Instruction Manual

GK-604D|*aos*

Inclinometer Readout Application

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1. INTRODUCTION

The GK-604D is made up of four components: An Inclinometer Probe, the Readout Unit, the Remote Module, and a Pulley Assembly.

1.1 Inclinometer Probe

The standard model is the 6100D digital probe (Figure 1).

Figure 1 - 6100D Digital Probe

Features Include:

- Waterproof, stainless steel housing.
- Rubber cushion on base to reduce shock.
- Superior quality, hermetically sealed connector with gold plated pins.
- Protective cap for connector when not in use.
- Replaceable wheels.
- Model 6100D Digital Probes feature a built-in compass.

1.2 Readout Unit

The Android readout unit and Remote Module components communicate wirelessly. This simplifies the handling of the system in the field as well as simplifying the transfer of data to your PC workstation for final analysis.

Features Include:
- Users will feel familiar with the Android operating system that is common to many smart phones.
- Long battery life, easily charged with micro USB cable.
- Ease of use.

1.2.1 GK-604D|aos Inclinometer Readout Application

The "GK-604D|aos" inclinometer readout application (shown in Figure 2) installs on devices running a minimum Android version of 4.0.3 and is designed to communicate wirelessly with Remote Modules connected to digital probes, both MEMS and force-balance type.

For users with existing analog probes that are connected through an interface unit, GK-604-4 or via the GK-604-3 reel system, the GK-604D|aos application will continue to read this discontinued hardware.

Figure 2 - Android Field Device Running GK-604D|aos

1.2.2 Before Using the GK-604D|aos

The readout software runs as an application under the Android operating system (minimum of 4.03) installed on a smart phone or other Android device.

- The user should familiarize themselves with Android and the device running it.

- It is assumed in the instructions below that the user can launch applications on the Android device (including file manager applications) and manage wireless settings.

- It is assumed that the user can use the on-screen keyboard to enter text and numbers.

- Please refer to the Maintenance requirements in Section 6.

1.3 Remote Module

The GK-604D Remote Module is housed in a weatherproof reel enclosure containing the cable (Figure 3), which connects directly to the inclinometer probe (Figure 1). The Readout Unit and Remote Module components communicate wirelessly. This simplifies the handling of the system in the field as well as simplifying the transfer of data to your PC workstation for final analysis.

For digital probes, the Remote Module is fully contained within the reel as depicted by.

Figure 3 - GK-604D Remote Module

Features Include:
- Lightweight
- Easy to use, one button operation.
- Rugged
- Lithium battery (Eight plus hours of continuous use)
- Automatic power down when the wireless connection is dropped or after several minutes of inactivity.
- Reliable connection to standard inclinometer probes (shown in Figure 1) is accomplished via model 6001-2 control cable (Figure 4), which features a lightweight, polyurethane jacket and is 8 mm in diameter. The control cable contains a central stainless steel aircraft wire and has breaking strength of 500 lb.

Figure 4 - Model 6001-2 Control Cable

1.4 Pulley Assembly

A pulley assembly (Figure 5) is used to grip the control cable. The pulley places no stress on the cable markers and removes any tendency for markers to slip over the cable as when using cable holds.

Figure 5 - Pulley Style Cable Grip

The pulley assembly is designed to fit casing sold by Geokon but will also fit most casings that have an internal diameter between 82 mm (3.25") and 59 mm (2.33"). When using casing that has an approximate I.D. of 76 mm (3"), the pulley assembly may be set directly into the top of the casing without adjustment. For all other casing sizes, complete the following:

Using the screwdriver provided, turn each of the **three** adjustment screws counter-clockwise, until they are recessed enough to allow the outer collar to be removed. Figure 6 and Figure 7 shows the collar removal sequence.

Figure 6 - Turn Adjustment Screws

Figure 7 - Remove Outer Collar

Next, turn the adjustment screws clockwise until they are set so that the cable hold will fit into the casing with as little movement as possible when it is seated. (All three screws should protrude approximately the same amount; this ensures that the pulley assembly is centered in the casing.) Figure 8 shows the adjustment screws at their full extension.

Figure 8 - Adjustment Screws Extended

2. INSTALLATION AND OPERATION

The steps described in Section 2.1 are an attempt to guide the user through the process of launching the GK-604D|aos, connecting to the probe and taking a survey. The steps below attempt to cover all cases and refer the user to the appropriate section of this manual when more information is needed.

2.1 Initial Start Sequence

The following steps are a guide to the typical operation of the "GK-604D|aos" and, if followed, should result in a successful "hole" survey being taken. **NOTE:** Always make sure that the inclinometer probe is attached to the reel before attempting the start sequence below.

1) If the Remote Module has not been previously connected to the Android field device or if a new wireless pairing is needed, please see Section 2.2 (Establishing Contact with the Remote Module).

2) Launch the GK-604D|aos by tapping on the "Apps" icon from the main screen of the Android device, then tap the "GK-604D aos" icon. If the GK-604D|aos application has not been installed, please see Section 2.3 (Installing the GK-604D|aos).

3) If the Initial Screen (Figure 9) is displayed instead of the Main Screen (Figure 10), please refer to Section 2.4 (Starting the GK-604D|aos app for the first time) before continuing to Step 4.
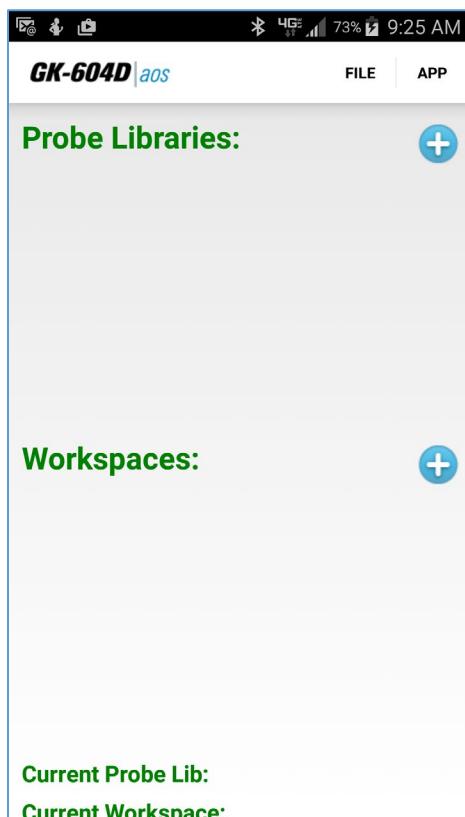
Figure 9 - Initial Screen
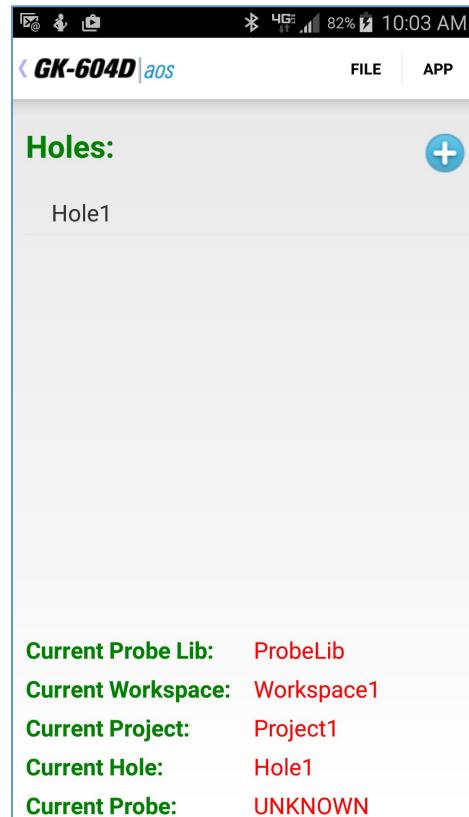
Figure 10 - Main Screen

4) If the Inclinometer System is a digital system (probe model numbers 6100D-E and 6100D-M), any new "probe" will be discovered upon connection to the Remote Module (covered in later steps).

5) At this point the "Main" screen should be displayed (Figure 10), a "Project" and "Hole" should have been created and/or selected.
If connecting to a digital system for the first-time, please select "UNKNOWN" for the hole parameter, "Probe Name:". If not the first-time connecting, skip to step eight.
If connecting to an analog system for the first-time, a "Probe" should have already been created in the Probe Library and the Probe's name selected for the current hole's "Probe Name:" parameter. If not the first-time connecting skip to step eight.

6) If one is not selected already, select a hole by tapping on one of the holes listed in the main screen, then tap "Select" from the resulting popup menu.

7) Insure that the correct wireless pairing is selected by tapping on "APP" then "System Configuration". From the System Configuration screen, make sure that the "Bluetooth Connection" parameter matches the current Remote Module to be connected to. If the Remote Module does not appear as a selection in the "Bluetooth Connection" "picker control, please refer to Section 2.2 for more information regarding wireless pairing. Dismiss the System Configuration screen.

8) Press the button labeled "POWER ON" on the Remote Module. A blue light should come on and start to blink, signifying that the Remote Module is waiting to connect to the android device.

