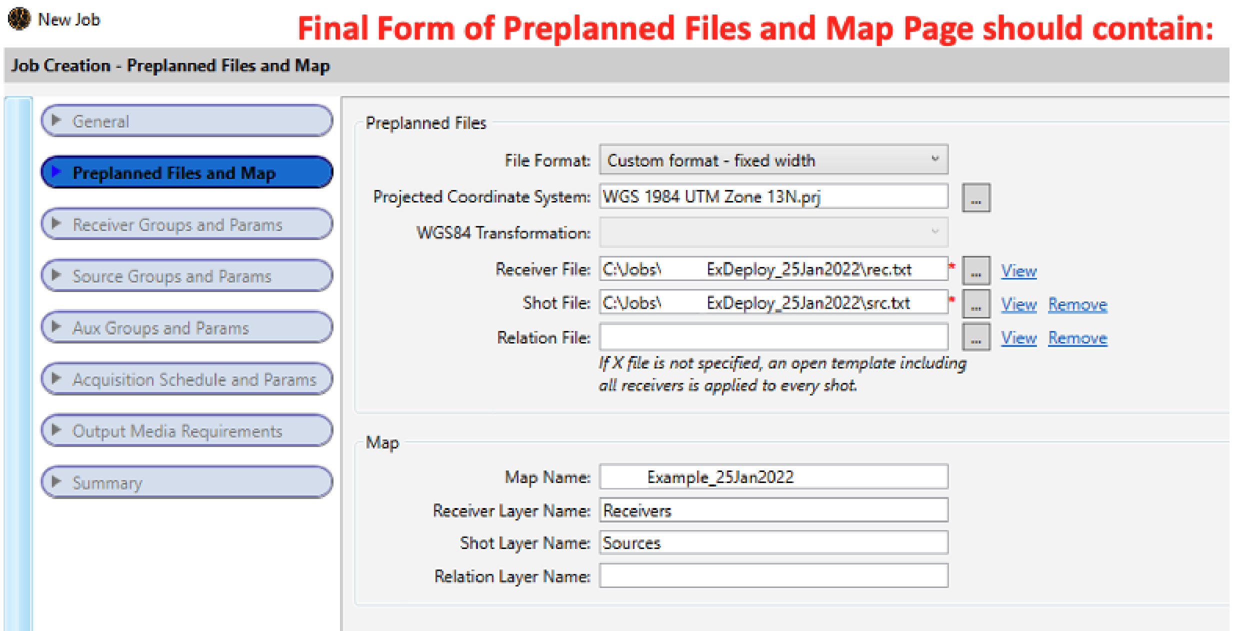


Figure 2-8 Final format of the Preplanned Files and Map page. Note that the 'Shot File' section should be set as previously shown for the 'Receiver File' in Fig 2-7. The 'Map' section should be auto-filled and not require any edits.

5. Node settings → Receiver Groups and Params & Source Groups and Params Pages

Receiver Groups and Params page:

Under Actions > Select the 'Edit Receiver Group' button (see Figure 2-9).

Set the following within this pop-up page, as shown in Figure 2-10. Take note of the settings in Sect 2.1 'Before going into the field' Items 6b-c. This information is critical in removing the instrument response from the raw data following the deployment.

- Receiver group: Internal 3C
- Sampling Interval: *set according to PI preference*
- Pre-amp gain: 18dB or PI preference
  (18dB found to work well from Jamie Farrell and University of Utah for ambient noise and active geyser studies)
- Nyquist filter: Linear Phase
- Low-cut filter: (Low cut filter disabled); leave box unchecked
- DC offset removal: Check box to remove DC Offset

Hit 'Ok' and 'Next' to proceed to the 'Source Groups and Params' page.

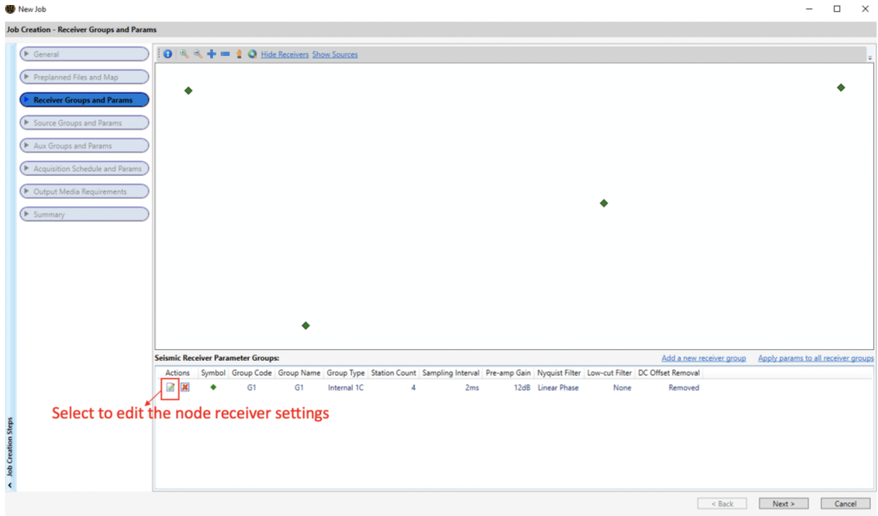


Figure 2-9 Receiver Groups and Params initial main page. Select the action designated in the red box to edit the parameter settings.

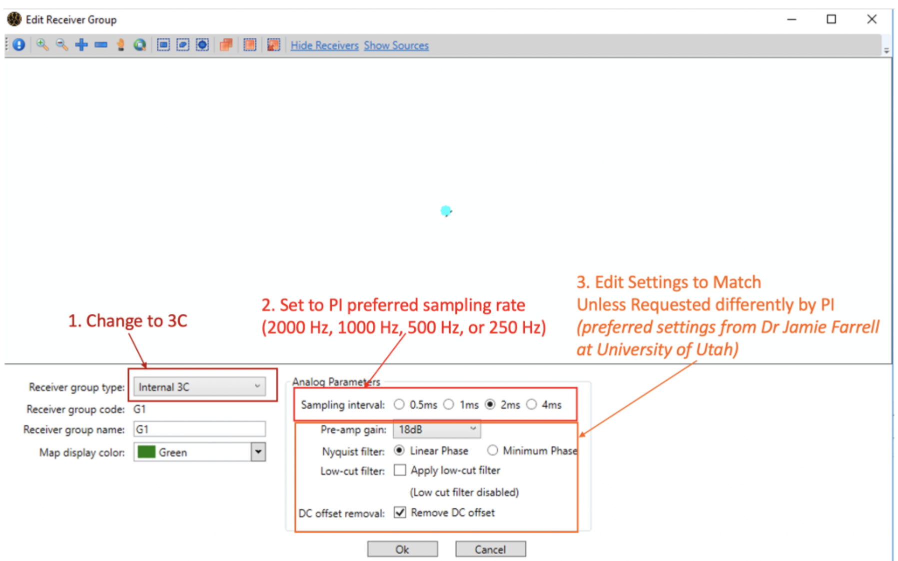


Figure 2-10 Suggested final receiver parameter settings (note the Sampling interval should be adjusted as requested by the PI). Access to this page is shown in Fig 2-9.

Source Groups and Params page:

Similar to the 'Receiver Groups and Params' page, edit the Source as follows:

- Source > Edit > Record Length 30s *(Note this page is not as important)*
- This is also shown in Figure 2-11.
- Hit 'Ok' and 'Next' to proceed.

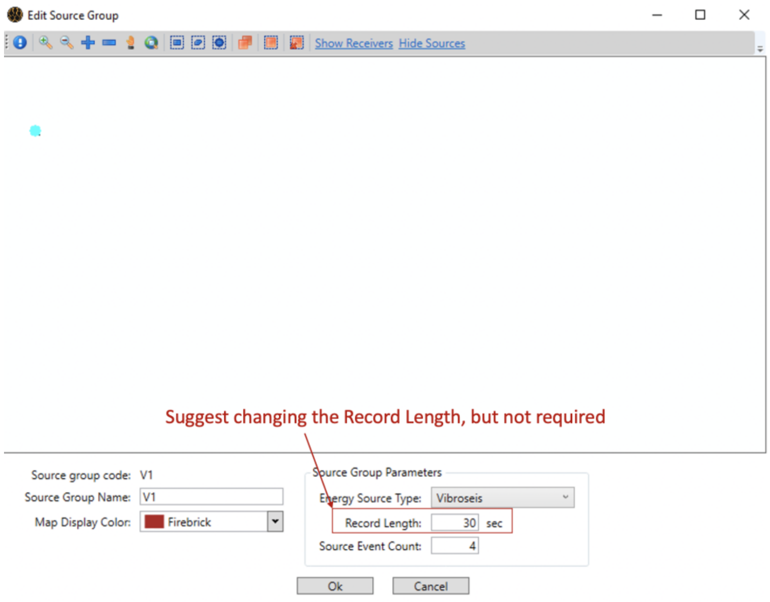


Figure 2-11 Source Group suggested settings accessed from the 'Source Group and Params' similarly to the receiver settings (see Fig 2-9 and 2-10).

6. Final Job Settings

Aux Groups and Params page: No changes needed (see Fig 2-12).

Hit 'Next' to proceed.

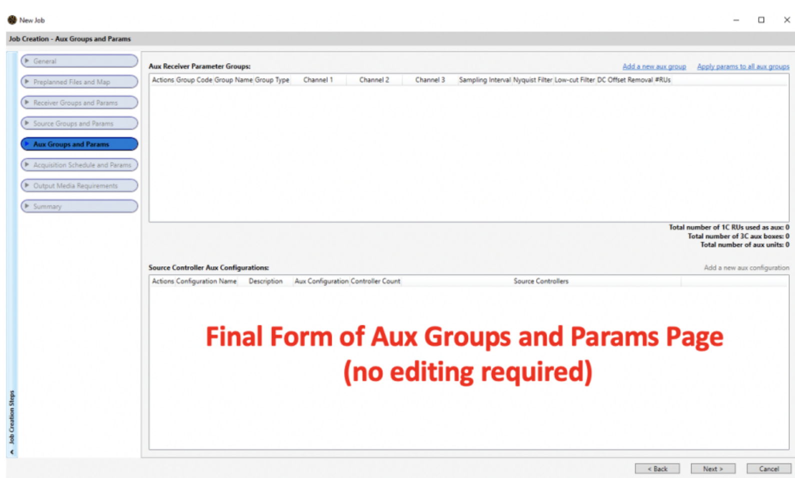


Figure 2-12 Final format of the Aux Groups and Params page (leave blank).

Acquisition Schedule and Params page (see Fig 2-13 for final settings):

- Set Acquisition Schedule to 'Continuous Acquisition'
- ZLand Remote Unit Timing Solution: Survey-In Mode

- Select ‘Next’ to proceed

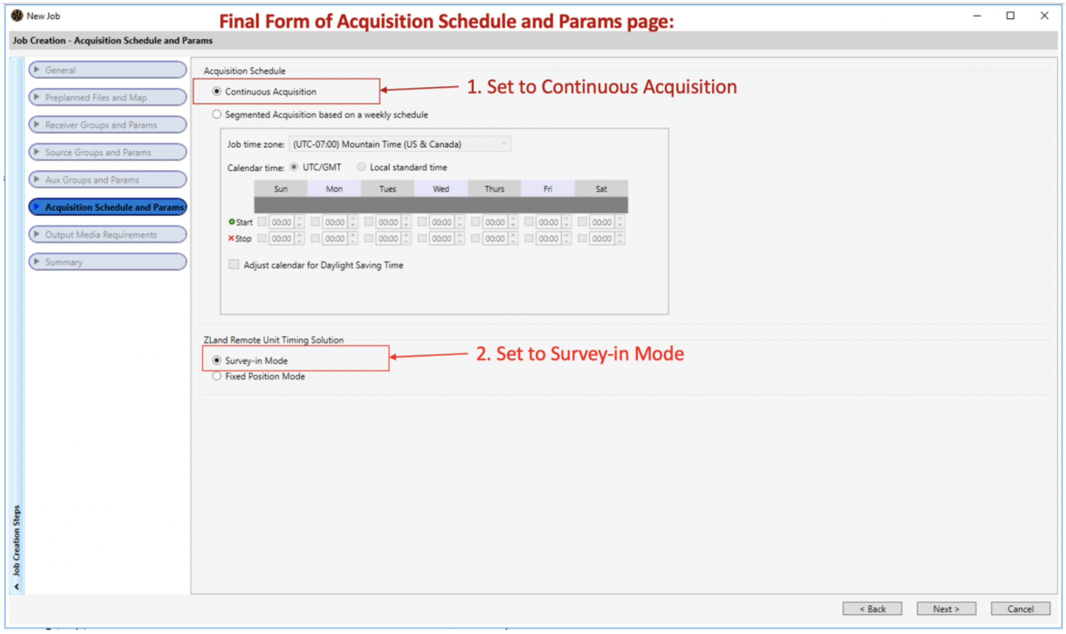


Figure 2-13 Acquisition Schedule and Params page with suggested settings.

Output Media Requirements: No changes needed (left-side of Fig 2-14)

Summary: Check the ‘Set as Active Job’ box; select ‘Finish’ (right-side of Fig 2-14)

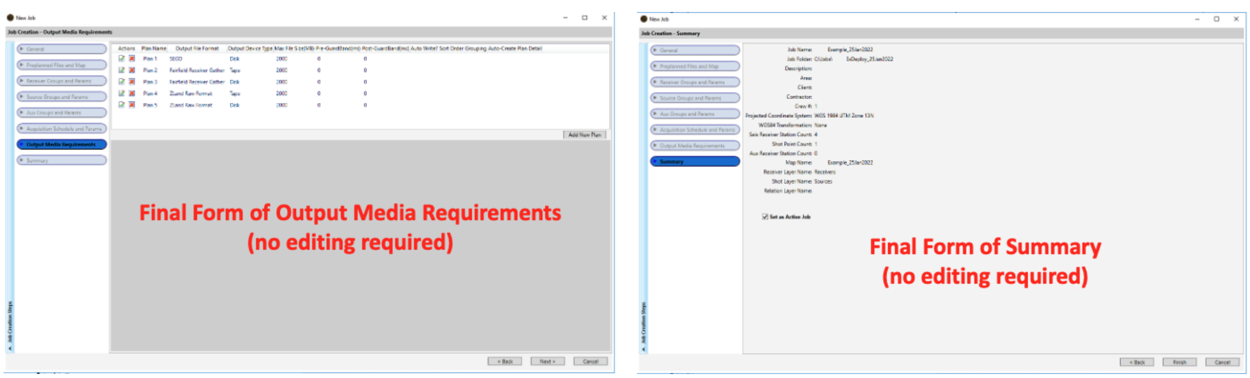


Figure 2-14 Output media requirements page (no editing) and the Summary page (no editing).

6. Create a map in ArcGIS

From the *System Dashboard* in *Job Overview* select ‘GIS Map,’ as shown in Fig 2-15.

Make sure that you are zoomed out to the range (see zoom and pan tools in right-side of Fig 2-15) preferred by the PI to ensure the field crew can add stations if needed. Stations can only be added if located within the preset area seen in the GIS map.