9) From the "Main" screen tap the "APP" button. Start the connection process by tapping on the "Live Readings" button. Tap on "OK" from the resulting reminder prompt (Figure 11).
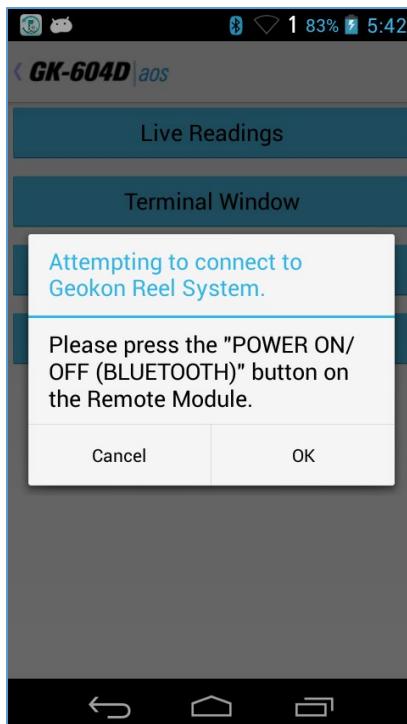
Figure 11 - Remote Module Power-On Reminder

If the Remote Module fails to connect with the Android device, the screen shown in Figure 12 will be displayed, indicating that the Remote Module is no longer trying to connect (timed out), that the wireless pairing is associated with another device, or that Bluetooth is disabled. Make sure the proper device is selected in the System Configuration settings then try again.
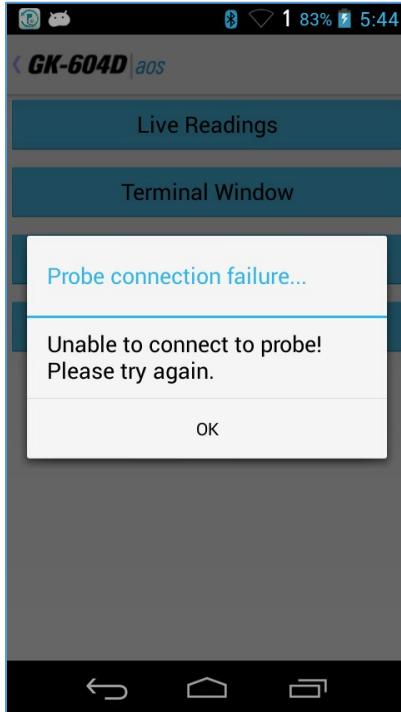
Figure 12 - Remote Module Connection Problem

After a few seconds, the blue light on the Remote Module should stop flashing and change to a steady state of blue. If connecting to a system that was previously connected, the Live Readings Screen will be displayed (Figure 13). Skip to step 10.
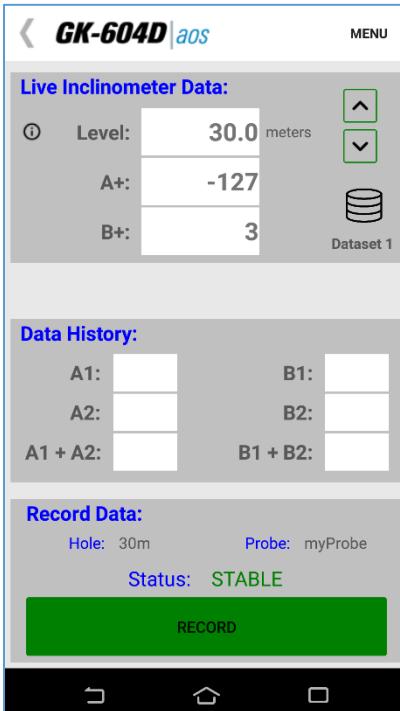
Figure 13 - Live Readings Screen

If connecting to a digital system for the first time (or the probe has changed):

a. If the window shown in Figure 14 is displayed, then the probe has not been previously detected by the GK-604D|aos. In this case, tapping "Yes" will cause the probe to be added to the Probe Library and the Probe Settings screen shown in Figure 15 to be displayed. This allows an opportunity to give the newly detected probe a user-friendly name and description. (See Section 4.2, Probe Configuration for more information on probe settings.)

When satisfied with the settings, tap "<" in the upper-left corner of the screen to exit (and save) the Probe Settings screen.
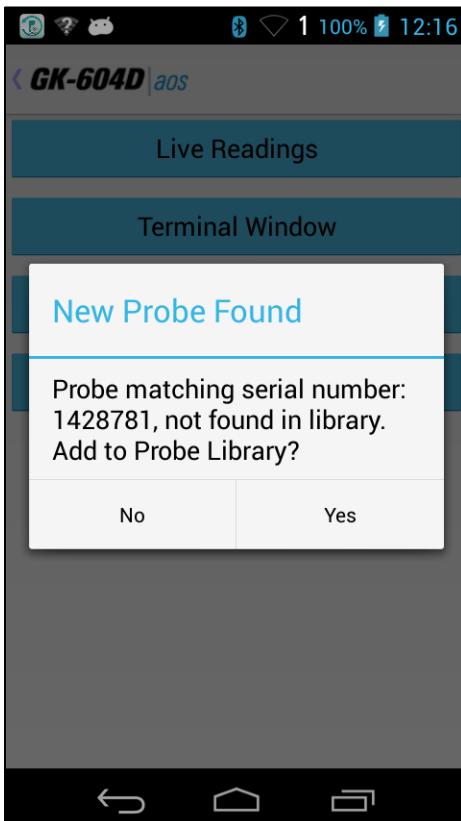
Figure 14 - New Probe Found
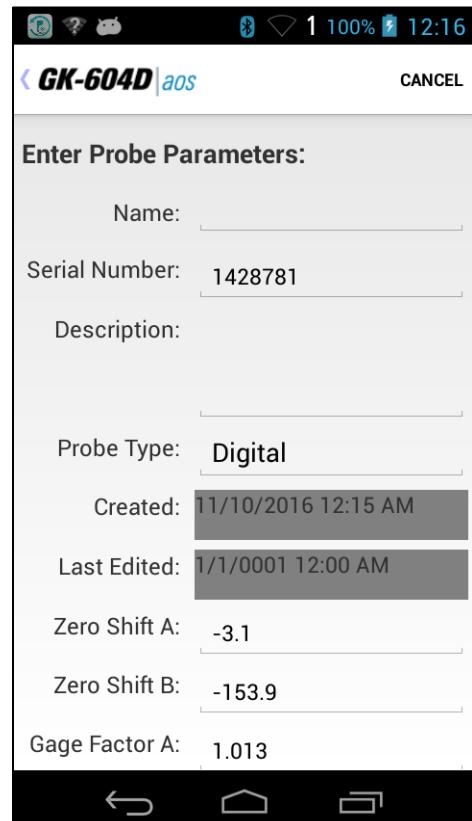
Figure 15 - Initial Probe Settings

Because the Probe Name parameter was set to "UNKNOWN" in step five, the window in Figure 16 will be displayed, allowing the name of the probe just found to be saved into the current hole configuration.
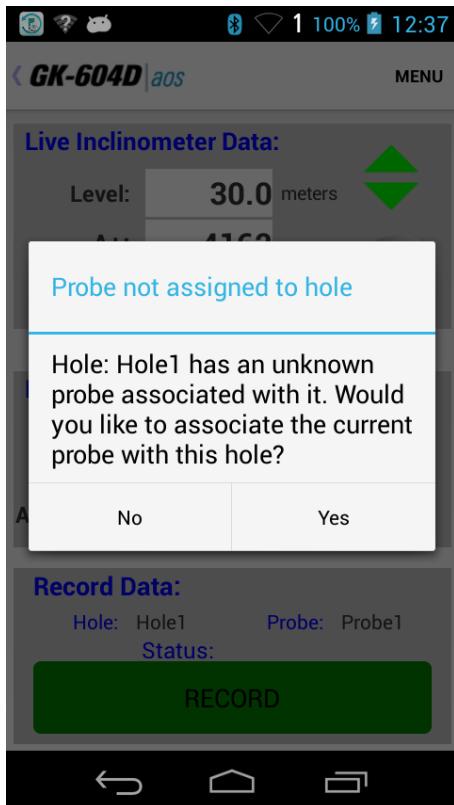
Figure 16 - No Probe Association Screen

b.   The Live Readings Screen will be displayed (Figure 17).
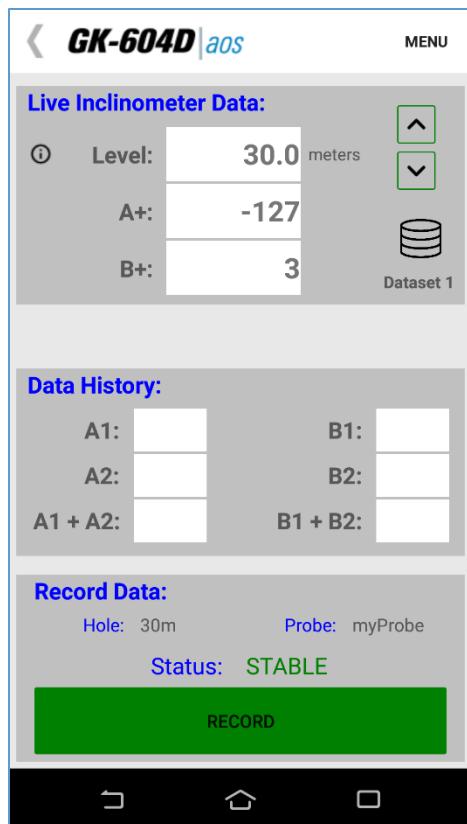
Figure 17 - Live Readings Screen

10) Refer to Section 3.2.1 for more information about taking a survey using the Live Readings window. Also refer to Section A.2 for information regarding the mechanical process of taking a survey.

11) After performing a survey, any saved data corresponding to a particular hole survey may be reviewed and/or reports generated by tapping the "File" menu then "View Data". See Section 3.3.3 for more information about the View Data option.

12) Raw data files may be exported to a file system folder of the user's choosing by tapping on "File" then "Export data to file". See Section 3.3.1 for more information regarding data export options.

13) To close the GK-604D|aos, tap on the Android "Recent Apps" button, then dismiss the GK-604D|aos application.

2.2 Establishing Contact with the Remote Module

The procedure below should be done once for each Remote Module that the Android device will be communicating with. Follow the steps below to ensure the wireless pairing with the Remote Module is established before using the readout application:

1) Enter the Settings screen of the Android device (see Figure 18). Insure that the slider next to the "Bluetooth" parameter is set to "ON". Tap "Bluetooth" to begin setting up a Bluetooth "partnership" (**Note**: For some Android versions the Bluetooth On/Off control may only appear on the Bluetooth Pairing screen (see Figure 19 in step two).
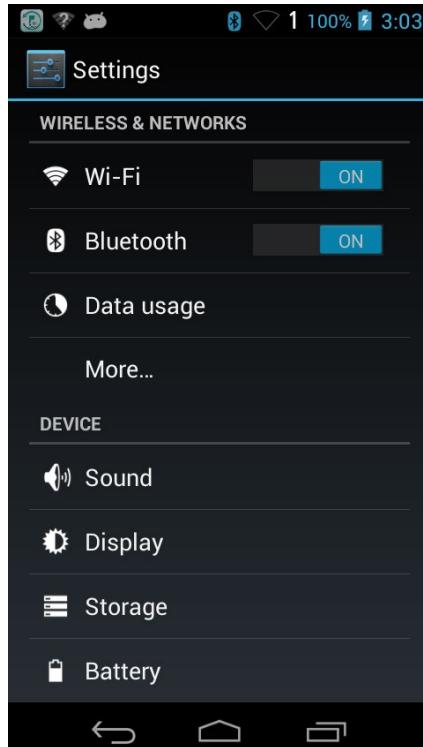
Figure 18 - Android Device Settings Screen

2) Press the button labeled "POWER ON" on the Remote Module before tapping "SEARCH FOR DEVICES" from the Bluetooth Pairing screen (Figure 19) to instruct the Android device to begin searching for available wireless devices to pair with.
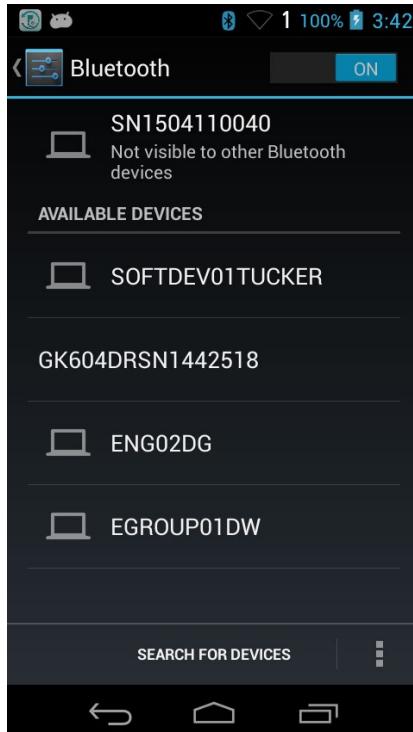
Figure 19 - Bluetooth Pairing Screen

3) Geokon Remote Modules typically have device names that start with "GK604DRSN" followed by the serial number of the reel. (Figure 19 shows an example device called "GK604DRSN1442518".) Tap on the device to begin the pairing process (Figure 20).
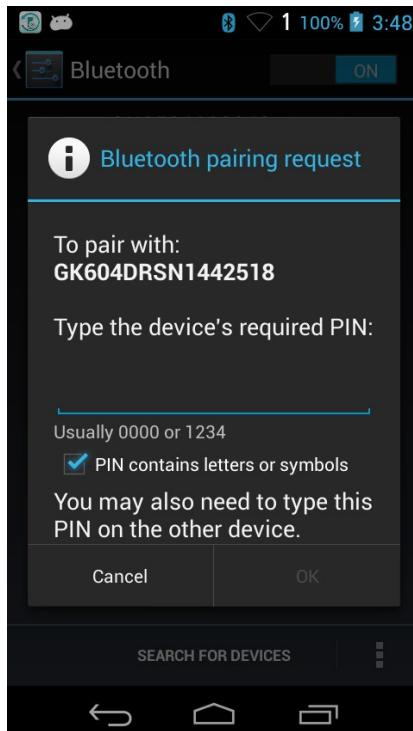
Figure 20 - Bluetooth Pairing Request Screen

Where requested, enter the PIN "default" and tap "OK". If the device pairing is successful, then the new paired device will be displayed under "Paired Devices" in the Bluetooth setting screen as shown in Figure 21.
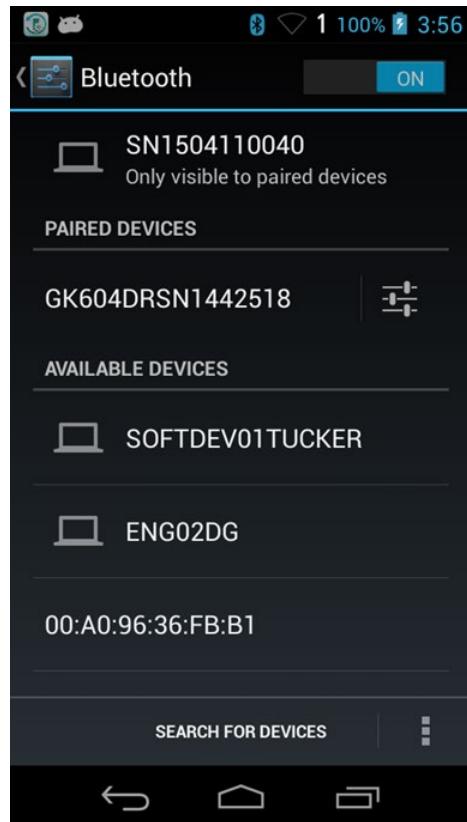
Figure 21 - Paired Devices

2.3 Installing the GK-604D|aos Application

The installation of the GK-604D|aos Application requires the following:

- Android device with cell phone capability (and data plan) or wireless internet connection to allow access to Google Play store. Alternatively, a USB connection from the Android device to a host PC, allowing file transfer of the application ".apk" install file.

- Android device with version 4.0.3 (Ice Cream Sandwich) or higher operating system.

- The Android device must have at least 50 Mbytes of free memory and be Bluetooth enabled.

2.3.1 Installing GK-604D|aos from Google Play store

From the Android device, tap on the "Google Play Store" icon: to launch Google Play application (see Figure 22).
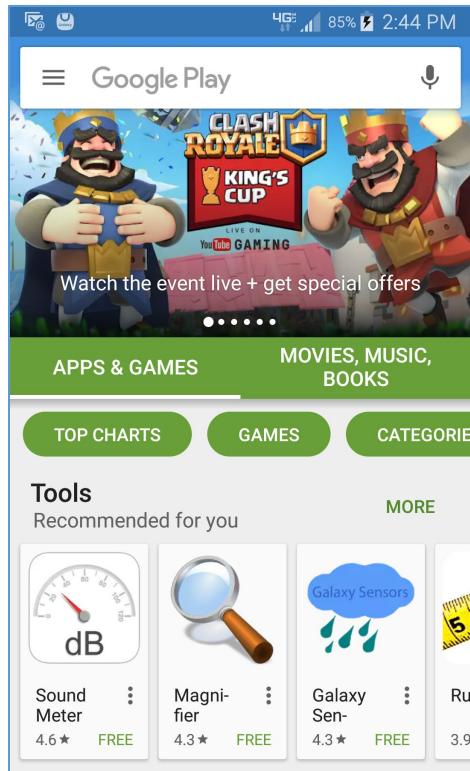
Figure 22 - Google Play Store Application

Search for "GEOKON" and select the "GK-604D|aos Inclinometer App" from the search results. Tap "Install" to begin the installation process. Follow the on-screen instructions to finish the GK-604D|aos application.
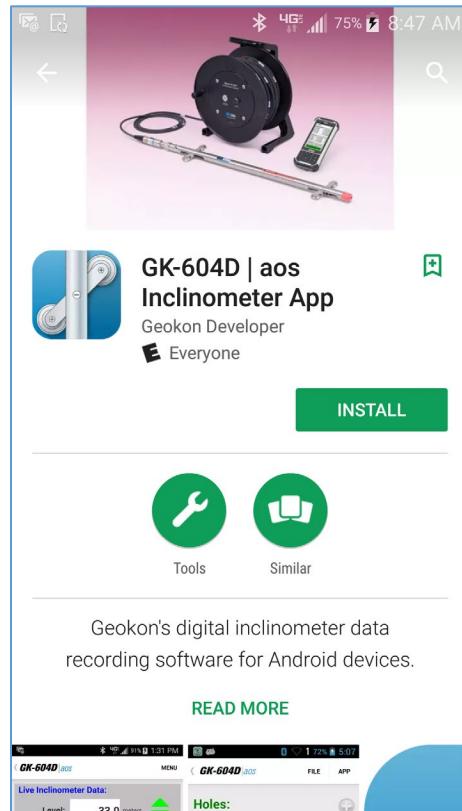
Figure 23 - Geokon GK-604D|aos Install Screen

2.3.2 Installing GK-604D|aos via USB Link to Host PC

The GK-604D|aos application can also be installed by copying an Android Application Package (.apk) file to the Android device from a host PC. The process is as follows:

1) Download the zipped installer from Geokon's software download webpage. File is called: "com.geokon.GK_604Daos-Aligned.zip ".

2) Open a Windows Explorer window and unzip the downloaded GK-604D|aos installer.

3) Copy this installer (com.geokon.GK_604Daos-Aligned.apk) to a directory on the Android device that can be easily accessed from the device's internal File Manager such as "Card" or "External Storage".

   Note: directory names can vary with different versions of Android as well as different manufacturers of Android devices.

4) Disconnect the USB cable from the PC to the Android device.

5) Using an Android file manager application, find the file copied from the PC and tap on it to start the install process.

6) If asked, select "Complete action using Package Installer".

7) Follow the on-screen instructions to finish the install.