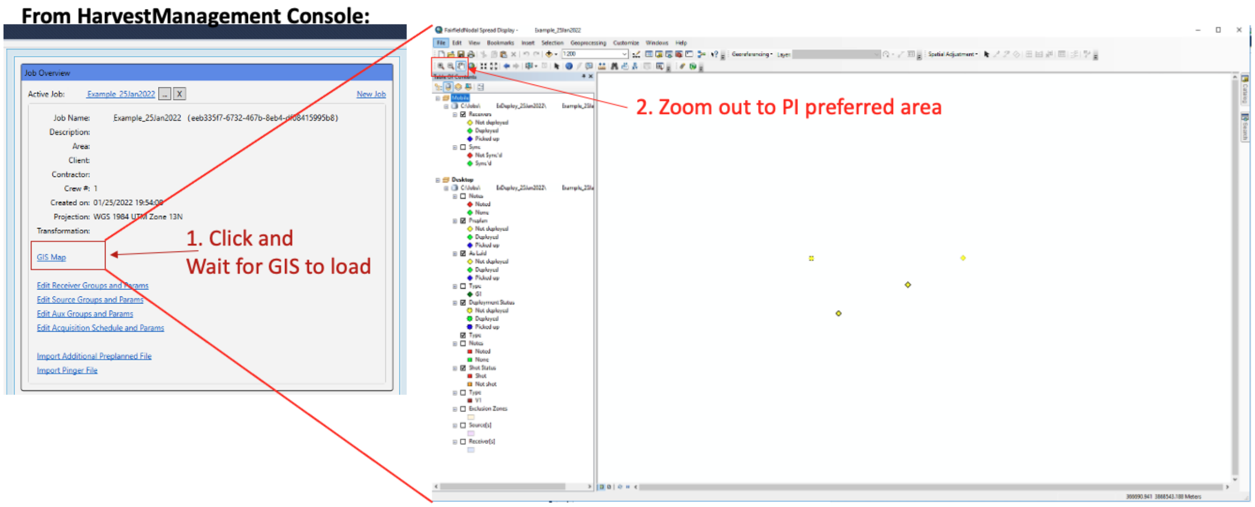


Figure 2-15 How to access the GIS map and where to zoom and pan from the generated ArcGIS interface.

2.4.4. Uploading the Job to the HHT

1. Plug the HHT into the computer.

   This should be done after charging the HHT to the point of being able to turn on and battery last long enough ($\geq$ 50%) for the duration of this process.

2. Make sure the HHT is connected in the Windows Mobile Device Center (see Figure 2-16).

   If not appearing, disconnect the HHT, make sure it is turned on, make sure the HHT's Field Tool Mobile application is not currently running (open and then close it), and then reconnect the HHT.

   If issue persists, make sure the program is running in the Windows Task Manager and repeat the previous steps. You may also need to reset the HHT, and/or the Windows computer. It is required to have the HHT connected (Figure 2-16) before proceeding.

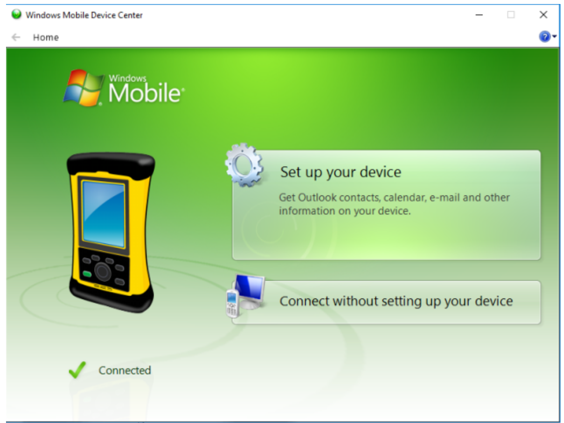


Figure 2-16 Correctly connected HHT as shown by the Windows Mobile Device Center.

3. Open the ArcGIS map that was just created, if not already open (see Figure 2-15).

   Harvest Management Console > Job Overview > GIS Map

   Be certain that the area is zoomed out (see zoom and pan tools in right-side of Fig 2-15) as preferred by the PI so the field deployment crew can add stations if needed. Stations can only be added if located within the preset area seen in the GIS map.

4. Activate the HHT

   Right Click on 'Mobile' in top *left* corner in the Layers tab and select 'Activate.' See Step 1 in Figure 2-17.

   Nothing will happen after selecting 'Activate,' but this is a critical step. Wait a few seconds to ensure this action is registered by both the Windows machine and the HHT.

   Reminder: Make sure the view of the stations looks correct and zoom out if needed for the deployment.

5. Load to the HHT

   5.1 Select *Load HHT* button in the top toolbar. This looks like a small yellow HHT. 

   See Step 2 in Figure 2-17 for reference of this button's location. Loading the pop-up menu after selecting the 'Load HHT' button will take a while but be patient.

   5.2 From the pop-up Load HHT menu (see Figure 2-17):

   - Set the Display Time to be UTC.
   - Set the desired tolerances as preferred by the PI (a good default is 100m).
   - Set the Deployment tests. A good default test is the Resistance test. The Resistance test information is not required to be saved by the those deploying the instruments in the field, but the numbers should be non-zero

if the station is operating correctly. This also functions as a visual queue of a successfully started station during fieldwork.

5.3 Select *Load HHT* to finalize these settings onto the HHT (see Fig 2-17).

5.4 After completing, hit Done.

5.5 Close and Save Changes to the ArcGIS map.

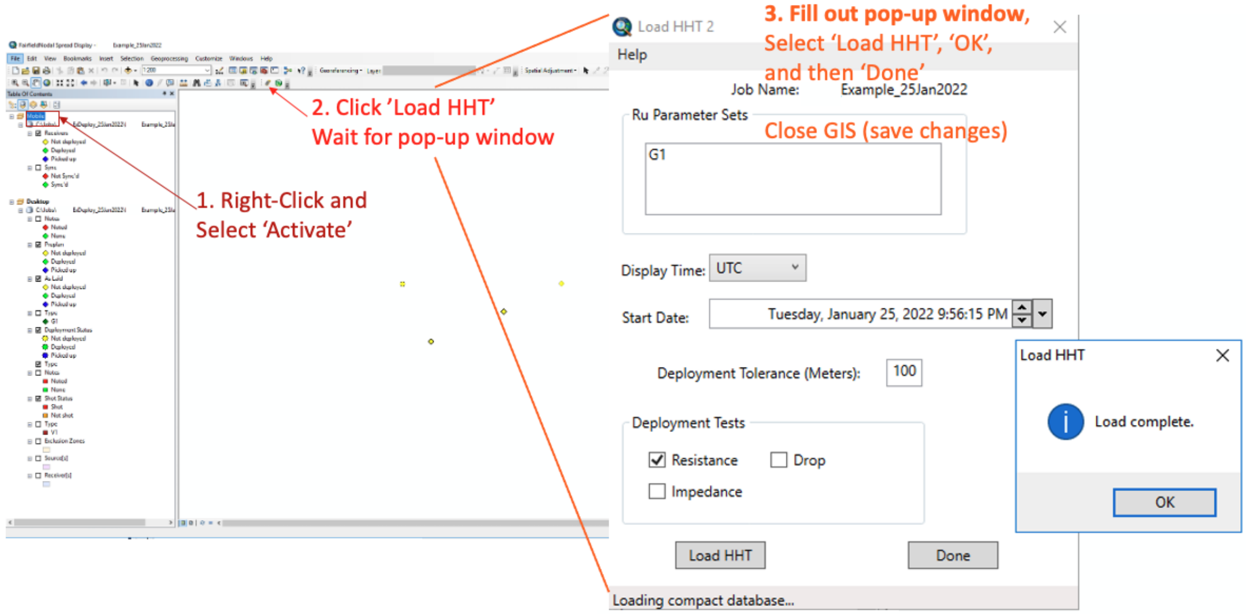


Figure 2-17 Map Settings to Activate and Load the preplanned deployment information to the HHT.

5.6 Unplug the HHT from the computer.

5.7 From the HHT, open the Field Tool Mobile application and check the deployment map looks correct. If needed, repeat the steps above with a more zoomed out map.

5.8 Make sure to denote which HHT the job was uploaded to in item 3 of the 'Before going into the field' notes (see Section 2.1).

3. FIELD DEPLOYMENT

In general, the field deployment of nodes is the easiest part and why the nodes are so valuable to seismologists. The stations are relatively quick to deploy, as the data logger, battery, seismic sensor, and GPS timing calibration are all in one unit. Also, any node can be used at any station. This section reviews how to correctly set up and deploy a node to record seismic data.

3.1. Setting up the Instrument

All field crew members doing deployment of nodes should familiarize themselves with using a compass to orient the nodes (see Figure 3-1 below). All field crew members should agree on a consistent magnetic orientation correction to use across all instruments to ensure highest accuracy of the three-components. Additionally, the compass should be held level at approximately 6" above the instrument to ensure the instrument's components do not affect the magnetic field of the compass. I suggest using a small level (see Figure 3-1 below) as this can lay directly on top of the node to aid in leveling the instrument. Once the station is oriented and leveled, which may take a few iterations back and forth, you are ready to connect the HHT and officially deploy the station to start recording.

Deployment Schematic

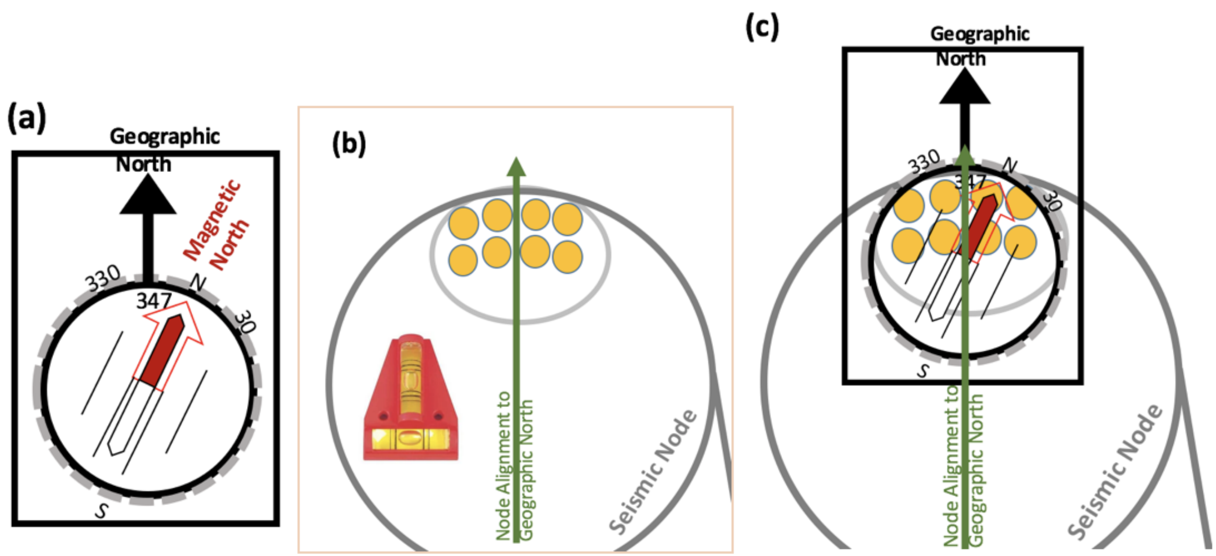


Figure 3-1 (a) Demonstration on how to orient a compass for Salt Lake City, Utah (declination of 347.5º). (b) Seismic nodal instrument showing how the instrument should be oriented to geographic north, with a line corresponding to geographic north going through the middle of the pins, and how the bubble level should appear (both bubbles centered). (c) Overlay of compass above the node to clarify nodal orientation; note that the compass should be ≥ 1.5 feet above the node to prevent the mechanical components within the instrument from affecting the magnetic reading.

3.2. Field Notes & How to Begin Recording

The following information within the 'In the Field' and 'Ongoing Succinct Field Notes' sections should be provided to the PI in order to guarantee a successful deployment of the Fairfield nodes. Note that each station needs to have the Line #, Station #, latitude and longitude coordinates, and last four digits of the Node Instrument Number written down to guarantee data is correctly attributed to the appropriate station after data collection. The Fairfield software has gone through a few updates, and previous versions did not necessarily keep track of this metadata information, which made associating output datafiles to specific stations difficult. The initial 'In the Field' section also includes information on starting a node recording and associating it with a specific station. Each node should be associated with a specific station and line number. Do not assign more than one node to a station location; instead, if needed, add a station to the pre-planned deployment. Following the detailed 'In the Field' section, the following 'Ongoing Succinct Field Notes' section includes only the critical information that needs to be recorded for each deployed station.

The metadata required for each deployed station includes the coordinates (latitude, longitude, and elevation) of the station, along with any necessary site conditions that may impact data quality later (burial, soil consistency, nearby vegetation, and/or anthropogenic structures). The location of the station should also be described to aid in station recovery following the deployment. Furthermore, it is *highly* suggested that, following the station notes, a photo of the page of notes and then a photo of the node location with references to road, vegetation, etc., be provided to aid in locating the instrument during retrieval. This method ensures the station location will be recognizable during station retrieval. The PI and field crew do not need to use a printout of this information and are instead welcome to use waterproof field notebooks, as long as the previously discussed metadata information is collected.

In some cases, it may be preferred to keep track of the stations deployed in a mobile application. This is entirely ok, but it is highly suggested that the deployed coordinates be noted anyway, and that the recorded information in the mobile application is formatted as Sta.Node# to enable easier extraction of that metadata during data extraction.

In the field   Magnetic declination used (see NOAA page/app): _________

For each node:

Line #: _________   Station #: __________   Node # (last 4 digits): __________

Latitude°, Longitude°, Elevation: ____

Start Time & Date (circle: Local or UTC): ____________________

To start the node from a pre-planned station:

1. *Connect the HHT to the node (you should hear a click)*
2. *On the HHT: Open FieldTool Mobile program, and then select the line & station you want for this node (drag the cursor over the station to view and select Line:Station information)*
3. *On the HHT, in the bottom toolbar: RU > Deploy.*
4. *If you have an error on the station being 'out of bounds,' turn off the GPS via: GPS > Disconnect*
   Then repeat steps 2-3
5. *WAIT until the Resistance test is complete, click ok, and then you should hear 'Starting Operation,' and the selected station should turn from yellow to green in the handheld. Now it is safe to disconnect the node from the HHT. Note that if the 'Auto-Deploy' is turned on in the field and resulting in an error during deployment, go into the Settings and turn off this feature.*

To start a node at a new Line/Station not pre-planned:

1. *Make sure the GPS is connected (on the Trimble in the FieldTool Mobile Program, GPS > Connect)*
2. *Connect the HHT to the node (should hear a click)*
3. *On the HHT: Map > Add Line / Station (from the lower toolbar). Create a line and station number, and then hit 'Ok.' Make sure the added Line/Station does NOT already exist!*
4. *Follow step 5 above for a pre-planned station.*

Is the node recording?

The station will change from a single blink every second (standby) to a 3-blink in fast succession (recording) once the node has a GPS satellite lock. This can take a couple of minutes.

General Notes about the Site (buried/unburied, coupling, site conditions, etc.):

____

____

Pick Up Time & Date (circle: Local or UTC): ____________________

Were Nodes 'Stopped' on the Trimble (Circle: Y / N)

Note, stopping the nodes may be beneficial, if wanting to use data recorded directly prior to pick-up and not worry about clock drift.

To Stop Recording for a node from the HHT:

1. *Connect the Trimble to the Node*
2. *Select the appropriate station for that node on the Trimble*
3. *RU > Stop (the green station should then turn blue on the Trimble)*

Ongoing Succinct Field Notes Magnetic declination: ______

Line #: __________ Station #: __________ Node # (last 4 digits): __________

Latitude°, Longitude°, Elevation: ____

Start Time & Date (circle: Local or UTC): ____________________ Photo Taken: (Y / N)

General Notes about the Site (buried/unburied, coupling, site conditions, etc.):

____

____

Pick Up Time & Date (circle: Local or UTC): ____________________

Were Nodes 'Stopped' on the Trimble (Circle: Y / N)

Line #: __________ Station #: __________ Node # (last 4 digits): __________

Latitude°, Longitude°, Elevation: ____

Start Time & Date (circle: Local or UTC): ____________________ Photo Taken: (Y / N)

General Notes about the Site (buried/unburied, coupling, site conditions, etc.):

____

____

Pick Up Time & Date (circle: Local or UTC): ____________________

Were Nodes 'Stopped' on the Trimble (Circle: Y / N)

Line #: __________ Station #: __________ Node # (last 4 digits): __________

Latitude°, Longitude°, Elevation: ____

Start Time & Date (circle: Local or UTC): ____________________ Photo Taken: (Y / N)

General Notes about the Site (buried/unburied, coupling, site conditions, etc.):

____

____

Pick Up Time & Date (circle: Local or UTC): ____________________

Were Nodes 'Stopped' on the Trimble (Circle: Y / N)

4. HARVESTING DATA

Following retrieval of the nodes, data need to be downloaded from the nodes via the Fairfield software, exported as FCNT files, converted to readable SAC/miniseed files, and then the instrument response removed. The latter process converts the raw instrument data, in units of counts, to universal measurement units (displacement, velocity, or acceleration). The section below on the Fairfield software data extraction is broken into an abbreviated overview and a detailed overview according to user familiarity. The data extraction and instrument response removal sections are shown via python.

4.1. Fairfield Software – Detailed Overview to Harvest & Extract Data

First, turn on the rack and Windows machine containing the Fairfield software. The section below is a detailed overview on harvesting data through the Fairfield software, but see Appendix B for a quick guide for experienced users of the Fairfield software. Before starting, please create the folder where you want the final data exported. This is typically located in the *Data (Z): > Completed Jobs* area, to accommodate the large size of data from deployments, and note this directory information for future reference.

4.1.1. Sync Metadata

To extract data from the instruments, first pull the field metadata from the HHT:

1. Ensure the correct job is activated (see Figure 2-5)

    See: *Job Overview > Active Job …*

2. Sync the HHT

    2.1 Close FieldToolMobile on HHT

    2.2 Plug in HHT, make sure it is connected via Windows Mobile Device Center.

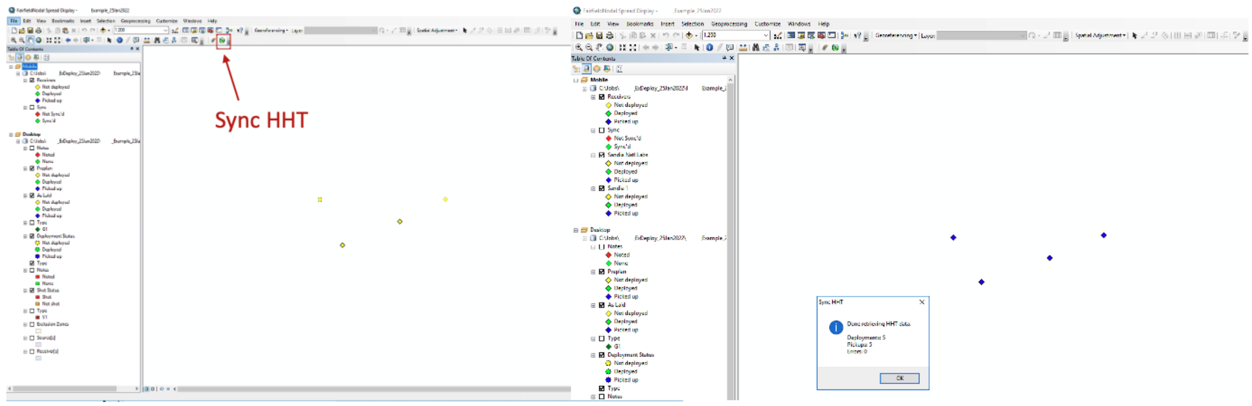
    See 'Uploading the Job to the HHT' in Sect 2.4.1 or Sect 2.4.2 and Figure 2-16 for more information.

    2.3 Open GIS Map from the *Job Overview* area in the HarvestManagement Console (see Figure 2-15)

    2.4 Press '*Sync HHT*' button on toolbar in ArcGIS (see left panel of Fig 4-1).

    Deployed/collected stations (right panel of Fig 4-1) should change color from the pre-planned stations (left panel of Fig 4-1).



i

Figure 4-1 (Left) ArcGIS initial page with the 'Sync HHT' button highlighted in red. **(Right)** Post-Sync-HHT screen in ArcGIS. Note the stations changed color after syncing.

4.1.2. Download data from the nodes

1. Connect nodes to rack
2. Make sure data has downloaded in Rack View and no errors occurred

   See 'Charging Nodes' in Sect 2.4.1 or Sect 2.4.2 and Figure 2-2 for an overview of docking the units and checking / troubleshooting errors.

3. Make sure the harvest process is complete and ALL nodes have collected data.

   Check all stations were associated with the Job via *System > View Unreconciled Deployments*. If there is anything listed for this Job (as shown in Fig 4-2), see the instructions immediately below for 'ADDED in the field' nodes.

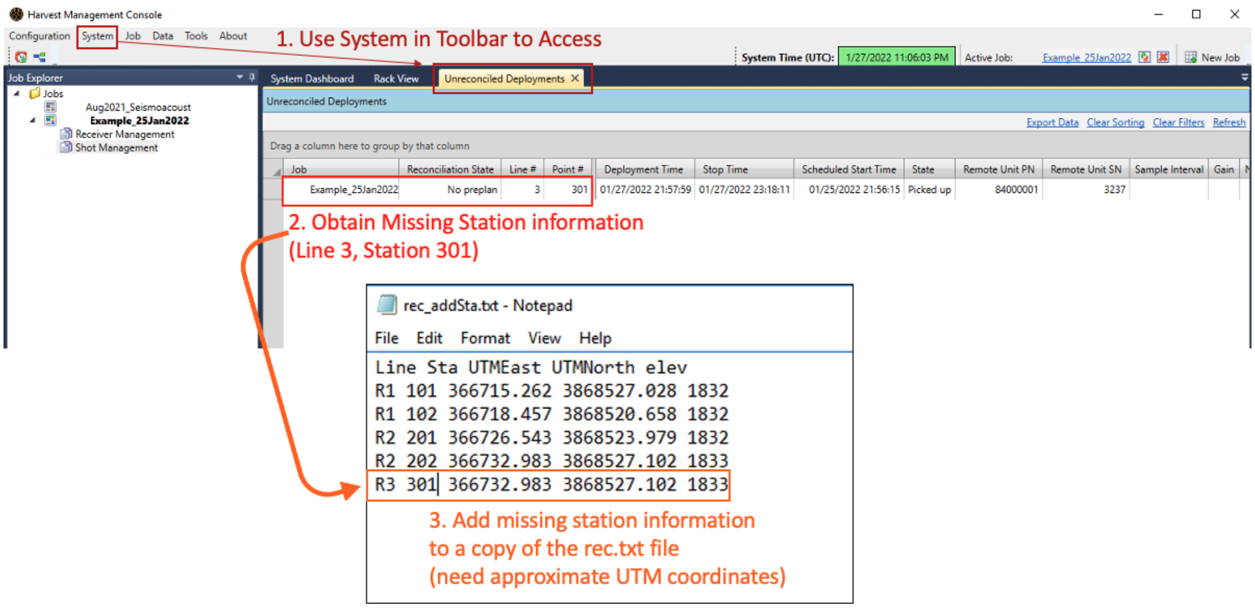


Figure 4-2 How to access Unreconciled station information, and how to edit the receiver station file.

If nodes were **ADDED in the field**, get information on the added node number, line number and station number, and perform the following steps:

3.1 Write down the Line# and Point# for the Unreconciled Station. If available, also obtain approximate UTM coordinates.

3.2 Create and edit a copy of the rec.txt file in the original System(C:) > Jobs > Your_job_folder. As shown in Figure 4-2, add the Unreconciled station information to this file. If location overlaps with another station, that's ok, just note which station(s) to add for the following steps.

3.3 From the HarvestManagement Console in the Job Overview section, select 'Import Additional Preplanned File,' as shown in Figure 4-3.

Edit the **Preplan File Importing settings** (see Fig 4-3):

- *Set the File Format to Custom format – fixed width.*
- *Set the File Type to R.*
- *Set the Operation to 'Incrementally Merge (add/update)'*
- *Add the new receiver File Location using the '…' button and adjust the header and columns (see Fig 4-3). Hit 'Ok.'*
- *Select Import and check things look correct in the pop-up 'Incrementally Merge' window (see Fig 4-3); if they are correct, hit 'Import.' Hit 'Next' to proceed.*

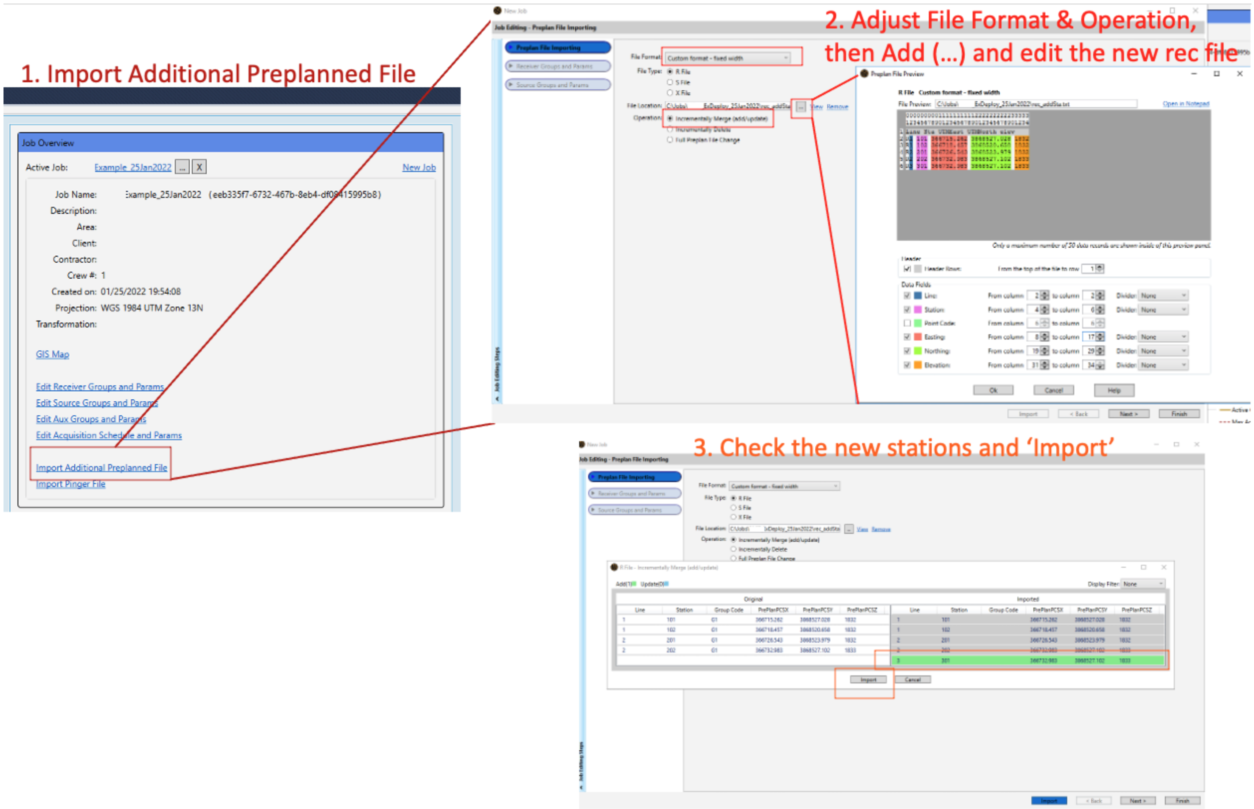


Figure 4-3 Overview detailing how to import an additional preplan receiver file to resolve Unreconciled stations.

Edit the **'Receiver Groups and Params'** page (see Fig 4-4):

- *Select 'Add a New Receiver Group'*
- *Update the parameters (Receiver group type: Internal 3C, select a Receiver group code, and a Receiver group name). Make sure the analog parameters match the pre-planned stations setting, so see previous notes in 'Before going into the field' in Sect 2.1. Also update the station color so it is easier to see the missing stations.*
- *Select the station(s) to add with the polygon tool and hit ok. I overlaid the stations of interest, so I select both the preplan and added station automatically.*
- *Make sure the total Station Count on the Receiver Groups and Params page is accurate and hit Next (see Fig 4-5). Otherwise, repeat the 'Add a New Receiver Group' to select missed stations.*
- 'Source Groups and Params' page: No edits required. Click Finish to proceed.

3.4 Confirm that you would like to import unreconciled deployments into this job from the pop-up window.

3.5 Select ‘Import All’ on the ‘Unreconciled Deployments’ page that appears.

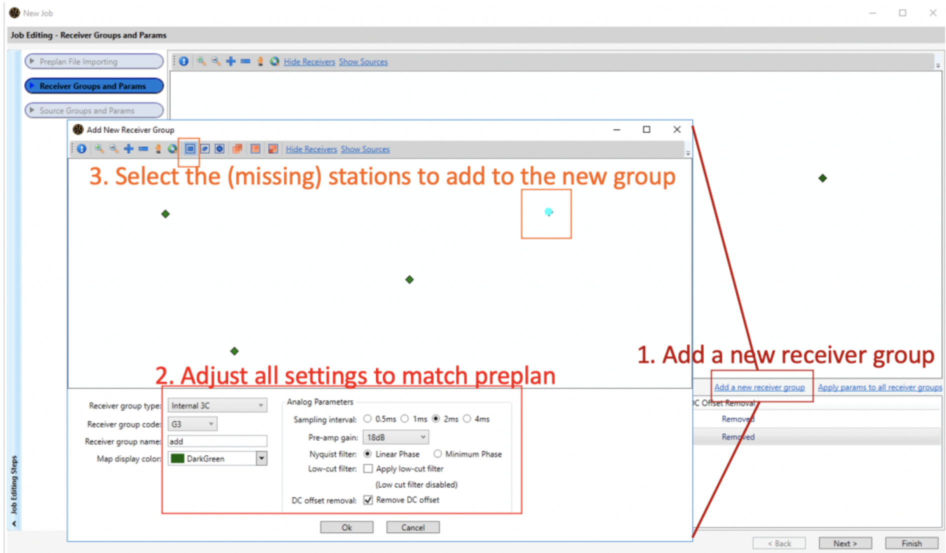


Figure 4-4 Detailed overview of step 3.4 in the ‘Import Additional Preplan File’ generated pop-up window.

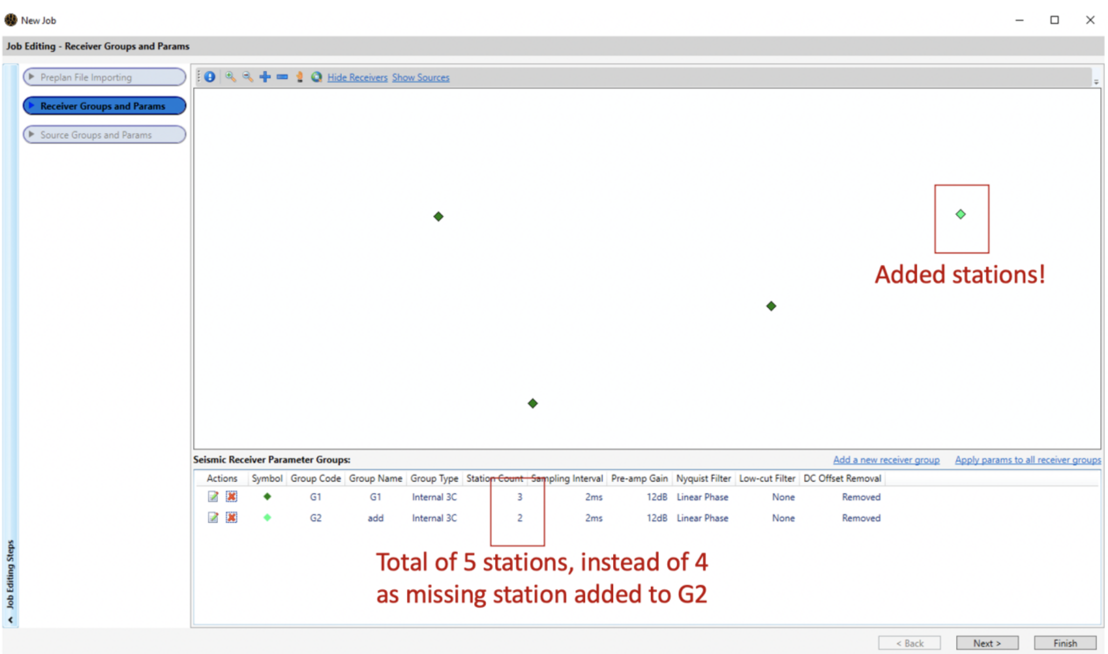


Figure 4-5 Final version of Receiver Groups and Params page.