Note: For customers using a PC running Window 10 operating system; Windows Mobile Device Center (WMDC) may no longer operate as it should because of an operating system update (released October of 2017) called "Fall Creator Update". If WMDC no longer launches when a mobile device is connected via USB cable or will not manually launch, the link below should help fix the issue. Please note that administrative privileges are need to launch some of the files involved in the fix so your local IT person may need to be involved. The fix can be accessed via the following link:
https://www.handheldgroup.com/support-rugged-computers/knowledgebase-KB/22996/

Should the link above fail to fix the WMDC launch problem, the link below offers another possible solution:
http://www.junipersys.com/Juniper-Systems-Rugged-Handheld-Computers/support/Knowledge-Base/Support-Knowledge-Base-Topics/Desktop-Connection-ActiveSync-or-Windows-Mobile-Device-Center/WMDC-in-Windows-10

2.4 Starting the GK-604D|aos for the first time

The readout software is launched by tapping the Android "Apps" icon:

Followed by the "GK-604 aos" icon:

When starting the GK-604D|aos application for the first time, the screen shown in Figure 24 will be displayed.
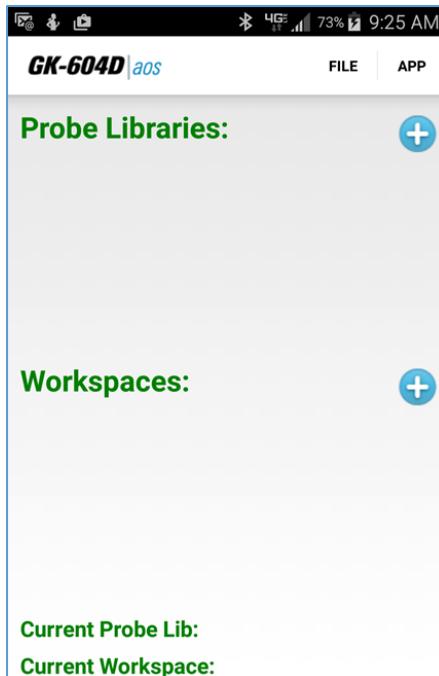
Figure 24 - Initial Screen

The GK-604D|aos uses "Workspaces" as the primary storage for "work". In the case of the GK-604D|aos, "work" consists of individual "projects" where hole configuration and data are stored. Much like "Workspaces", "Probe Libraries" are where probe configurations are stored.

Initially no workspaces or probe libraries will be defined. A new workspace can be created by tapping the "+" sign immediately to the right of the green "Workspaces:" label. Doing so causes the Workspace Settings screen to be displayed (see Figure 25).

The workspace name parameter can be any combination of letters and numbers, should be descriptive in nature and is the only required parameter for a workspace. After creation, this name will be displayed in the "Workspaces" list. Any number of workspaces can be created. The Workspace Settings screen is saved and dismissed by tapping the "<" symbol in the upper-left hand corner of the screen.
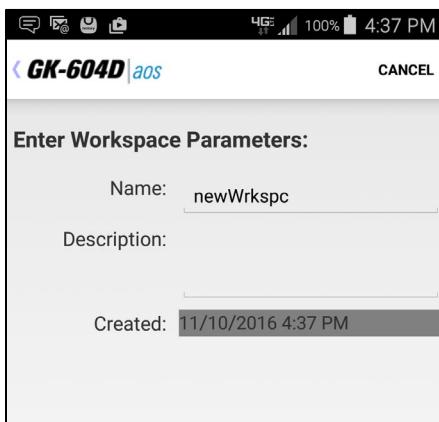
Figure 25 - Workspace Settings Screen

After the workspace has been created, a probe library should be created in a similar fashion to the workspace. The Probe Library Settings screen is shown in Figure 26. Just as with the workspace, the probe library name is the only required parameter.
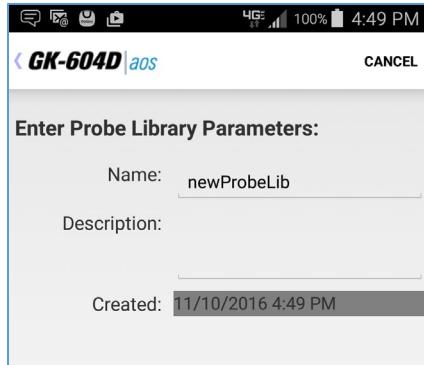
Figure 26 - Probe Library Settings Screen

The Probe Library Settings screen is saved and dismissed by tapping the "<" symbol in the upper-left hand corner of the screen. After creation, this probe library name will be displayed in the "Probe Libraries:" list. With both workspaces and probe libraries, the name parameter must be unique.

For Analog Inclinometer Systems only: A probe should be created in the new probe library at this time. Tapping on the new probe library's name in the "Probe Libraries" list causes a popup menu to be displayed. Tap "Select" from this menu to cause the Probes screen to be displayed. See Section 4.2 for more information about probe configuration.

After the initial workspace and probe library are created (Figure 27) the new workspace should be selected to advance the program flow to the Projects screen. Select a workspace by tapping on a name in the "Workspaces:" list. Tap "Select" as shown in Figure 28, causing the Projects screen to be displayed (Figure 29 on the following page).
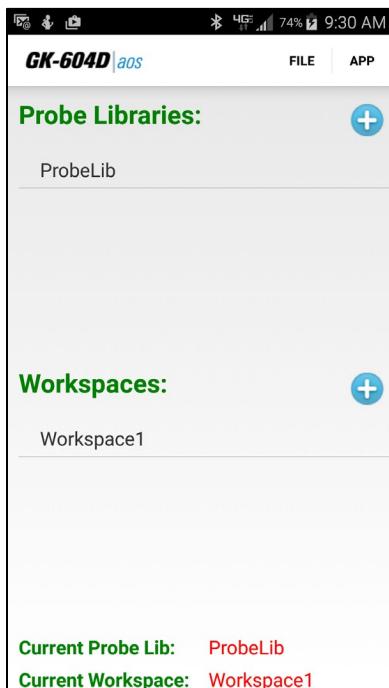
Figure 27 - Workspace and Probe Library Created
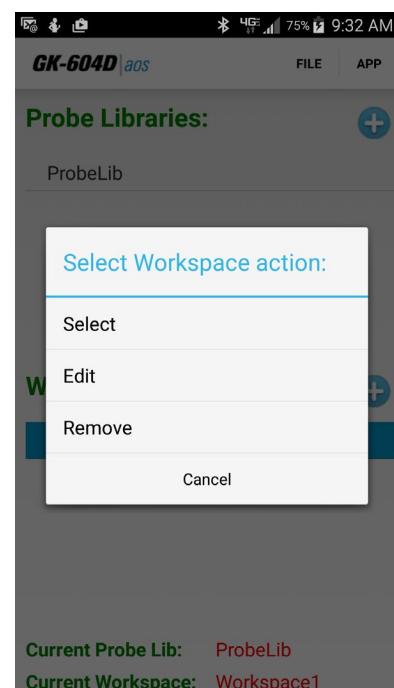
Figure 28 - Select Workspace
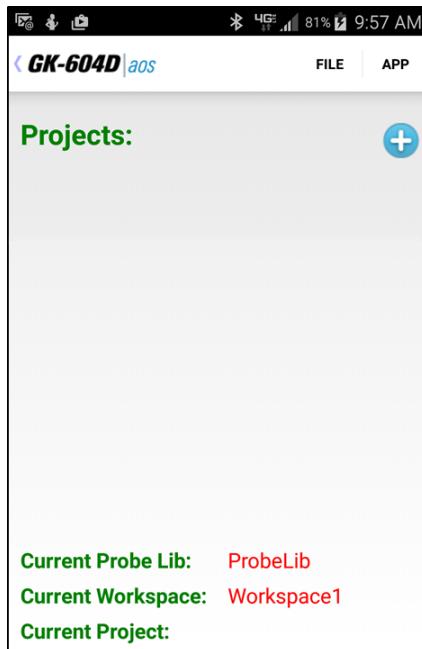
Figure 29 - Projects Screen

Figure 29 shows the Projects screen with the newly created workspace and probe library displayed as "Current Workspace:" and "Current Probe Library:" respectively. Notice that there are no projects in the "Projects" list and no "Current Project". New projects can be added to the current workspace by tapping on the "+" sign to the right of the green "Projects:" label. As with workspaces and probe libraries, the only required parameter for projects is "Name". The Project Settings screen is saved and dismissed by tapping the "<" symbol in the upper-left hand corner of the screen.

After dismissing the Projects Settings screen, select the new project by tapping on the new project name in the "Projects" list. Tap on "Select" from the resulting popup menu to cause the Holes screen to be displayed (see Figure 30).
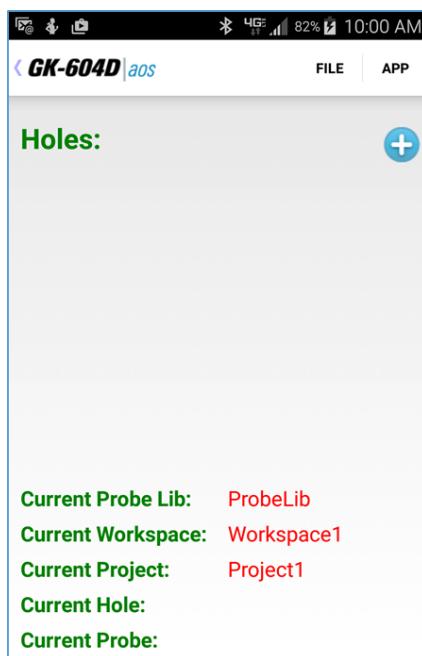
Figure 30 - Holes Screen

New holes can be added to the current project by tapping on the "+" sign (to the right of the green "Holes:" label), causing the Hole Setting screen to be displayed (see Figure 31). Unlike workspaces, probe libraries and projects, most hole parameters are required. See Section 4.1 for more information about hole configuration.
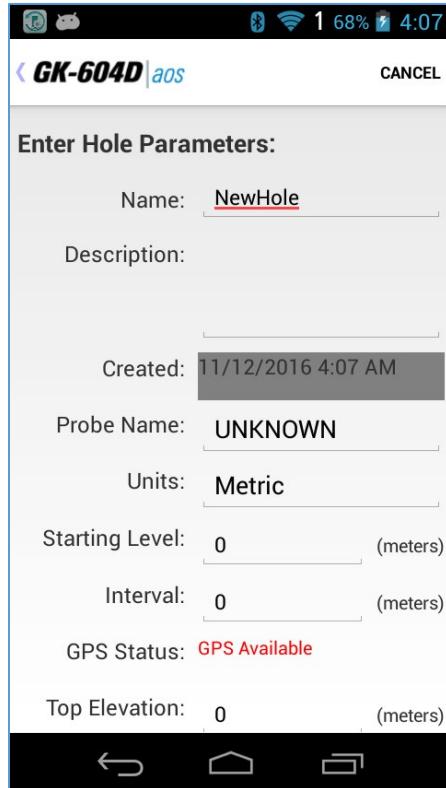
Figure 31 - Hole Settings Screen

After saving and dismissing the Hole Settings screen, the GK-604D|aos application is nearly ready to take live readings. Please refer to Section 2.1 (Initial Start Sequence), starting with step "D".