4. Create a folder named ‘harvested’ in this project’s Z-drive job folder (*Data (Z): > Completed Jobs > YourCompletedJob)*, as shown in Figure 4-6.

Figure 4-6 Folder architecture of where data will be exported.

5. Go to HarvestManagement console, and at the bottom left click ‘Job Explorer’ tab (see Fig 2-5).

6. Right-click on Shot Management (under your Job) and select Shooting Simulation (see Fig 4-7).

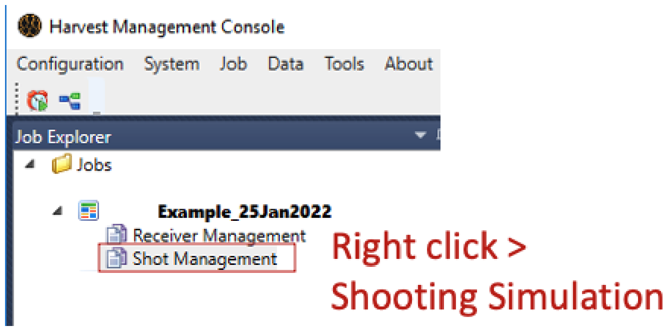


Figure 4-7 How to access the shooting simulation.

7. Select all devices (checkbox). Press Shoot.

9. Go to Media Output Console (separate program from HarvestManagement Console).

10. Select your current job from the drop-down menu and click on the green plus sign (see Fig 4-8).

11. Name your plan. Select Output File Format: Fairfield Continuous. Adjust other parameters as preferred, and then hit ‘Save.’ See Figure 4-8 for suggested final settings of the Create New Output Plan pop-up window.

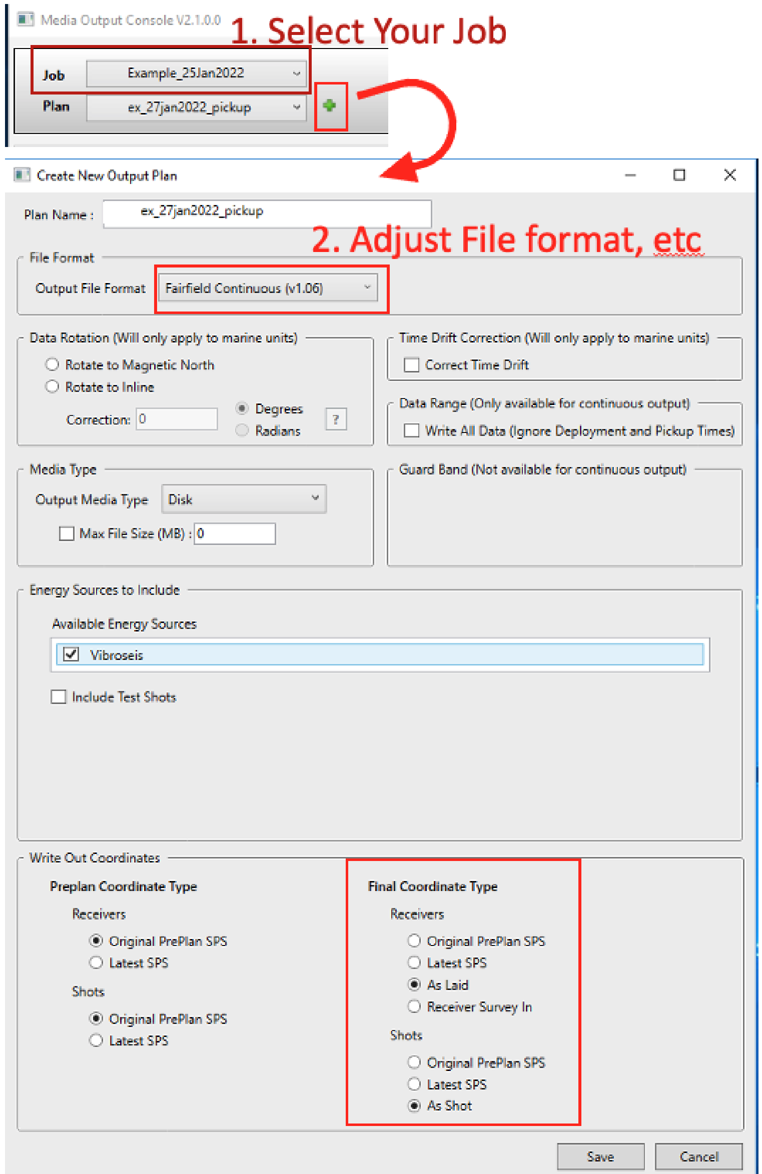


Figure 4-8 Media Output Console initial setup.

12. Click on *Create New Selection* (see Fig 4-9).

13. Click ‘Select All’ and then ‘Update’ to select all of the stations in the line. *Selected Station Count should match the number of recorded stations (see Fig 4-9).*

14. Set Record Trace length (30000 ms) and click Save Changes (see Fig 4-9).

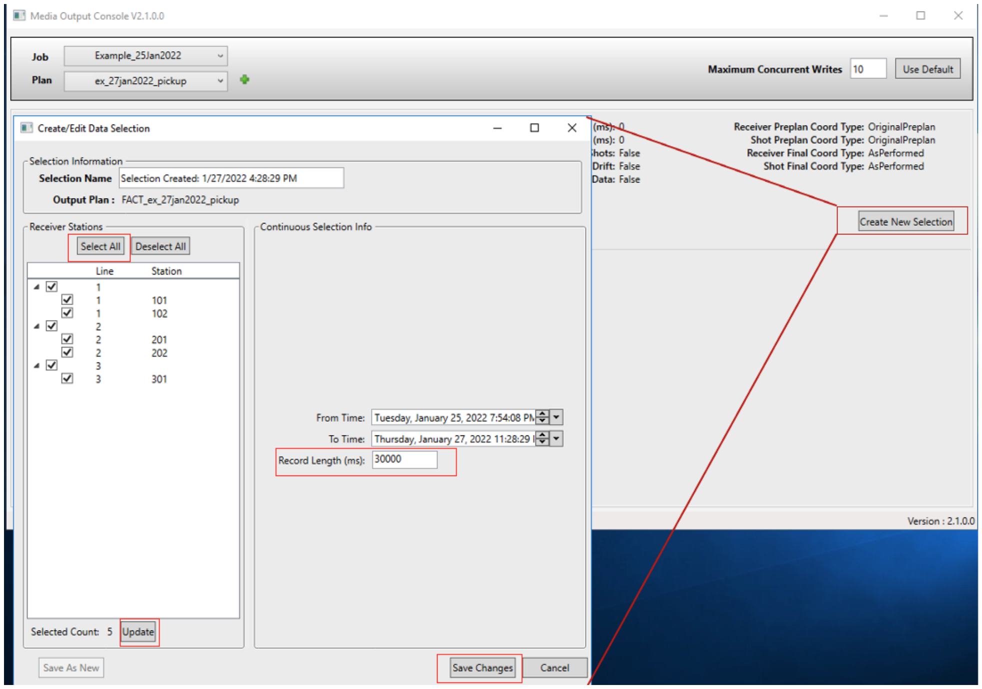


Figure 4-9 Create New Selection setup.

15. As shown in Fig 4-10, click on the disk icon (*Save to New Storage Unit*) and write to your empty 'harvested' folder (*Data (Z): > Completed Jobs > YourCompletedJob > harvested*). Use either the Ordered File Number (does not create subfolders) or the Standard File Naming convention (will create subfolders).

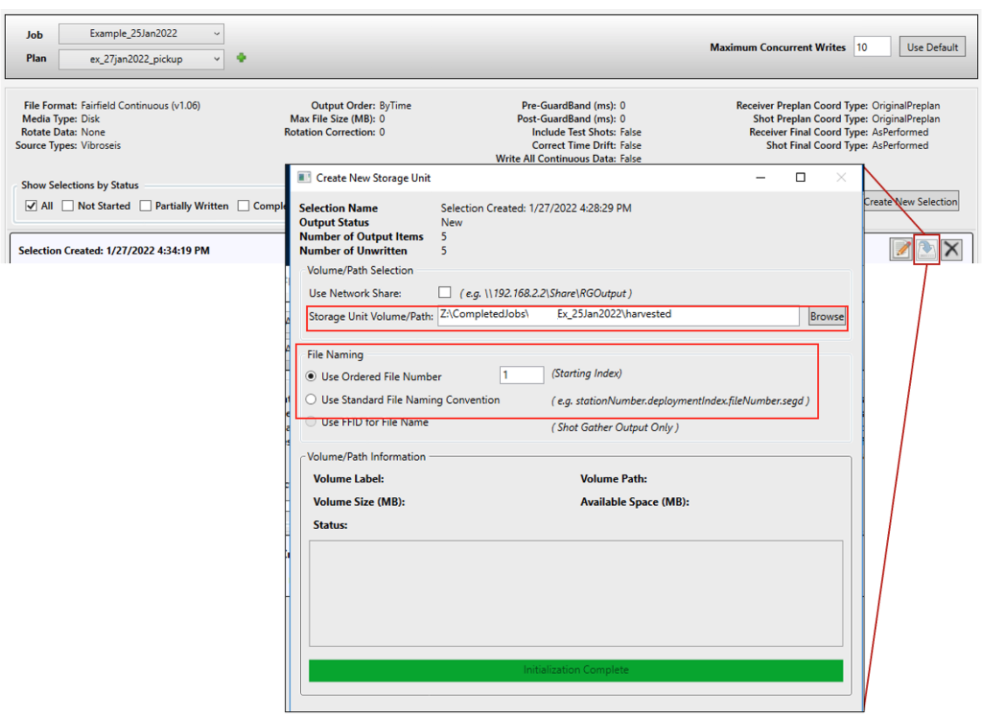


Figure 4-10 Final step to export data to file.

16. Note that if ‘OutputComplete’ is not shown, create a new ‘harvested’ folder (e.g., harvest_v1) and try to first repeat the previous step (step 15). If this still fails, repeat ‘Create New Selection’ onward that begins at step 12 above.

17. Also, export the Files Report (see Fig 4-11), to ensure information will be available for association of output files to collected station data via:

- Storage Units > View Output Files Report (looks like a file)
- Export Data
- Select All, change to Your Folder on the Z drive and Save
- Check the csv file looks ok
- This enables connect station # and line # to .fcnt filename.

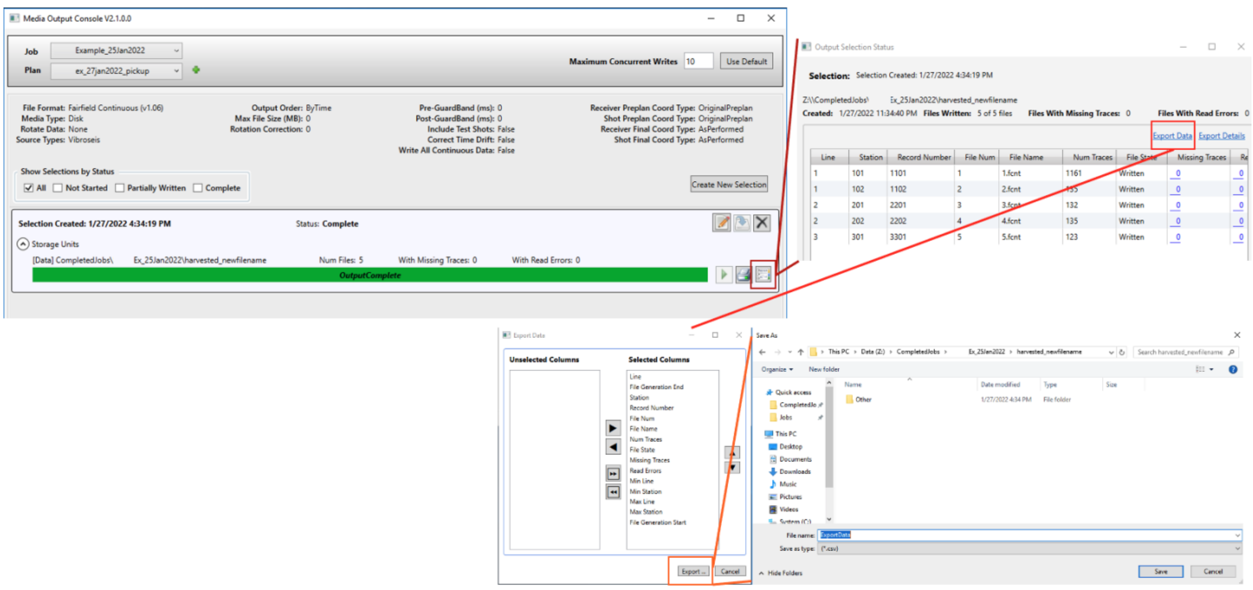


Figure 4-11 Final step to export csv file with critical file information.

4.1.3. *Visualize Collected Seismic Data – Detailed Overview*

To See Collected Data within the Fairfield software (only do this for short data collections, as you can overload the system), as shown in Fig 4-12:

1. Open Seismic Visualization Tool (separate program)
2. On the left-hand tab select your harvested folder
   (*Data (Z): > Completed Jobs > YourCompletedJob > harvested)*
3. Double click on an .fcnt file within this folder

-

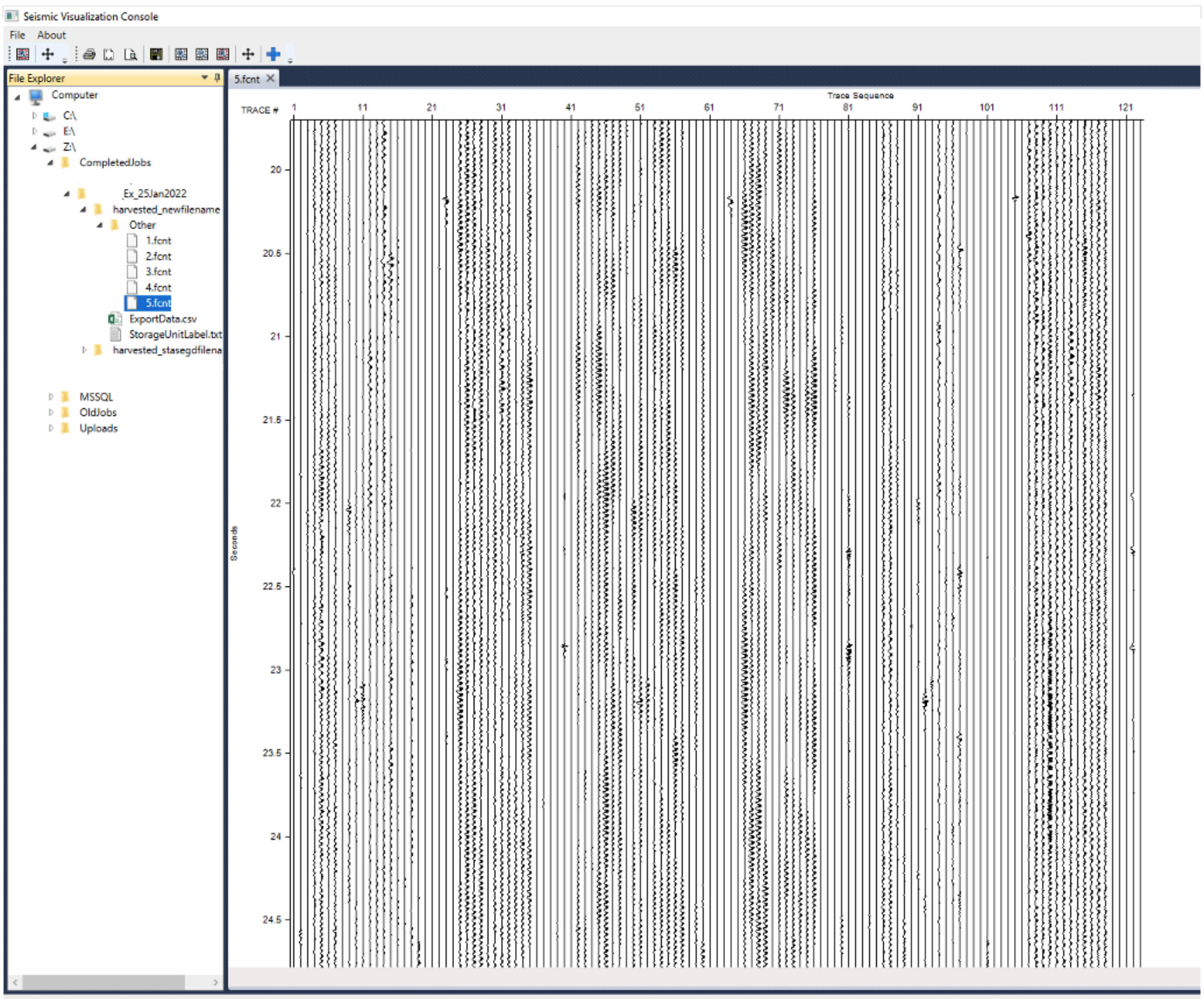
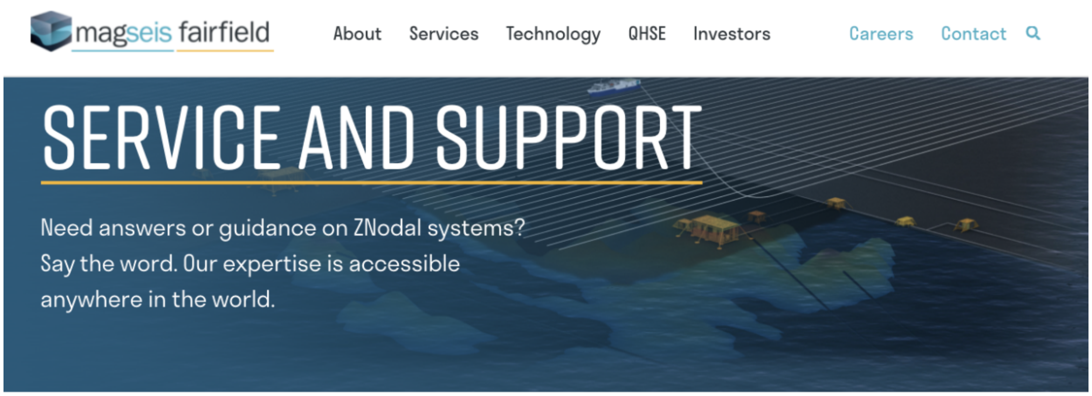


Figure 4-12 Seismic Visualization Console and example waveforms

5. FAIRFIELD CONTACT INFORMATION

If there is trouble with the nodes, HHT, or software on the Windows machine, please contact the Fairfield personnel.

More assistance has previously been provided by Alfredo Bolado or Ian Dipasupil, *https://magseisfairfield.com/service-and-support*



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6. STATION LISTS FROM PYTHON CODES

The content provided below is created via a series of Python Jupyter Notebooks for an example deployment of Fairfield nodes near Albuquerque, New Mexico. The full notebooks are available to SNL users through SNL's GitLab under: SetupExtractionNodeData page as part of the SeismoAcousticDeploymentStandards group. Included in this report are the most pertinent sections of the Jupyter Notebooks to enable external users to create station lists compatible with the Fairfield software.

6.1. Estimating Elevation from Latitude/Longitude Coordinates

Input file (space-delimited) with coordinates for each station:

```
ExampleDeployment_rawcoords.txt
Sta Lat Lon
101 34.950505 -106.459695
102 34.950448 -106.459659
201 34.950479 -106.459571
202 34.950508 -106.459501
```

Output file:

```
ExampleDeployment_sta_lat_lon_elevmeters.txt
Sta Lat Lon elev_meters
101 34.950505 -106.459695 1832
102 34.950448 -106.459659 1832
201 34.950479 -106.459571 1832
202 34.950508 -106.459501 1833
```

Python File (Jupyter Notebook):
LatLonUTM_Notebooks/ ExampleDeployment_EstimateElevation.ipynb

Example Deployment Estimate Elevation

Station List Creation: Add Elevation Estimates (meters)

This does not cover how to create the lat/lon list, as this assumes that is already available.

Station locations are initially picked in Google Earth

and then the invdividual lat/lon coordinates saved to file: **ExampleDeployment_rawcoords.txt**

In this section we will:

1. Read in the lat/lon station coordinates for 4 stations
2. Determine elevation for the lat/lon coordinates

Note that there are only a few stations, so it would also be feasible and potentially easier to find the UTM coordinates via Google Earth instead.

Use your own judgement in doing the simplest, least-problematic approach for future efforts

See the full Jupyter Notebook for information on proxy settings for SNL users.

Obtain Elevation (meters) for lat/lon coordinates

In [1]:
```
# Setup information
#  Note that this section may require disconnecting from the vpn


# these are the necessary functions and packages, do not tweak this section
import requests
import urllib
import pandas as pd

# USGS Elevation Point Query Service
url = 'https://nationalmap.gov/epqs/pqs.php?'
#url = r'https://nationalmap.gov/epqs/pqs.php?'


def elevation_function(df, lat_column, lon_column):
    """Query service using lat, lon. add the elevation values as a new column."""
    elevations = []
    for lat, lon in zip(df[lat_column], df[lon_column]):

        # define rest query params
        params = {
            'output': 'json',
            'x': lon,
            'y': lat,
            'units': 'Meters'
        }

        # format query string and return query value
        result = requests.get((url + urllib.parse.urlencode(params)))
        elevations.append('%d'%(result.json()['USGS_Elevation_Point_Query_Service']
                          ['Elevation_Query']['Elevation'])) #converts to integer

    df['elev_meters'] = elevations
```

In [2]:
```
# Tweak this section for your coordinates
### load a file already containing station information ####
maindir='/Users/eliberg/Research/Deployments/SAND_Guide/LatLonUTM_Notebooks'#main directory working within
inputfile=maindir+'/StationLists/     ExampleDeployment_rawcoords.txt'
df=pd.read_csv(inputfile,sep=' ',index_col=False)#space-delimited file
#################################################################
print('input file: \n',inputfile,'\n contains:')
display(df)

#save the output as a file
outpath=maindir+'/StationLists'
outfile='     ExampleDeployment_sta_lat_lon_elevmeters.txt'


elevation_function(df, 'Lat', 'Lon')
print('obtained elevations successfully!\n')
print('output file: \n',outfile,'\n will contain:')
display(df)

#write out as a space-delimited file
df.to_csv(outpath+'/'+outfile,sep=' ',index=False)
print('output results to file: \n',outpath+'/ \n'+outfile)
```

```
input file:
 /Users/eliberg/Research/Deployments/SAND_Guide/LatLonUTM_Notebooks/StationLists/     ExampleDeployment_rawcoords.txt
 contains:
```

	Sta	Lat	Lon
0	101	34.950505	-106.459695
1	102	34.950448	-106.459659
2	201	34.950479	-106.459571
3	202	34.950508	-106.459501

```
obtained elevations successfully!

output file:
      ExampleDeployment_sta_lat_lon_elevmeters.txt
 will contain:
```

	Sta	Lat	Lon	elev_meters
0	101	34.950505	-106.459695	1832
1	102	34.950448	-106.459659	1832
2	201	34.950479	-106.459571	1832
3	202	34.950508	-106.459501	1833

```
output results to file:
 /Users/eliberg/Research/Deployments/SAND_Guide/LatLonUTM_Notebooks/StationLists/
     ExampleDeployment_sta_lat_lon_elevmeters.txt
```

End of Python File (Jupyter Notebook):
LatLonUTM_Notebooks/ ExampleDeployment_EstimateElevation.ipynb

6.2. Estimating UTM Coordinates from Latitude/Longitude

Input file, input_stationlist.txt should be formatted:

ExampleDeployment_sta_lat_lon_elevmeters.txt
Sta Lat Lon elev_meters
101 34.950505 -106.459695 1832
102 34.950448 -106.459659 1832
201 34.950479 -106.459571 1832
202 34.950508 -106.459501 1833

Output files:

ExampleDeployment_sta_utmE_utmN_elevM_utm13.txt
Sta UTMEast UTMNorth elev_meters utm_zone
101 366715.262 3868527.028 1832 13N
102 366718.457 3868520.658 1832 13N
201 366726.543 3868523.979 1832 13N
202 366732.983 3868527.102 1833 13N

ExampleDeployment_sta_estimatedFromUTMZone13_Lat_Lon.txt
Sta Lat Lon
101 34.950505 -106.459695
102 34.950448 -106.459659
201 34.950479 -106.459571
202 34.950508 -106.459501

Python File (Jupyter Notebook):
LatLonUTM_Notebooks/
ExampleDeployment_UTMZoneCoordinates_fromLatLon.ipynb

Example Deployment Obtain UTM Zone & Coordinates

Station List Creation: Obtain UTM Zone and Coordinates

This does not cover how to create the lat/lon list, as this assumes that is already available.

This step assumes you have a file with station name, latitutde, longitude, and elevation: **ExampleDeployment_sta_lat_lon_elevmeters.txt**

In this section we will:

3. Determine UTM zone for the stations
4. Determine UTM coordinates based on one UTM zone and export to file
5. Convert the UTM coordinates to lat/lon and export to file

Note that there are only a few stations, so it would also be feasible and potentially easier to find the UTM coordinates via Google Earth instead. Use your own judgement in doing the simplest, least-problematic approach for future efforts

In [1]:
```
#required imports and packages for the steps below

import numpy as np
import pandas as pd
from pyproj import Proj
```

```
In [2]: ### load a file already containing station information ####
maindir='/Users/eliberg/Research/Deployments/SAND_Guide/LatLonUTM_Notebooks'#main directory working within
inputfile=maindir+'/StationLists/      ExampleDeployment_sta_lat_lon_elevmeters.txt'
df=pd.read_csv(inputfile,sep=' ',index_col=False)#space-delimited file
outpath=maindir+'/StationLists' #where to put output files
###################################################################
print('input file \n',inputfile,'\n contains:')
display(df)


# get utm zone

def zone(coordinates):
    #from: https://gist.github.com/twpayne/4409500#file-utm-py-L23
    if 56 <= coordinates[1] < 64 and 3 <= coordinates[0] < 12:
        return 32
    if 72 <= coordinates[1] < 84 and 0 <= coordinates[0] < 42:
        if coordinates[0] < 9:
            return 31
        elif coordinates[0] < 21:
            return 33
        elif coordinates[0] < 33:
            return 35
        return 37
    tmpval=int((coordinates[0] + 180) / 6) + 1
    tmptxt='%d'%(tmpval)
    if coordinates[1]>0:
       letter='N'
    else:
       letter='S'

    return tmptxt+letter
    #return tmpval


#probably don't need this, but just in case..
def letter(coordinates):
    return 'CDEFGHJKLMNPQRSTUVWXX'[int((coordinates[1] + 80) / 8)]

#go through the entire dataframe
def get_utm_array(df):
    utmzone = []
    #utmletter=[]
    for lat, lon in zip(df['Lat'], df['Lon']):
        utmzone.append(zone([lon,lat]))
        #utmletter.append(letter([lon,lat])) #don't need this..

    df['utm_zone'] = utmzone
    #df['utm_letter']=utmletter

    return df

# get the UTM zone and letter!
df=get_utm_array(df)
display(df)


#check all utm zones are the same..
print('\n')
utmzonetmp=df['utm_zone'].iloc[0]
print('checking all coordinates have the same utm, using: ',utmzonetmp)
print('\n')
print('Coordinates with a different utm (should be empty dataframe):')
print(df.loc[df['utm_zone'] != utmzonetmp])
```

```
input file
 /Users/eliberg/Research/Deployments/SAND_Guide/LatLonUTM_Notebooks/StationLists/      ExampleDeployment_sta_lat_lon_e
levmeters.txt
 contains:
```

	Sta	Lat	Lon	elev_meters
0	101	34.950505	-106.459695	1832
1	102	34.950448	-106.459659	1832
2	201	34.950479	-106.459571	1832
3	202	34.950508	-106.459501	1833

	Sta	Lat	Lon	elev_meters	utm_zone
0	101	34.950505	-106.459695	1832	13N
1	102	34.950448	-106.459659	1832	13N
2	201	34.950479	-106.459571	1832	13N
3	202	34.950508	-106.459501	1833	13N

```
checking all coordinates have the same utm, using:  13N


Coordinates with a different utm (should be empty dataframe):
Empty DataFrame
Columns: [Sta, Lat, Lon, elev_meters, utm_zone]
Index: []
```

Convert to UTM coordinates with the same zone

In [3]:
```
### use the zone from the first line of the dataframe.. ###
utmzone=df['utm_zone'].iloc[0][:-1]
print('Using UTM zone: ',utmzone)

#set up the projection..
myproj = Proj(proj='utm',zone=utmzone,ellps='WGS84', preserve_units=False)
###########################################################


### hard code the zone ####
#myproj = Proj(proj='utm',zone=13,ellps='WGS84', preserve_units=False)
###########################################################

def get_utmx_utmy_coordinates(df):
    utmx = []
    utmy = []
    for lat, lon in zip(df['Lat'], df['Lon']):
        UTMx, UTMy = myproj(lon, lat)
        utmx.append(UTMx)
        utmy.append(UTMy)

    df['UTMEast'] = utmx
    df['UTMNorth'] = utmy

    return df

df=get_utmx_utmy_coordinates(df)

print('obtained UTM coordinates! ')
print('all information: ')
display(df)

#write to file, containing Sta UTMEast UTMNorth Elev_m
outfile='      ExampleDeployment_sta_utmE_utmN_elevM_utm%s.txt'%utmzone
df.to_csv(outpath+'/'+outfile,sep=' ',index=False,float_format='%.3f',
          columns=['Sta','UTMEast','UTMNorth','elev_meters','utm_zone'])

print('wrote results to file: \n',outpath,'/ \n',outfile)
```

```
Using UTM zone:  13
obtained UTM coordinates!
all information:
```

	Sta	Lat	Lon	elev_meters	utm_zone	UTMEast	UTMNorth
0	101	34.950505	-106.459695	1832	13N	366715.262233	3.868527e+06
1	102	34.950448	-106.459659	1832	13N	366718.457358	3.868521e+06
2	201	34.950479	-106.459571	1832	13N	366726.543430	3.868524e+06
3	202	34.950508	-106.459501	1833	13N	366732.982556	3.868527e+06

```
wrote results to file:
 /Users/eliberg/Research/Deployments/SAND_Guide/LatLonUTM_Notebooks/StationLists /
      ExampleDeployment_sta_utmE_utmN_elevM_utm13.txt
```