3. USER INTERFACE

3.1 Overview

The GK-604D|aos user interface contains several navigation controls designed to make the job of selecting application elements and functions easier. These navigation controls present an organizational view of the active workspace, inform the user about the state of the application, and provide the user with tools to configure and control Geokon devices.
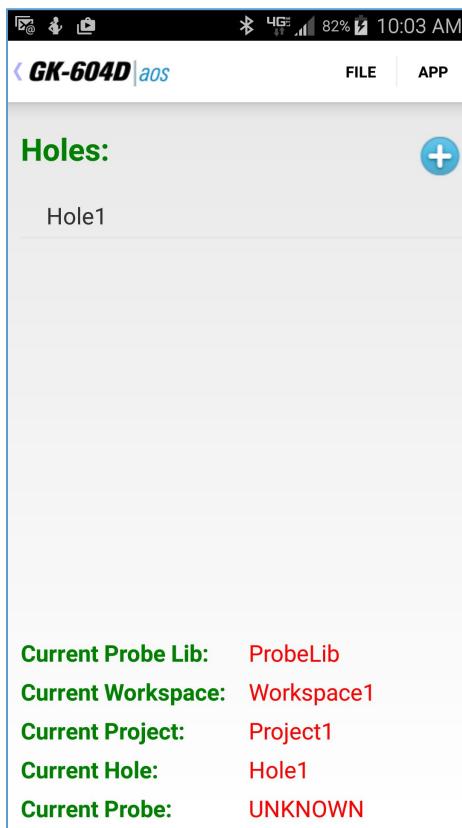
Figure 32 - Main Screen

The GK-604D aos User Interface is comprised of the following components:

"APP" Menu	Allows display of live readings, a debug terminal, installed application status and system configuration.
"FILE" Menu	Data exporting, importing and deletion. Data view/reporting options.
Status Area	Displays the currently selected hole and probe, project, workspace and probe library.
〈 *GK-604D*｜*aos*	Navigation "back" button, also save any pending edits.

A more detailed description of the "APP" and "FILE" menus appear below:

3.2 APP Menu

The GK-604D|aos "APP" menu provides access to high level application functionality. It is in the upper-right corner of the main window screen (Figure 32 above). Tapping on the "APP" menu causes the screen shown in Figure 33 to be displayed. The APP menu subitems are further described in the subsections below.
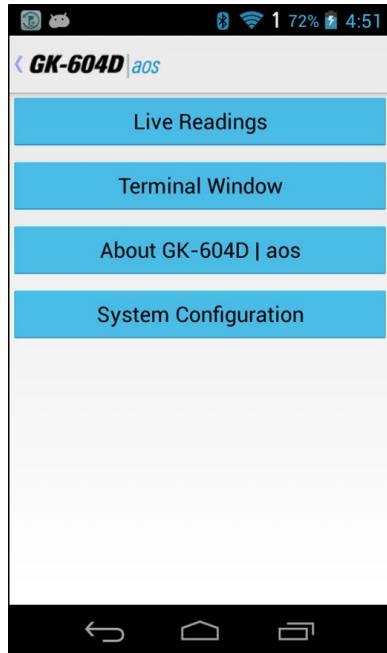
Figure 33 - APP Menu

3.2.1 Live Readings

Tapping on this menu item initiates the Remote Module connection process and after a successful connection, the Live Readings screen will be displayed (see Figure 34).
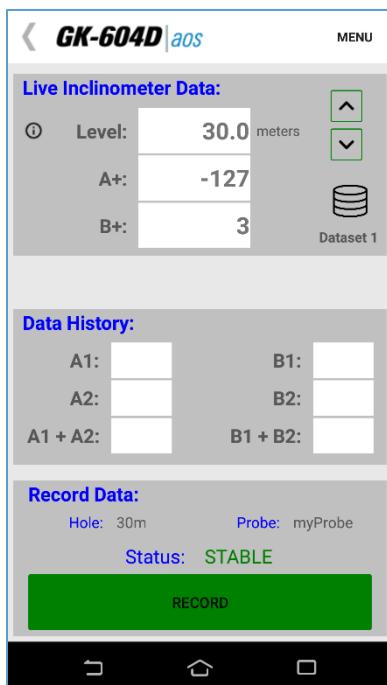
Figure 34 - Live Readings Screen

Should the connection attempt fail, the window shown in Figure 35 will be displayed. The usual problems are: no pairing between the Remote Module and the Android device and/or Bluetooth is not enabled on the Android device.
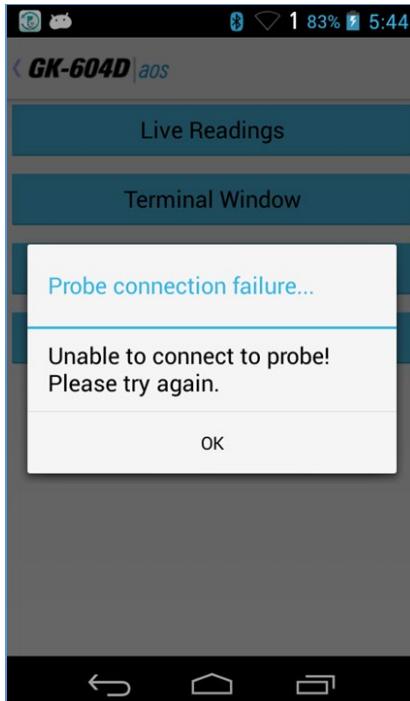
Figure 35 - Remote Module Connection Problem

Note: When attempting to connect to the Remote Module, please ensure that the "Power On" button on the Remote Module has been pressed (blue light will be blinking) before tapping on the "Live Readings" menu item. Figure 36 shows a reminder to turn on the Remote Module before connecting.
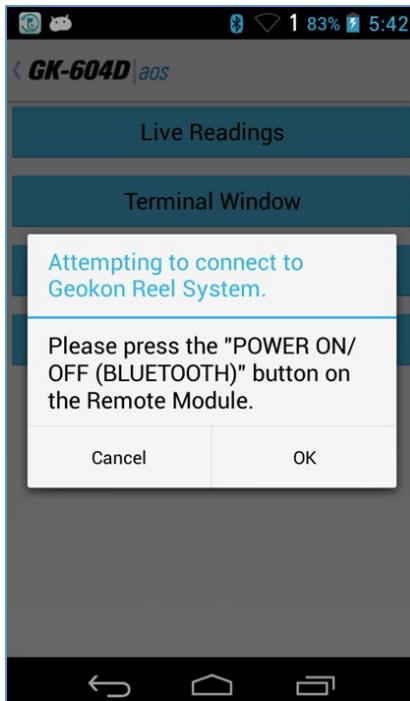
Figure 36 - Remote Module Power-On Reminder

After the Remote Module successfully connects to the Android device, the blue "POWER ON" indicator will transition from blinking to steadily lit and one of two possible screens will be displayed:

1) The "Live Readings" screen is displayed (Figure 37).
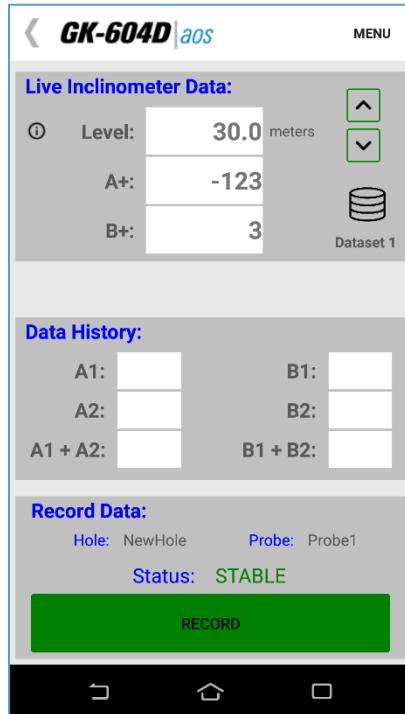
Figure 37 - Live Readings Screen

2) Figure 38 shows the message displayed if the GK-604D|aos detects temporary data left over from a previous survey that wasn't saved. Tapping "Yes" loads the previous data and then displays the Live Readings. Tapping "No" displays the Live Readings.
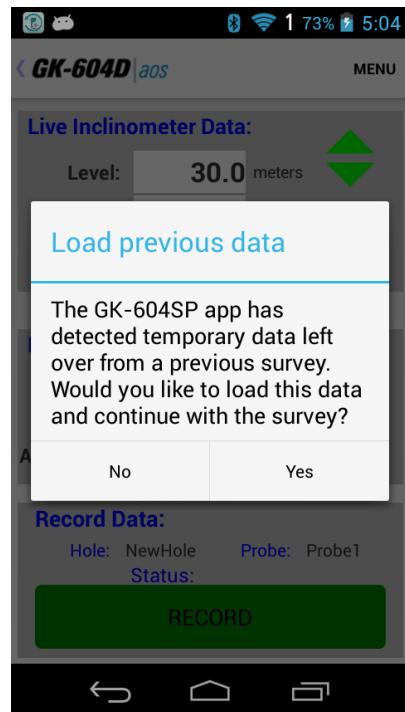
Figure 38 - Temporary File Data Prompt

The Live Readings screen (see Figure 34) is where all survey data points are read from the probe and stored in the application's database. Readings are continuously updated from the Remote Module. The data set always starts with 'Dataset 1' but can be switched at any time to 'Dataset 2' (after rotating the probe 180 degrees).

- At the start of a survey, the 'Level' is set to the "Starting Level" configured for a particular hole. Tapping the large green "Record" button (with a finger or tap of the stylus) records the displayed set of A and B values and automatically changes the 'Level' (on screen) by the amount based on the hole configuration "Interval" value (see Section 4.1).

- A sound may be heard when the "Record" button is tapped, depending on the Android device's settings, confirming that the reading has been stored. If no beep is heard, press the "Up Volume" control at the top right or left side of the Android device to adjust the volume.

- Be sure to move the probe to the new level and wait for the readings to stabilize before recording the next reading.

- At any point you can scroll the 'Level' using the green up and down arrow buttons on the screen and view data stored and checksums ("Data History:" section of the screen). The level can also be directly changed by tapping on the current level value and entering a new a level at the prompt.

- When done taking readings, tap ‹ **GK-604D** |*aos* to dismiss the screen. The application will detect if readings have been recorded and if so, an opportunity to save the readings will be presented to the user (Figure 39).
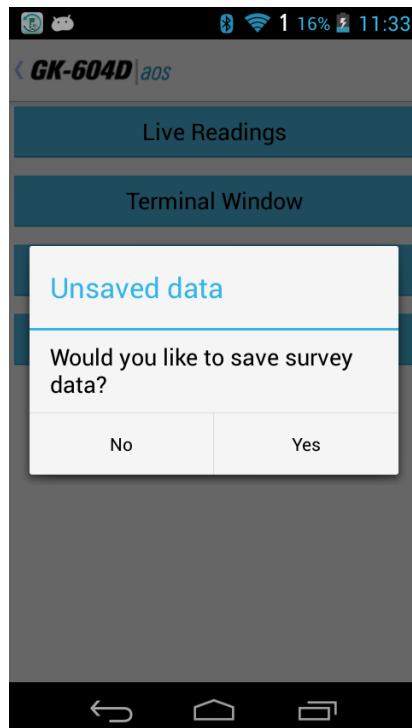
Figure 39 - Unsaved Data Prompt

o Even if "No" is selected from the Unsaved Data Prompt (Figure 39), the readings will be saved to a temporary database table and can be restored the next time "Live Readings" is entered (see Figure 40 and Figure 41).
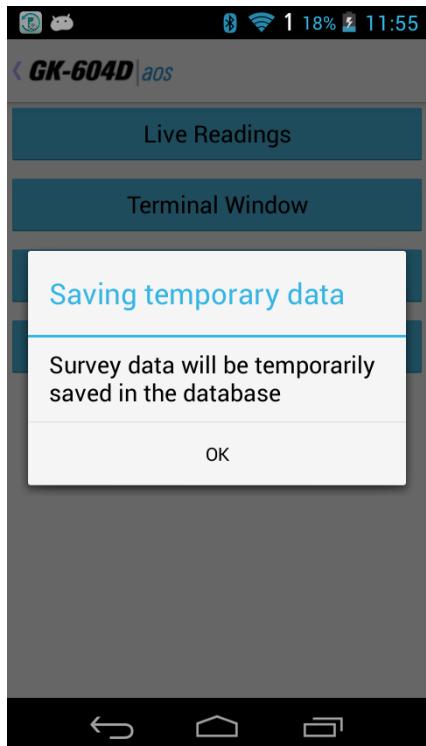
Figure 40 - Saving Temporary Data
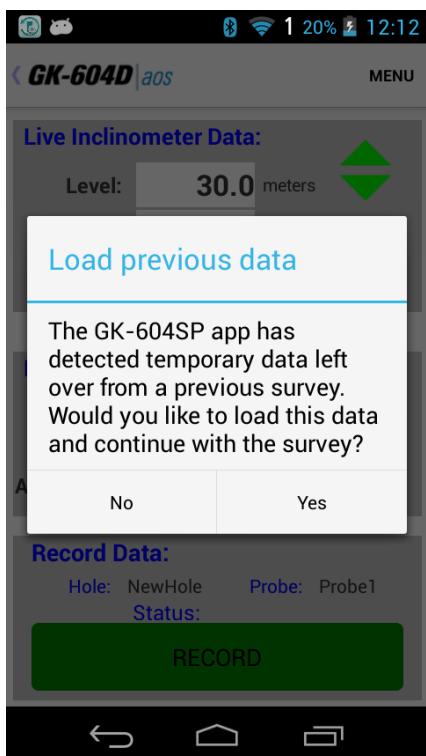
Figure 41 - Load Previous Data Prompt

- o If "Yes" is selected from the Unsaved Data Prompt (see Figure 39), then the readings will be saved to the database and the survey will be saved with the name given to it in the Survey Metadata Settings (see Section 3.2.1.1, Survey Metadata topic). If no name was entered in the Survey Metadata Settings, the survey will be saved using a three-digit numerical suffix combined with the "Hole" name. For example, if there were four previous surveys saved for a hole with the name of "HL123_Dam75", the new survey would be named: "HL123_Dam75_005".

See Section 3.2.4 (System Configuration) for more information about options that affect Live Readings and taking surveys.

3.2.1.1 Live Readings Screen Menu Options

Figure 42 shows the available options from the Live Readings "Menu" item when a Digital Inclinometer/Compass probe is detected. These options are described below:
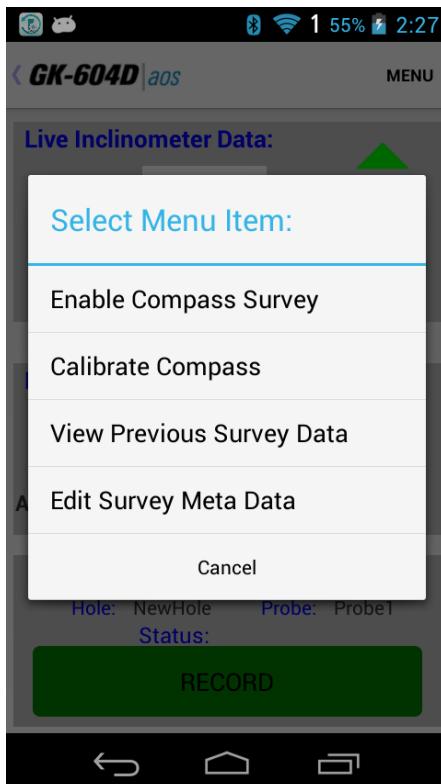
Figure 42- Menu Options (Live Readings screen)

Enable /Disable Compass Survey: For GK-604D systems with a reel firmware version of V2.7 (or greater) AND a probe firmware version of V2.7 (or greater), the capability exists to take a Compass Survey of the selected hole at the same time as the inclinometer survey. This menu item is only shown if a compass probe is detected. See Appendix G for a complete description of the integral Compass portion of the inclinometer Probe. Tapping this menu item will enable the digital compass, dismiss the menu and cause a message the message, "Compass enabled, survey will take longer", to be displayed. Tapping the Live Readings "MENU" icon with the compass enabled yields the menu options shown in Figure 43.
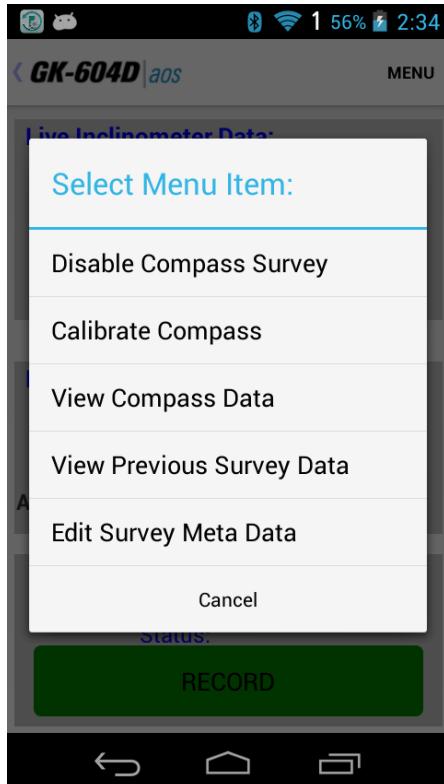
Figure 43 - Live Readings Menu Options (Compass Enabled)

Calibrate Compass: Tapping this item causes the Compass Calibration dialog to be displayed where a procedure to calibrate the Digital Inclinometer/Compass probe can be followed. This menu item is only shown if a compass probe is detected. See Appendix G for a complete description of the Compass Calibration procedure.

View Compass Data: When a compass survey is enabled, this menu item is enabled and allows the compass heading to be displayed in place of inclinometer "A" data. This item toggles between "View Compass Data" and "View Inclinometer Data" depending on the data currently being viewed (see Figure 44 and Figure 45). This menu item is only shown if a compass probe is detected. See Appendix G for a complete description of the Compass Probe.
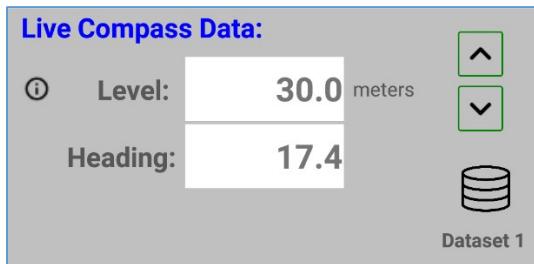
Figure 44 - Viewing Compass Data
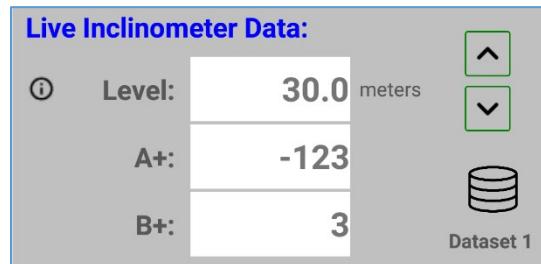
Figure 45 - Viewing Inclinometer Data

View Previous Survey Data: Allows viewing (and loading) of previous survey data. When tapped, the user must first select the previous survey to view. After selecting a survey, the screen shown Figure 46 will be displayed. After dismissing this window by tapping "<", a prompt is displayed asking the user if they'd like to load this survey. Tap "Yes" to load the data or "No" to continue with the current survey.
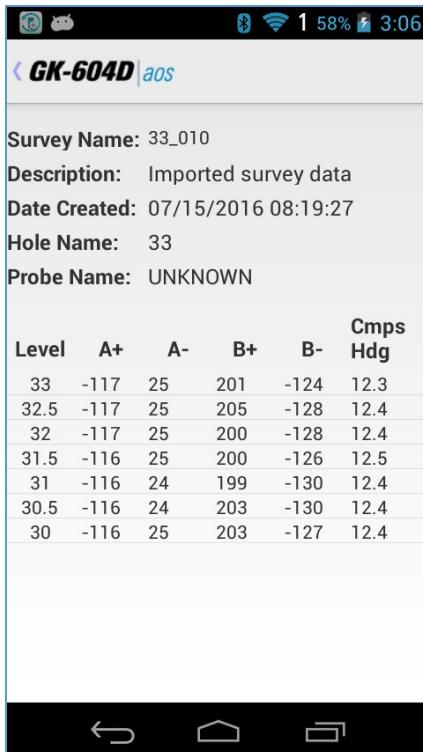
Figure 46 - View Previous Survey