Convert from UTM to Lat/Lon

This is useful if a series of stations were created from an initial estimated UTM coordinates, and the lat/lon is required for Navigator applications

In [4]:
```
#convert from UTM northing and easting to lat/lon

#utmzone=13 #note, you can state the utmzone of the inputfile
### UPDATE THE FILE!!! ###
inputfile=outpath+'/     ExampleDeployment_sta_utmE_utmN_elevM_utm%s.txt'%utmzone
##########################
print('inputfile: ',inputfile)


dfutm=pd.read_csv(inputfile,sep=' ',index_col=False)
print('read in dataframe dfutm: ')
display(dfutm)

### pick single UTM zone if listed in the file.. ###
#use UTM zone from first row of data in file (if available)
utmzone=dfutm['utm_zone'].iloc[0][:-1]
##############################################

### hardcode UTM zone (comment this out if using above section) ###
#utmzone=13
##############################################

print('using utmzone: ',utmzone)
myProj = Proj(proj='utm',zone=utmzone,ellps='WGS84', preserve_units=False)

#get the lat/lon
lon,lat=myProj(df['UTMEast'].values, df['UTMNorth'].values, inverse=True)
dfutm['Lon']=lon
dfutm['Lat']=lat

#show the results
print('converted to lat/lon from UTM coordinates, dataframe dfutm: ')
display(dfutm)

### output all results to file.. Update the columns and filename as needed! ###
outfile='     ExampleDeployment_sta_estimatedFromUTMZone%s_Lat_Lon.txt'%(utmzone)
df.to_csv(outpath+'/'+outfile,sep=' ',index=False,float_format='%.6f',
         columns=['Sta','Lat','Lon'])
##############################################################################

print('output results to file: \n',outpath+'/ \n'+outfile)
```

```
inputfile:  /Users/eliberg/Research/Deployments/SAND_Guide/LatLonUTM_Notebooks/StationLists/      ExampleDeployment_st
a_utmE_utmN_elevM_utm13.txt
read in dataframe dfutm:
```

	Sta	UTMEast	UTMNorth	elev_meters	utm_zone
0	101	366715.262	3868527.028	1832	13N
1	102	366718.457	3868520.658	1832	13N
2	201	366726.543	3868523.979	1832	13N
3	202	366732.983	3868527.102	1833	13N

```
using utmzone:  13
converted to lat/lon from UTM coordinates, dataframe dfutm:
```

	Sta	UTMEast	UTMNorth	elev_meters	utm_zone	Lon	Lat
0	101	366715.262	3868527.028	1832	13N	-106.459695	34.950505
1	102	366718.457	3868520.658	1832	13N	-106.459659	34.950448
2	201	366726.543	3868523.979	1832	13N	-106.459571	34.950479
3	202	366732.983	3868527.102	1833	13N	-106.459501	34.950508

```
output results to file:
 /Users/eliberg/Research/Deployments/SAND_Guide/LatLonUTM_Notebooks/StationLists/
     ExampleDeployment_sta_estimatedFromUTMZone13_Lat_Lon.txt
```

End of Python File (Jupyter Notebook):
LatLonUTM_Notebooks/
ExampleDeployment_UTMZoneCoordinates_fromLatLon.ipynb

7. HOW TO CONVERT FCNT DATA FILES TO MSEED AND REMOVE RESPONSE

To obtain the correct response file to create a StationXML inventory for any Fairfield deployment of nodes, the settings described in ‘Before going into the field’ in Sect 2.1 are required. With this information, the response file can be obtained from IRIS’s Nominal Response Library, or NRL, maintained by Templeton (2017) and accessed using the NRL Client from the Obspy toolbox version 1.2.2 (Beyreuther et al., 2010; Krischer et al., 2015).

The tool to read in the FCNT files, formatted specifically to Fairfield ZLand nodes, is provided by Chambers & Pestourie (2022) as part of the Receiver Gather 1.6-1 format reader in Obspy toolbox version 1.2.2 (Beyreuther et al., 2010; Krischer et al., 2015).

All full Jupyter Notebooks are available from the Sandia National Labs’ CEE-GitLab SetupExtractionNodeData page as part of the SeismoAcousticDeploymentStandards group. The information provided should be sufficient for external users to create their own versions for full deployments from the Quick Example (see Section 7.2) functions.

7.1. FCNT to MSEED, Obtaining StationXML Inventory, and Removing Response for an Entire Deployment

However, the brief example is not suitable for converting data from an entire deployment. Instead, to see how to convert multiple data files and build a StationXML for the ***entire*** deployment, please see the Jupyter Notebook ExampleDeployment_FCNTtoMSEED.ipynb within the FCNTtoMSEED_Notebooks directory on GitLab under SeismoAcousticDataStandards/FairfieldNodes, or use the Quick Example below as a guide to create your own set of jupyter notebooks. The station azimuth and dip settings used in this notebook are taken from the seismic standard, as described by Behr et al. (2018).

Similarly, to see how to remove the instrument response for multiple mseed files, please see the Jupyter Notebook ExampleDeployment_MSEED_RemoveResponse.ipynb within the FCNTtoMSEED_Notebooks directory on GitLab.

7.2. Quick Example of FCNT to MSEED Conversion and Removing Response for a Single FCNT file

Below shows a brief example of how to read in a fcnt data file, convert to mseed format, and, finally, remove the response. This content is created via a Python Jupyter Notebook, which is also available on GitLab.

Python File (Jupyter Notebook):
FCNTtoMSEED_Notebooks/QuickExample/

QuickExample_FCNTtoMSEED_RmResp.ipynb

Example Deployment Response

Quick Example from FCNT to Removed

Compiled by Elizabeth M. Berg

This notebook reviews:

1. How to create a StationXML file with example metadata
2. Converting any fcnt file to mseed
3. Removing the instrument response from an mseed file

Required files :

1. Information regarding the system settings used for the deployment (from the **'Before going into the field'** notes)
2. An example FCNT file

The output of converted files will be:

1. Data: QuickExample.net.sta.chan.mseed
2. Metadata (including response attached): QuickExample.xml

Useful Links:

1. Removing the response in Obspy Examples for various response file formats: https://docs.obspy.org/tutorial/code_snippets/seismometer_correction_simulation.html
2. Obspy remove_response function: https://docs.obspy.org/packages/autogen/obspy.core.trace.Trace.remove_response.html
3. StationXML file creation information: https://docs.obspy.org/tutorial/code_snippets/stationxml_file_from_scratch.html
4. Reading Fairfield Waveforms: https://docs.obspy.org/master/packages/obspy.io.rg16.html
5. Station orientation default info: https://ds.iris.edu/mda/YB/MOJA/00/BHN/?starttime=2018-04-24&endtime=2020-06-13

In [1]:

```
import numpy as np
import obspy
import datetime
from obspy.core.utcdatetime import UTCDateTime
import pandas as pd
import os
import matplotlib
import matplotlib.pyplot as plt

import glob
from obspy.core.inventory import Inventory, Network, Station, Channel, Site
from obspy import read_inventory

from obspy.clients.nrl import NRL

import copy

mdir='/Users/eliberg/Research/Deployments/SAND_Guide'
```

Obtain Response Information from NRL

```
In [2]: nrl = NRL()
        print(nrl)
        print(nrl.sensors)
        print(nrl.dataloggers)


        # testing getting the correct sensor information
        print(nrl.sensors['Magseis Fairfield'])
        print(nrl.sensors['Magseis Fairfield']['Generation 2'])
        print(nrl.sensors['Magseis Fairfield']['Generation 2']['5 Hz'])

        # testing getting the correct datalogger information
        print(nrl.dataloggers['Magseis Fairfield'])
        print(nrl.dataloggers['Magseis Fairfield']['Zland 1C or 3C'])
        print(nrl.dataloggers['Magseis Fairfield']['Zland 1C or 3C']['18 dB (8)'])
        print(nrl.dataloggers['Magseis Fairfield']['Zland 1C or 3C']['18 dB (8)']['500'])
        print(nrl.dataloggers['Magseis Fairfield']['Zland 1C or 3C']['18 dB (8)']['500']['Linear Phase'])
        print(nrl.dataloggers['Magseis Fairfield']['Zland 1C or 3C']['18 dB (8)']['500']['Linear Phase']['Off'])


        #final keys used to pull the response for the sensor and datalogger
        sensorkeys=['Magseis Fairfield','Generation 2','5 Hz']
        dataloggerkeys=['Magseis Fairfield','Zland 1C or 3C','18 dB (8)','500','Linear Phase','Off']

        response=nrl.get_response(sensor_keys=sensorkeys,datalogger_keys=dataloggerkeys)
        print(response)
```

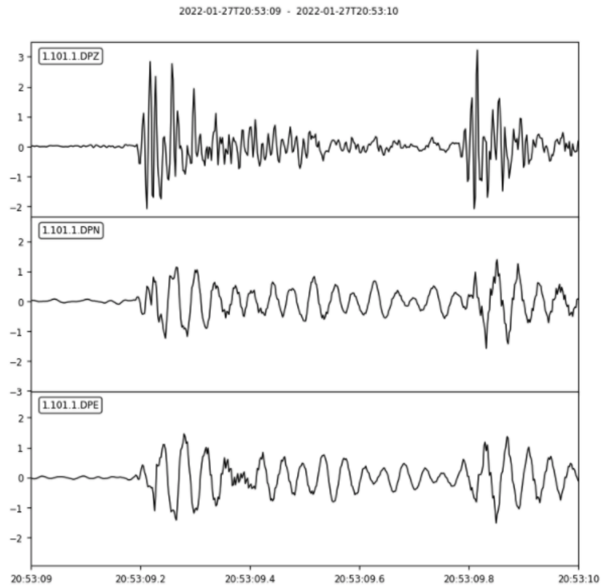
[Output of this section Not Included for Brevity; see GitLab Jupyter Notebooks for full output]

Read in an FCNT file and write to MSEED format

```
In [3]: fcntdir=mdir+'/FCNTtoMSEED_Notebooks/QuickExample'

        #where to put mseed file and inv
        outdir=mdir+'/FCNTtoMSEED_Notebooks/QuickExample'


        #pick a random fcnt file..
        filename=fcntdir+'/101.0.0.fcnt'

        print(filename)
        #snag the metadata from the fcnt file..
        # get starttime and endtime
        st = obspy.read(filename, format='rg16', headonly=True,contacts_north=True)
        print(st[0].stats)
        print(st)

        starttimeall = st[0].stats.starttime
        difftime=0
        for ii in np.arange(1,len(st)):
            difftimetmp=st[ii].stats.endtime-starttimeall
            if difftimetmp>difftime:
                difftime=difftimetmp

        endtimeall=starttimeall+datetime.timedelta(seconds=difftime)


        print('Starttime of FCNT file: ',starttimeall)
        print('Endtime of FCNT file: ',endtimeall)
        print('total seconds of file: ',difftime)
        print('total minutes of file: ',difftime/60)
        print('total hours of file: ',difftime/60/60)
        print('total days of file: ',difftime/60/60/24)

        ndays=np.floor(difftime/60/60/24)+1 #number of days to loop over..
        print('#days to loop over: ',ndays)

        oneday=datetime.timedelta(days=1)
```

```python
#loop through each day..
for dayidx in np.arange(ndays):

    starttimetmp=starttimeall #update at end of loop..
    cktime=starttimeall+oneday

    if cktime>endtimeall:
        endtimetmp=endtimeall
    else:
        endtimetmp=cktime

    print('starttime for this section: ',starttimetmp)
    print('endtime for this section: ',endtimetmp)

    #ACTUALLY READ IN SOME DATA
    st = obspy.read(filename, format='rg16', starttime=starttimetmp,
                endtime=endtimetmp, merge=True, contacts_north=True)


    break #one day for testing

print(st[0].stats)

zoomtime1=UTCDateTime('2022-1-27T20:53:09')
zoomtime2=UTCDateTime('2022-1-27T20:53:10')

st.plot(starttime=zoomtime1,endtime=zoomtime2)


for tr in st:


    writenet=str(tr.stats['network'])
    writechan=tr.stats['channel']
    writesta=str(tr.stats['station'])


    wfile=writenet+'.'+writesta+'.'+writechan+'.mseed'
    print(wfile,'\n\n')
    #fileswritten.append(writesta+'/'+wfile)

    tr.write(filename=outdir+'/QuickExample.'+wfile,format='MSEED')
    print('wrote trace to file!')
    break
```

```
/Users/eliberg/Research/Deployments/SAND_Guide/FCNTtoMSEED_Notebooks/QuickExample/101.0.0.fcnt
         network: 1
         station: 101
        location: 1
         channel: DPN
       starttime: 2022-01-27T19:03:52.026000Z
         endtime: 2022-01-27T19:04:22.024000Z
   sampling_rate: 500.0
           delta: 0.002
            npts: 15000
           calib: 1.0
         _format: RG16
1161 Trace(s) in Stream:

1.101.1.DPN | 2022-01-27T19:03:52.026000Z - 2022-01-27T19:04:22.024000Z | 500.0 Hz, 15000 samples
...
(1159 other traces)
...
1.101.1.DPZ | 2022-01-27T22:16:52.026000Z - 2022-01-27T22:17:22.024000Z | 500.0 Hz, 15000 samples

[Use "print(Stream.__str__(extended=True))" to print all Traces]
Starttime of FCNT file:  2022-01-27T19:03:52.026000Z
Endtime of FCNT file:  2022-01-27T22:17:22.024000Z
total seconds of file:  11609.998
total minutes of file:  193.49996666666667
total hours of file:  3.2249994444444443
total days of file:  0.13437497685185185
#days to loop over:  1.0
starttime for this section:  2022-01-27T19:03:52.026000Z
endtime for this section:  2022-01-27T22:17:22.024000Z
         network: 1
         station: 101
        location: 1
         channel: DPE
       starttime: 2022-01-27T19:03:52.026000Z
         endtime: 2022-01-27T22:17:22.024000Z
   sampling_rate: 500.0
           delta: 0.002
            npts: 5805000
           calib: 1.0
         _format: RG16
      processing: ['ObsPy 1.2.2: trim(endtime=None::fill_value=None::nearest_sample=True::pad=False::starttime=UTCDat
eTime(2022, 1, 27, 19, 3, 52, 26000))', 'ObsPy 1.2.2: trim(endtime=UTCDateTime(2022, 1, 27, 22, 17, 22, 24000)::fill_
value=None::nearest_sample=True::pad=False::starttime=None)']
```




```
1.101.DPE.mseed

wrote trace to file!
```

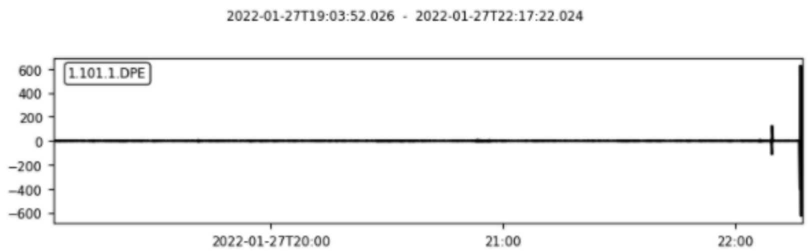
In [4]:

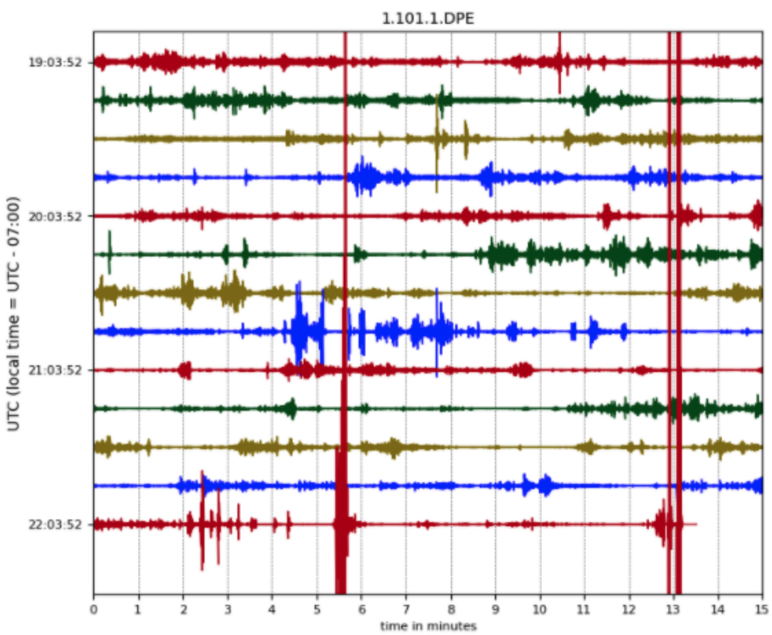
```python
inv = Inventory(
    # We'll add networks later.
    networks=[],
    # The source should be the id whoever create the file.
    source="E Berg IRIS NRL Test of Responses")

net = Network(
    # This is the network code according to the SEED standard.
    code=tr.stats['network'],
    # A list of stations. We'll add one later.
    stations=[],
    description="A test stations.",
    # Start-and end dates are optional.
    #start_date=obspy.UTCDateTime(2016, 1, 2))
    )

sta = Station(
    # This is the station code according to the SEED standard.
    code=writesta,
    latitude=1.0,
    longitude=2.0,
    elevation=345.0,
    creation_date=obspy.UTCDateTime(tr.stats['starttime']),
    site=Site(name="First station"))

cha = Channel(
    # This is the channel code according to the SEED standard.
    code=tr.stats['channel'],
    # This is the location code according to the SEED standard.
    location_code=tr.stats['location'],
    # Note that these coordinates can differ from the station coordinates.
    latitude=1.0,
    longitude=2.0,
    elevation=345.0,
    depth=10.0,
    azimuth=0.0,
    dip=-90.0,
    sample_rate=tr.stats['sampling_rate'])

cha.response = response
sta.channels.append(cha)
net.stations.append(sta)
inv.networks.append(net)

inv.write(outdir+"/QuickExample.xml", format="stationxml", validate=True)
```

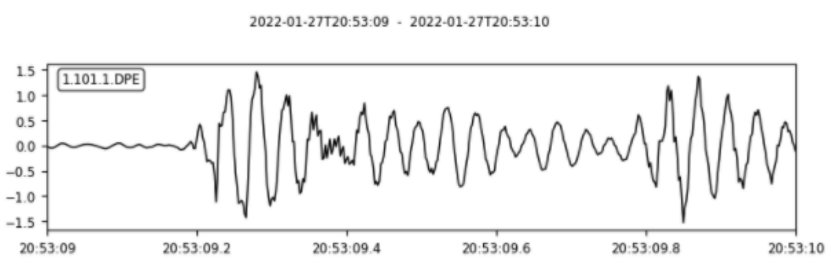
Look at Raw MSEED file Results to Check

In [5]:
```python
print(outdir+'/QuickExample.'+wfile)

testraw=obspy.read(outdir+'/QuickExample.'+wfile)

#using tmp= to suppress double output in jupyter notebook
tmp=testraw.plot()
tmp=testraw.plot(type='dayplot')
tmp=testraw.plot(starttime=zoomtime1,endtime=zoomtime2)
```

```
/Users/eliberg/Research/Deployments/SAND_Guide/FCNTtoMSEED_Notebooks/QuickExample/QuickExample.1.101.DPE.mseed

/Users/eliberg/Research/Deployments/SAND_Guide/FCNTtoMSEED_Notebooks/QuickExample/QuickExample.1.101.DPE.mseed
```



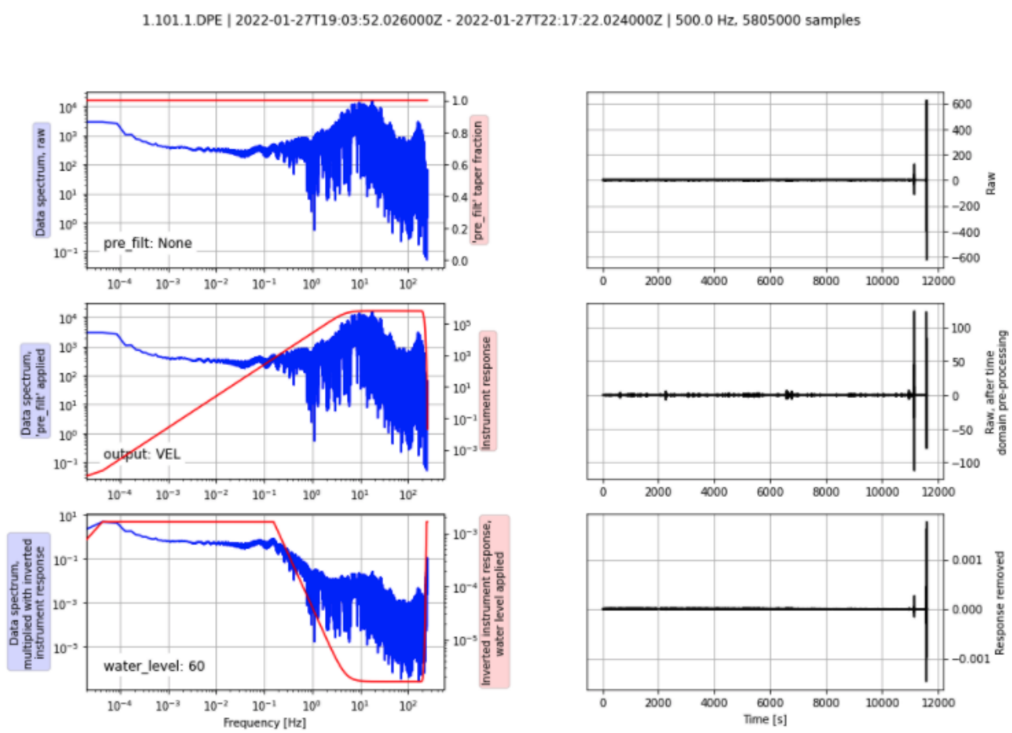




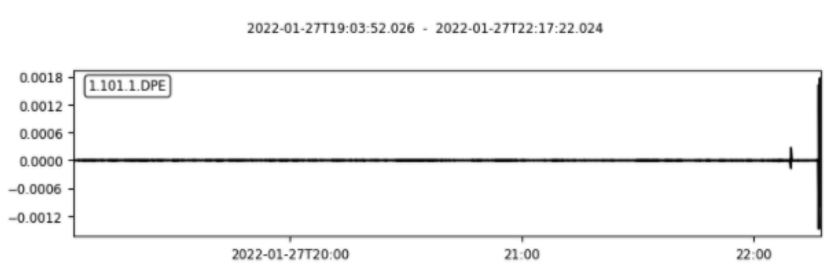
Remove the Response using the Inventory

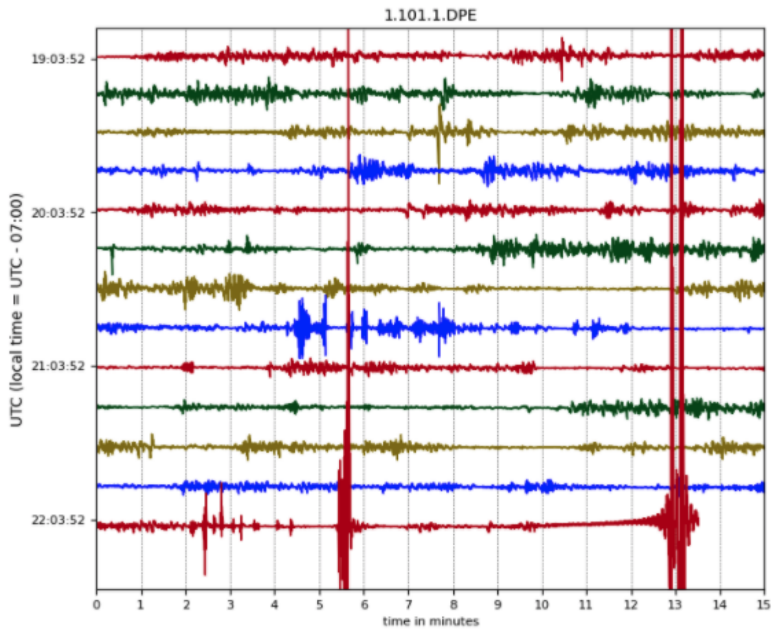
In [6]:
```
#read in the xml inventory
testinv=obspy.read_inventory(outdir+'/QuickExample.xml')

testrr=copy.deepcopy(testraw)
#############################
### Preprocessing ###
testrr.detrend('demean') #demean
testrr.detrend('linear') #detrend
#############################

#############################
### remove the resonse ###

#remove response without a filter; plot the results (you can add a pre-filter and a taper here, if preferred)
#more information: https://docs.obspy.org/packages/autogen/obspy.core.trace.Trace.remove_response.html
testrr.remove_response(inventory=testinv,output='VEL',plot=True) #remove response, output to Vel in m/s, no pre-filter

testrr.write(outdir+'/RemovedResp_QuickExample_'+wfile)
```

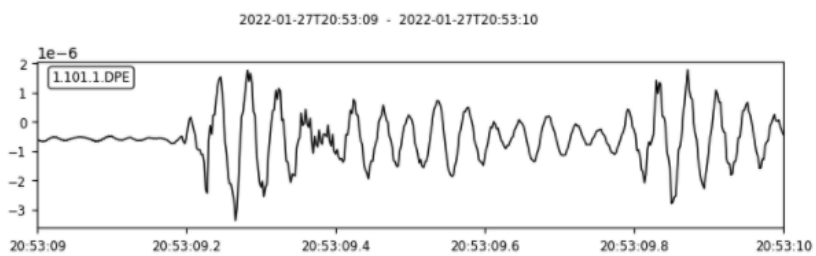
```
/Users/eliberg/opt/anaconda3/envs/FCNT_env/lib/python3.8/site-packages/obspy/io/mseed/core.py:790: UserWarning: The e
ncoding specified in trace.stats.mseed.encoding does not match the dtype of the data.
A suitable encoding will be chosen.
  warnings.warn(msg, UserWarning)
```



In [7]:
```
#Plot the data after removing the instrument response
tmp=testrr.plot()
tmp=testrr.plot(type='dayplot')
tmp=testrr.plot(starttime=zoomtime1,endtime=zoomtime2)
```







End of Python File (Jupyter Notebook):
FCNTtoMSEED_Notebooks/QuickExample/
QuickExample_FCNTtoMSEED_RmResp.ipynb

APPENDIX A. CONDENSED INFORMATION TO PROVIDE PI'S

This section is the condensed information to provide and communicate to PI's.

A.1. Station Lists

Inform the PI's that a station list will be required of them that at a minimum will look like:

```
Line Station Lat Lon
1 101 48.6330 -93.9667
```

If provided in this format, you will need to estimate UTM coordinates.

Alternatively, request a UTM coordinates station list that includes elevation. The same UTM zone needs to be used across all coordinates, and the format needs to by a WGS1984 coordinate system. This would look like:

```
Line Sta UTMEast UTMNorth elev
R1 101 366715.262 3868527.028 1832
R1 102 366718.457 3868520.658 1832
R2 201 366726.543 3868523.979 1832
```

See Sect 2.3.1 for more information on station lists.

A.2. Before going into the field

1. Dates & Equipment Used: _________________

2. Principal Investigator: __________________

3. HHT(s) used from inventory:

4. Directory on computer running Fairfield software with rec.txt and Fairfield-generated files: ____

5. Job Name within Fairfield software: ___________________

6. Fairfield Software settings for this job:

   a. UTM Zone: _______
   b. Sampling Rate: _________
   c. Other settings. *Unless requested differently, settings will be set to:*
      Pre-amp gain: 18dB Nyquist filter: Linear phase
      Low-cut filter: none DC offset removal: yes

7. Suggested magnetic declination for this area (from NOAA): ________
8. Required materials for the field:
   a. Field Notebook
   b. Compass (1 per team)
   c. Level (1 per team minimum)
   d. Shovel or Post-Hole Digger (if burying nodes)
   e. Connector for the Handheld Trimble to Node Connector
   f. Handheld Trimble Wall Charger
   g. Handheld Trimble Stylus
   h. Survey flags to mark buried node locations

A.3. Field Deployment Information

Deployment Schematic

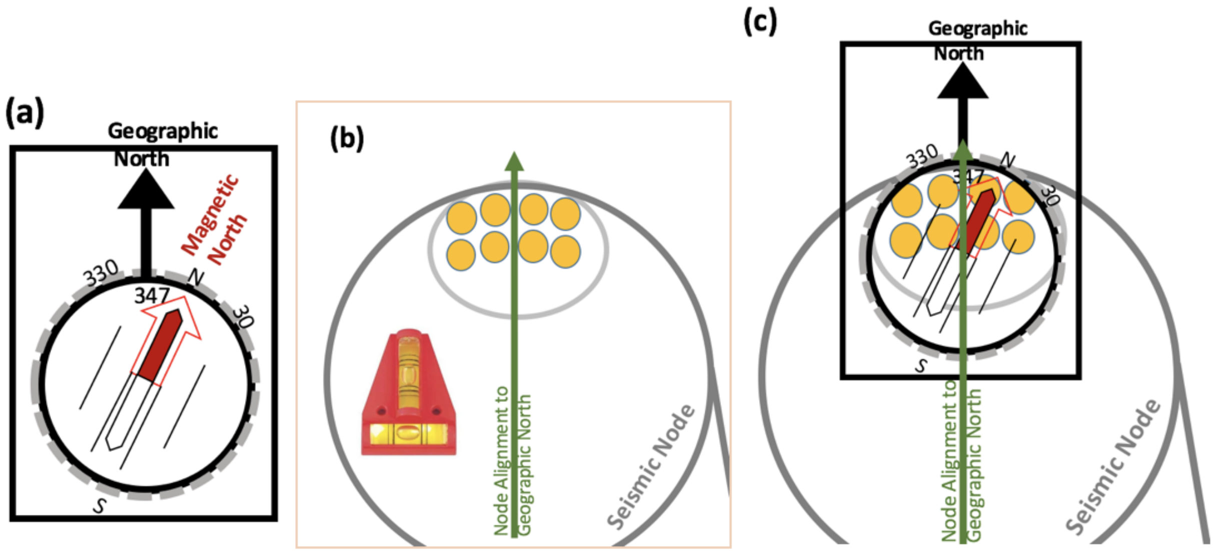


Figure A-1 (a) Demonstration on how to orient a compass for Salt Lake City, Utah (declination of 347.5º). (b) Seismic nodal instrument showing how the instrument should be oriented to geographic north, with a line corresponding to geographic north going through the middle of the pins, and how the bubble level should appear (both bubbles centered). (c) Overlay of compass above the node to clarify nodal orientation; note that the compass should be ≥ 1.5 feet above the node to prevent the mechanical components within the instrument from affecting the magnetic reading.

In the field **Magnetic declination used** (see NOAA page/app): _________

For each node:

Line #: _________ Station #: __________ Node # (last 4 digits): __________

Latitude°, Longitude°, Elevation: ____

Start Time & Date (circle: Local or UTC): ____________________

To start the node from a pre-planned station:

6. *Connect the HHT to the node (you should hear a click)*
7. *On the HHT: Open FieldTool Mobile program, and then select the line & station you want for this node (drag the cursor over the station to view and select Line:Station information)*
8. *On the HHT, in the bottom toolbar: RU > Deploy.*
9. *If you have an error on the station being 'out of bounds,' turn off the GPS via: GPS > Disconnect*
   Then repeat steps 2-3
10. *WAIT until the Resistance test is complete, click ok, and then you should hear 'Starting Operation,' and the selected station should turn from yellow to green in the handheld. Now it is safe to disconnect the node from the HHT. Note that if the 'Auto-Deploy' is turned on in the field and resulting in an error during deployment, go into the Settings and turn off this feature.*

To start a node at a new Line/Station not pre-planned:

5. *Make sure the GPS is connected (on the Trimble in the FieldTool Mobile Program, GPS > Connect)*
6. *Connect the HHT to the node (should hear a click)*
7. *On the HHT: Map > Add Line / Station (from the lower toolbar). Create a line and station number, and then hit 'Ok.' Make sure the added Line/Station does NOT already exist!*
8. *Follow step 5 above for a pre-planned station.*

Is the node recording?

The station will change from a single blink every second (standby) to a 3-blink in fast succession (recording) once the node has a GPS satellite lock. This can take a couple of minutes.

General Notes about the Site (buried/unburied, coupling, site conditions, etc.):

____

____

Pick Up Time & Date (circle: Local or UTC): ____________________

Were Nodes 'Stopped' on the Trimble (Circle: Y / N)

Note, stopping the nodes may be beneficial, if wanting to use data recorded directly prior to pick-up and not worry about clock drift.

To Stop Recording for a node from the HHT:

1. *Connect the Trimble to the Node*
2. *Select the appropriate station for that node on the Trimble*
3. *RU > Stop (the green station should then turn blue on the Trimble)*

Ongoing Succinct Field Notes Magnetic declination: ______

Line #: __________ Station #: __________ Node # (last 4 digits): __________

Latitude°, Longitude°, Elevation: ____

Start Time & Date (circle: Local or UTC): ____________________ Photo Taken: (Y / N)

General Notes about the Site (buried/unburied, coupling, site conditions, etc.):

____

____

Pick Up Time & Date (circle: Local or UTC): ____________________

Were Nodes 'Stopped' on the Trimble (Circle: Y / N)

Line #: __________ Station #: __________ Node # (last 4 digits): __________

Latitude°, Longitude°, Elevation: ____

Start Time & Date (circle: Local or UTC): ____________________ Photo Taken: (Y / N)

General Notes about the Site (buried/unburied, coupling, site conditions, etc.):

____

____

Pick Up Time & Date (circle: Local or UTC): ____________________

Were Nodes 'Stopped' on the Trimble (Circle: Y / N)

Line #: __________ Station #: __________ Node # (last 4 digits): __________

Latitude°, Longitude°, Elevation: ____

Start Time & Date (circle: Local or UTC): ____________________ Photo Taken: (Y / N)

General Notes about the Site (buried/unburied, coupling, site conditions, etc.):

____

____

Pick Up Time & Date (circle: Local or UTC): ____________________ Photo Taken: (Y / N)

Were Nodes 'Stopped' on the Trimble (Circle: Y / N)

A.4. Post Deployment Information

Directory with raw fcnt files on the computer running Fairfield software:___________________

Files Available for PI's (on External HardDrive PI provides):

1. Fcnt raw files

2.1. Mseed files containing the raw data with the format:
Station / UTC_datetime.Network.Station.Channel.mseed

2.2 Mseed files with instrument response removed formatted and processed as preferred by PI (with or without preprocessing demean and detrend steps, and with or without tapering and filtering)

2.2 StationXML file with metadata information. .

Information (Jupyter Notebooks) on converting FCNT raw files to MSEED format and removing the instrument response is covered in Section 7.

APPENDIX B. EXPERIENCED USER FAIRFIELD SOFTWARE GUIDE

B.1. Quick Guide: Deployment Plan in Fairfield Software

If you are already familiar with using the Fairfield software, please continue with this Quick Guide for Experienced Users. If you are unfamiliar with the software, or require clarification on any of the steps below, please see Section 2.4.1 for a more detailed overview.

B.1.1. Quick Guide: Charging Nodes

Steps:

1. Turn on Windows machine and start the HarvestManagementConsole program.

2. Turn on the node rack and open the 'Rack View' in the HarvestManagementConsole program (access via double-clicking *Rack* in *Racks Overview* from the *System Dashboard*).

3. Dock all nodes. There should be an audible click if correctly docked. It will take a few minutes for the rack to detect and work with the nodes.

4. View Lights on dock (red/green and flashing/not flashing)

5. See the 'Rack View' in the HarvestManagementConsole program for information on node status. Should be charged, data extracted, and show 'RTD' when ready-to-deploy.

If there are issues with docking the nodes, see the 4 trouble-shooting steps below:

1. From *Task Manager* [Ctrl Shift Esc] under *Services* make sure all ZLand programs are running, which is easily viewed by sorting by Name to obtain reverse-alphabetical order. If some ZLand programs are not running, right click and start them manually.

2. Disconnect and reconnect the node from the rack. You may find success by disconnecting and reconnecting the node from the rack after each of the suggestions below, too.

2. Soft reset in *Rack View*: Select a device with an error, right-click, *View Docking Processor*, select 'Soft Reset' option. If the unit is not being detected, also try *'Reboot Docking Processor'* from this page. Go back to Rack View to see if the problem is resolved (will take a few minutes).

3. If error persists, right click, select *View Docking Processor*, and then select 'Hard Reset.'

4. Lastly, right click the device and select *Bypass Deployment QC*.

5. If you see an error that says, *'RU attachment without USB connection'* then select the device in *Rack View*, select *View Docking Processor* followed by 'Reboot Docking Processor'

6. If the trouble persists, try attaching this node to another spot on the rack. Also check the pins for this location on the rack, and that the pin connection points of the node are clear of debris.

B.1.2. *Quick Guide: Receiver and Shot Files*

Make a folder to contain the deployment information on the computer running the Fairfield software. This is typically located *System (C): Jobs* > *YourJobDirectoryName*.

Place the previously created receiver (and shot / source, if previously created) file (rec.txt) into this directory and note the name of the directory for this job in the 'Before going into the field' notes under Item 4 in Section 2.1.

Use the Notepad program to ensure the spacing and line separations are consistent with the original station file, as often there is a discrepancy between Windows and Mac/Linux operating systems.

If a source file is not already available, create one (src.txt) in the same directory. Note that the first line from the receiver file can be used to create the source file.

Example Receiver file, rec.txt:

Line Station UTMEast UTMNorth ElevMeters
R1 101 524889.0 4567891.0 1412
R1 102 524889.0 4567892.0 1412
R1 103 524889.0 4567894.0 1412

Example Source file (contains only the header and first line of the Receiver file), *src.txt*:

Line Station UTMEast UTMNorth ElevMeters
S1 101 524889.0 4567891.0 1412

B.1.3. *Quick Guide: Creating a Job*

Open HarvestManagementConsole.

From the *System Dashboard,* select 'Job Overview' on the right, close all Active Jobs via the X.

1. Set the Folder (typically located within *System (C): Jobs*)

If a folder for this job DOES exist:
Select *New Job* → *Jobs* → Select previously created folder for this job

If folder for job does NOT yet exist:
Select *New Job* → *Jobs* → Create a folder for this job

Make sure the Directory of the job is listed in the 'Before going into the field' notes (see Section 2.1) under Item 4.

2. Check receiver and shot files

Check that rec.txt and src.txt are in this folder.
If not, add them via File Explorer and edit in Notebook (see Section 2.3.4).

3. Job Settings

Create Job → Add name and crew name

Note the 'Name' of the job in the 'Before going into the field' notes (see Section 2.1) under Item 5.

4. Add source and receiver files

Select *Custom File Format with fixed width*

Set the Project coordinates via the Projected Coordinate System ... Option: Projected Coordinate Systems > UTM > WGS 1984 > (Hemisphere of Choice) > (UTM Zone of choice; e.g., WGS 1984 UTM Zone 13N.prj).
This was previously determined to create the source and receiver text files.
Note this information under Item 6a in the 'Before going into the field' notes (Section 2.1).

Add the shot and receiver files

Highlight fields from the shot and receiver files; Deselect Point Code

No relation file needed for passive study

Hit Next (*Do NOT select Preview Map, but allow the 'Creating GIS map' to generate which may take some time*)

If Create GIS map fails, remove any files created directly by the Fairfield software in the *System (C): Jobs > YourJobDirectoryName* directory you created and try again.

5. Node settings

Actions > Edit Receiver Group > Select > Internal 3C

Set Internal, Interval, and Gain Settings (include in Sect 2.1 'Before going into the field' Items 6b-c, as this is critical in removing the instrument response from the raw data following the deployment):

- Receiver group: Internal 3C
- Sampling Interval: *set according to PI preference*
- Pre-amp gain: 18dB or PI preference (18dB found to work well from Jamie Farrell and University of Utah for ambient noise and active geyser studies)
- Nyquist filter: Linear Phase
- Low-cut filter: (Low cut filter disabled); leave box unchecked
- DC offset removal: Check box to remove DC Offset

Source > Edit > Record Length 30s *(Note this page is not as important)*

Don't add anything to the Aux Groups and Parameters Page

Set acquisition / duration schedule (set to Continuous); make sure survey-in mode is selected

Leave Output Media Requirements as-is

Review the Summary of Job; Set as Active Job, and click Finish

6. Create a map in ArcGIS

    From the *System Dashboard* in *Job Overview* select ‘GIS Map’

    Make sure that you are zoomed out to the range preferred by the PI to ensure the field crew can add stations if needed. Stations can only be added if located within the preset area seen in the ArcGIS map.

B.1.4. Quick Guide: Uploading the Job to the HHT

1. Plug the HHT into the computer.

    This should be done after charging the HHT to the point of being able to turn on and battery last long enough (≥ 50%) for the duration of this process.

2. Make sure the HHT is connected in the Windows Mobile Device Center.

    If this is not appearing, disconnect the HHT, make sure it is turned on, make sure the HHT’s Field Tool Mobile application is not currently on (open and then close it), and then reconnect the HHT.

    If issue persists, make sure the program is running in the Windows Task Manager and repeat the previous steps.
    You may also need to reset the HHT, and/or the computer.

3. Open the ArcGIS map that was just created, if not already open.

    Harvest Management Console > Job Overview > GIS Map

    Reminder: Make sure the view of the stations looks correct and zoom out if needed for the deployment.

4. Activate the HHT

    Right Click on ‘Mobile’ in top *left* corner in the Layers tab and select ‘Activate’

    Nothing will happen, but this is a critical step. Wait a few seconds to ensure this is registered.

    Reminder: Make sure the view of the stations looks correct and zoom out if needed for the deployment.

5. Load to the HHT

    - Select *Load HHT* button in the top toolbar. This looks like a small yellow HHT.
      This will take a while, so be patient, but a pop-up menu labeled ‘Load HHT 2’ will appear.
    - From the pop-up menu, select UTC time and the desired tolerances (set the deployment tolerance according to preference from the PI. A good default is 10m up to 100m).

The Resistance test information is not required to be saved by the those deploying the instruments in the field, but the numbers should be non-zero if the station is operating correctly. This also functions as a visual queue of a successfully started station during fieldwork.

- Select *Load HHT* to finalize from the pop-up window.
  After completing, hit Done.
- Close and Save Changes to the ArcGIS map.
- Unplug the HHT from the computer.
- From the HHT, open the Field Tool Mobile application and check the deployment map looks correct. If needed, repeat the steps above with a more zoomed out map.
- Make sure to denote which HHT the job was uploaded to in item 3 of the 'Before going into the field' notes (see Section 2.1).

B.2. Quick Guide: Harvesting Data

First, turn on the rack and Windows machine containing the Fairfield software. Please see the detailed section (4.1.1) for clarification. Before starting, please create the folder where you want the final data exported. This is typically located in the *Data (Z): > Completed Jobs* area, to accommodate the large size of data from deployments, and note this directory information for future reference.

B.2.1. Quick Guide: Sync Metadata

To extract data from the instruments, first:

1. Ensure the correct job is activated

   See: *Job Overview > Active Job …*

2. Sync the HHT

   1. Close FieldToolMobile on HHT

   2. Plug in HHT, make sure it is connected via Windows Mobile Device Center

      See 'Uploading the Job to the HHT' in Sect 2.4.1 or Sect 2.4.2 and Figure 2-16 for more information.

   3. Open 'GIS Map' from the *Job Overview* area in the HarvestManagement Console

   4. Press *HHT Sync* button on toolbar in ArcGIS
      Deployed/collected stations should change color from the pre-planned stations

B.2.2. Download data from the nodes

1. Connect nodes to rack

2. Make sure data has downloaded in Rack View and no errors occurred

See 'Charging Nodes' in Sect 2.4.1 or Sect 2.4.2 and Figure 2-2 for an overview of docking the units and checking / troubleshooting errors.

3. Make sure the harvest process is complete and ALL nodes have collected data. Check all stations were associated with the Job via *System > View Unreconciled Deployments*. If there is anything listed for this Job, see the instructions immediately below.

> If nodes were ADDED in the field, get information on the added node number, line number and station number, and perform the following steps:
>
> *3.1 Write down the Line# and Point# for the Unreconciled Station. If available, also obtain approximate UTM coordinates.*
>
> *3.2 Create and edit a copy of the rec.txt file in the original System(C:) > Jobs > Your_job_folder. Add the Unreconciled station information to this file. If overlapping with another station, that's ok, just note which station(s) to add for the following steps.*
>
> *3.3 From the HarvestManagement Console in the Job Overview section, select 'Import Additional Preplanned File' and fill out as needed. Select Import and check things look correct.*
>
> *3.4 From the 'Receiver Groups and Params' select 'Add a New Receiver Group' and update the parameters as needed (also update the station color so it is easier to see selected stations). Select the station(s) to add with the polygon tool and hit ok.*
>
> *3.5 Make sure the total Station Count on the Receiver Groups and Params page is accurate and hit Next. Otherwise, repeat the 'Add a New Receiver Group' to select missed stations.*
>
> *3.3 Confirm that you would like to import unreconciled deployments into this job.*
>
> *3.4 Select 'Import All' on the 'Unreconciled Deployments' page that appears.*

4. Create a folder named 'harvested' in this project's Z-drive job folder (*Data (Z): > Completed Jobs > YourCompletedJob)*.

5. Go to harvest management console, and at the bottom left click 'Job Explorer' tab.

6. Right-click on Shot Management (under your Job) and select Shooting Simulation.

7. Select all devices (checkbox). Press Shoot.

9. Go to Media Output Console (separate program from HarvestManagement Console).

10. Select your current job and click on the green plus sign.

11. Name your plan and select Fairfield continuous output file format.

12. Click on *Create New Selection*.

13. Select all the stations in the line (*Select All > Update*)
Selected Station Count should match the number of recorded stations.

14. Set Record Trace length (30000 ms) and click Save Changes.

15. Click on the disk icon (Save to New Storage Unit) and write to your empty 'harvested' folder (*Data (Z): > Completed Jobs > YourCompletedJob > harvested*). Use either the Ordered File Number (does not create subfolders) or the Standard File Naming convention (will create subfolders).

16. Also, export the Files Report via:

Storage Units > View Output Files Report (looks like a file)

Export Data

Select All, change to Your Folder on the Z drive and Save

Check the csv file looks ok (Notepad or Excel)

This enables connect station # and line # to .fcnt filename.

B.2.3. Quick Guide: Data Visualization

To See Collected Data within the Fairfield software (only do this for short data collections, as you can overload the system):

1. Open Seismic Visualization Tool
2. On the left-hand tab select your job > Harvest folder
3. Double click on an .fcnt file

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