Edit Survey Meta Data: When tapped, the application will display the edit screen shown in Figure 47. The Meta Data Editor allows a survey to be named and a brief description added. Optionally a picture can be selected/taken of the site and saved to the Android file system. Buttons to take and select photos (from the gallery) are off the screen when this editor is first launched and must be scrolled down to (see Figure 48).
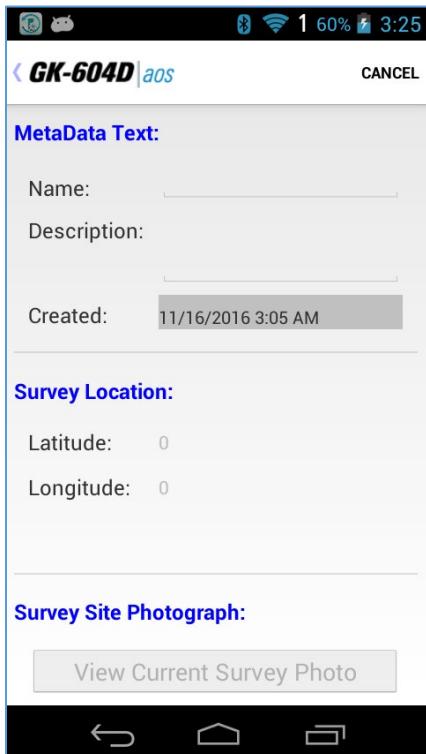
Figure 47 - Meta Data Editor
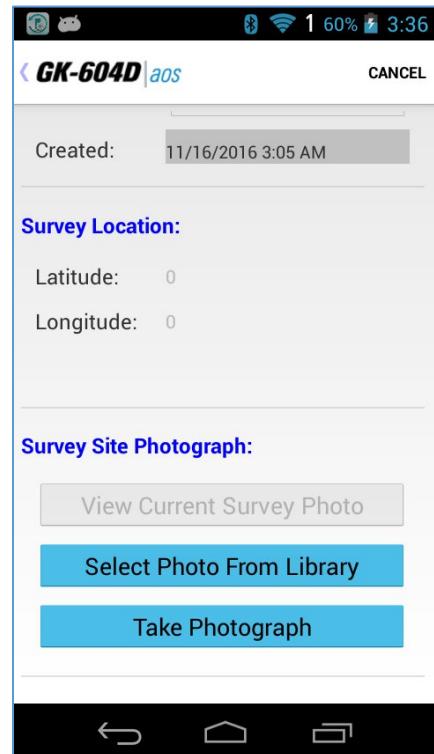
Figure 48 - Meta Data Editor (Screen 2)

3.2.2 Terminal Window

This feature requires an active connection to a Remote Module. If a connection cannot be made, the window shown in Figure 49 will be displayed.
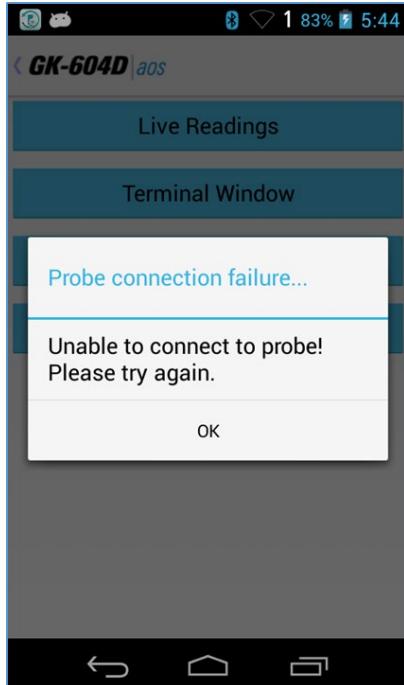
Figure 49 - Remote Module Connection Problem

If a connection is made, the "Terminal Window" will be displayed (Figure 50). Use the on-screen keyboard to enter a one or two-character command into the "Command Text" field. After typing in a command, tapping the "Send (CR)" button will cause the command to be sent to the Remote Module. Figure 50 shows the response to a sent command of "4" (Firmware Version command).
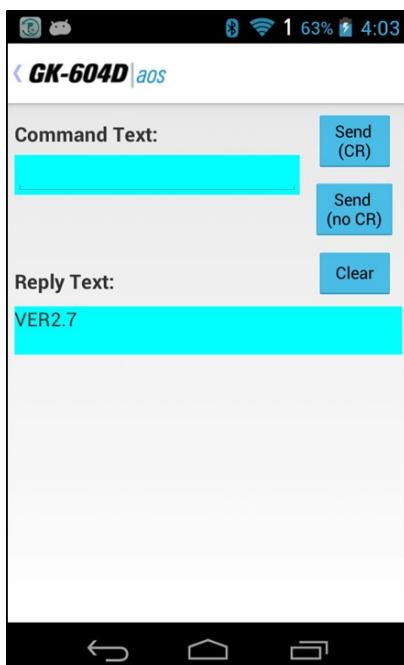
Figure 50 - Terminal Window

Alternately, tapping the "Send (no CR)" menu gives the user the ability to send a character to the Remote Module without a Carriage Return (CR) appended to the character string. This is useful when a confirmation character is required (such as for the calibration routine) but no carriage return.

See Appendix D for more information on the Remote Module command structure.

3.2.3 About GK-604D

This displays an information panel giving copyright information as well as the application version (see Figure 51). Tapping on the "Remote Module Status" button will display another screen (Figure 52) reminding the user that a probe must be connected to a Remote Module and the Remote Module ready to connect (blue light blinking).
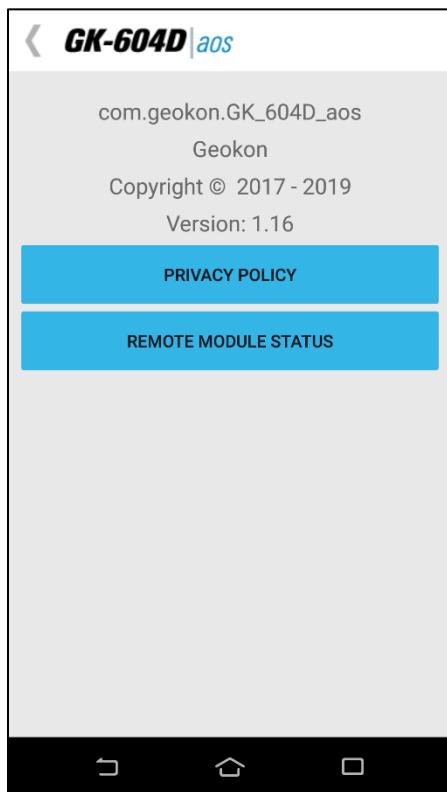
Figure 51 - About GK-604D|aos
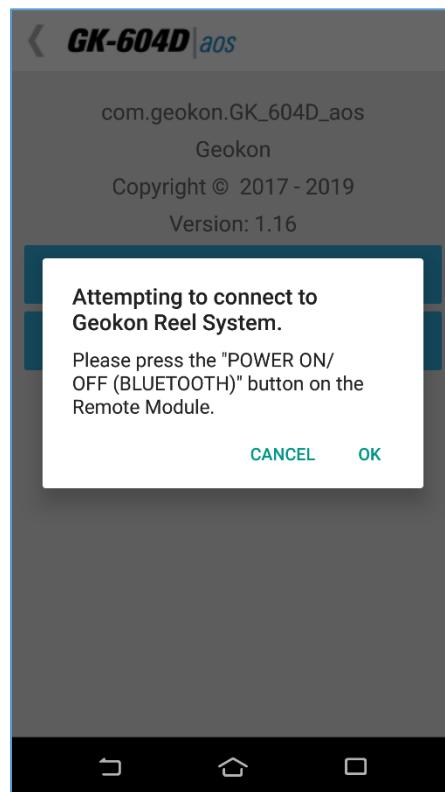
Figure 52 - Remote Module Power-On Reminder

Tapping on the "OK" icon from the reminder prompt causes the GK-604D|aos app to initiate the connection process with the Remote Module. If the connection is successful then the screen shown in Figure 53 is displayed, giving status about the Remote Module and probe. In Figure 53, the status available for a digital Remote Module and probe are depicted. For analog systems, only the Remote Module version and battery voltage is listed.
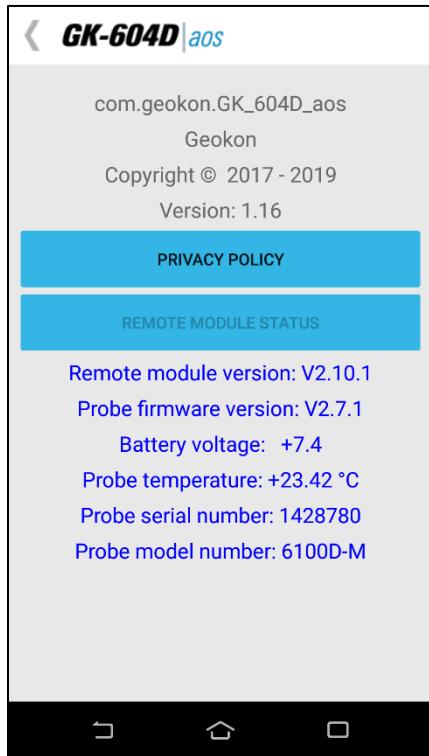
Figure 53 - Remote Module/Probe Status

3.2.4 System Configuration

This screen allows selecting options that affect how the system works and how surveys are taken (see Figure 54). The subsections that follow describe each parameter in detail.
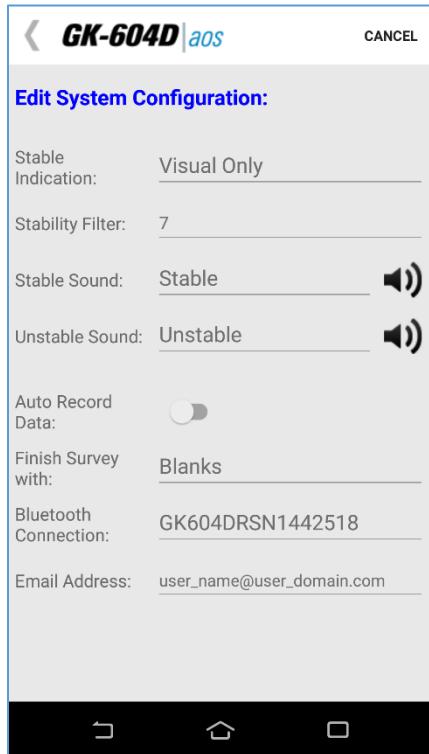
Figure 54 - System Configuration

3.2.4.1 Stable Indication

Valid choices for this selection include:

None: On the Live Readings Screen, the only indication of stability will be to monitor the A and B readings.

Visual Only: When this stability indication is selected the "Record" button is displayed on the Live Readings Screen in the color green if the reading is stable (Figure 55) or in the color red if the reading is unstable (see Figure 56).
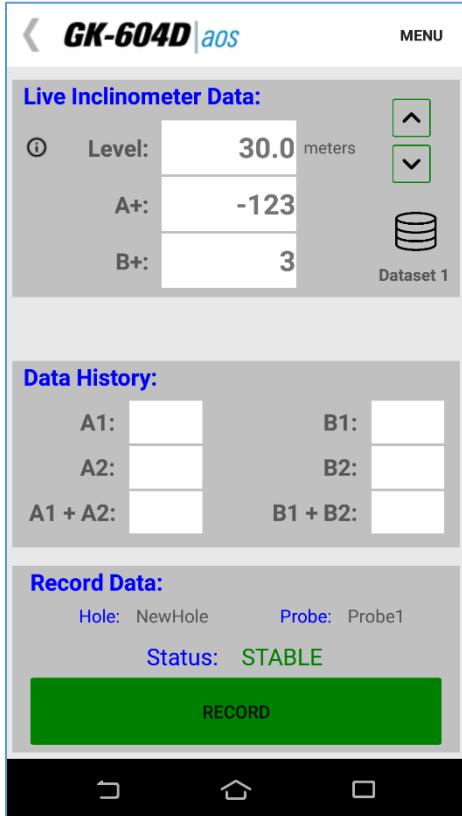
Figure 55 - Stable Indication
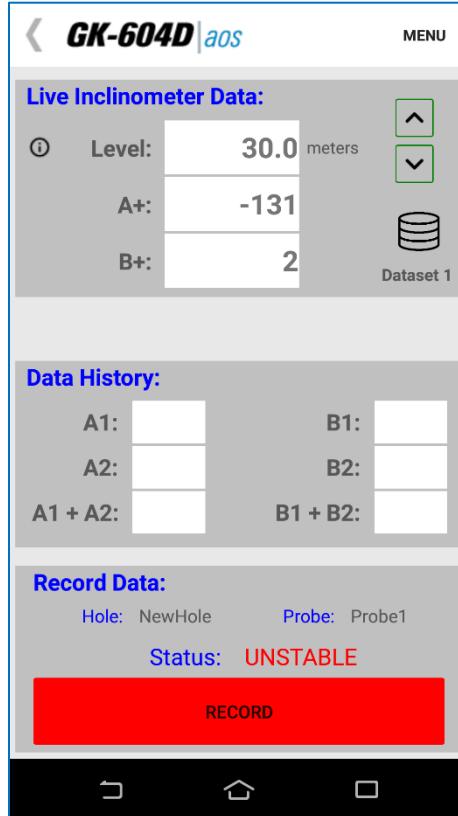
Figure 56 - Unstable Indication

Visual/Audible: When this stability indication is selected, in addition to the "Record" button colors described above, an audible indication is played indicating readings stability or instability. See Sections 3.2.4.3 and 3.2.4.4 below for information on setting the stable and unstable sounds.)

3.2.4.2 Stability Filter

If the "Stable Indication" selection is set to something other than "None", this parameter will be enabled, and an integer number can be entered. This number is used to determine readings stability (a value less than 10 is recommended).

When taking live readings, if the difference between two subsequent readings of the A and B channels are less than or equal to the "Stability Filter" then the reading will be

deemed stable and, if enabled, the "Stability Indication" icon (see Figure 55 and Figure 56) will be set accordingly.

3.2.4.3 Stable Sound

If the "Stable Indication" (see Section 3.2.4.1) selection is set to "Visual/Audible", this parameter will be enabled and a dropdown list will display the choices of "sounds" that the HHD can make when a stable reading is achieved in the "Live Readings" screen (see Figure 55).

Tapping on the icon to the right of the "Stable Sound" plays a preview of the actual sound heard.

3.2.4.4 Unstable Sound

If the "Stable Indication" (see Section 3.2.4.1) selection is set to "Visual/Audible", this parameter will be enabled and a dropdown list will display the choices of "sounds" that the HHD can make when the readings achieved in the "Live Readings" screen are determined to be unstable (see Figure 56).

Tapping on the icon to the right of the "Unstable Sound" plays a preview of the actual sound heard.

3.2.4.5 Auto Record Data

Slide the "switch" to the right (switch will be green) to enable the Auto Record Data feature. See section 3.2.5, "Auto Record Sequence", for more information regarding this feature.

3.2.4.5 Finish Survey With

This parameter deals exclusively with "unfinished" survey data files. A survey is unfinished if readings were not taken at each level from starting up to the zero level. Many surveys may not completely finish because the geometry of the probe will not allow the last reading or two to be taken while the probe is still in the casing.

NOTE: Surveys MUST start at the "Starting Level" and continue in a contiguous manner until the survey is ended (by tapping on "<"). Readings **cannot** be skipped at the beginning or in the middle of the survey, only at the end.

Valid choices for this selection include:

Nothing: The survey will not be filled in and will remain unfinished. "READINGS" will be modified to reflect the actual number taken (see Figure 57).

```
            :
            :
            :
#READINGS:5
FLEVEL,  A+,  A-,  B+,  B-
    5.0,  45,  12,  -87,  81
    4.5,  46,  12,  -84,  81
    4.0,  44,  12,  -85,  82
    3.5,  46,  13,  -85,  82
    3.0,  44,  13,  -86,  82
```

Figure 57 - Unfinished Survey

NaN(s): Each missing level "row" of the survey will be filled in with "NaN(s)", which is the floating-point representation of a nonnumerical value (see Figure 58). (NaN is an abbreviation for "Not a Number".)

```
           :
           :
           :
#READINGS:11
FLEVEL,  A+,  A-,  B+,  B-
   5.0,  32,  25,  -81,  82
   4.5,  33,  24,  -81,  82
   4.0,  30,  24,  -81,  82
   3.5,  30,  24,  -80,  81
   3.0,  29,  24,  -80,  81
   2.5,  29,  24,  -81,  81
   2.0,  30,  24,  -83,  81
   1.5,  NaN,  NaN,  NaN,  NaN
   1.0,  NaN,  NaN,  NaN,  NaN
   0.5,  NaN,  NaN,  NaN,  NaN
   0.0,  NaN,  NaN,  NaN,  NaN
```

Figure 58 - Missing Survey Rows Filled in with "NAN"

Blanks: Each missing level "row" of the survey will be filled in with blank characters (see Figure 59).

```
           :
           :
           :
#READINGS:11
FLEVEL,  A+,  A-,  B+,  B-
   5.0,  46,  17,  -86,  80
   4.5,  46,  17,  -86,  82
   4.0,  46,  14,  -86,  81
   3.5,  42,  19,  -86,  80
   3.0,  50,  18,  -86,  80
   2.5,  45,  12,  -86,  80
   2.0,   ,    ,    ,
   1.5,   ,    ,    ,
   1.0,   ,    ,    ,
   0.5,   ,    ,    ,
   0.0,   ,    ,    ,
```

Figure 59 - Missing Survey Rows Filled in with Blank Character

3.2.4.6 Bluetooth Connection

This parameter must be a previously paired Bluetooth device that is selected from a list of known Bluetooth devices.

NOTE: A survey will not be performed, and no connection will be possible to the Remote Module if this parameter is not set correctly. Please see Section 2.2 (Establishing Contact with the Remote Module) for more information regarding Bluetooth pairing.

3.2.4.7 Email Address

This parameter allows entry of an email address so that the Android device can export a data file as an email attachment.

3.2.5 Auto Record Sequence

If the System Configuration parameter, "Auto Record Data" is set to "On" (see Section 3.2.4.5), upon entry into the "Live Readings" screen, the "Auto Record" feature will be enabled (Figure 60).
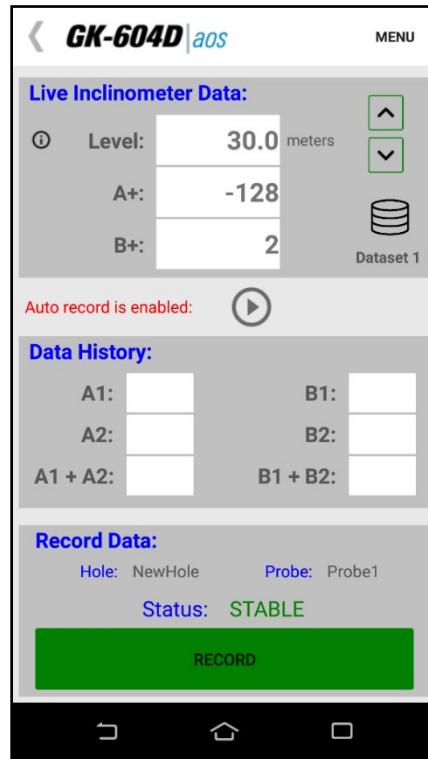
Figure 60 - Auto Record Enabled

To activate the "Auto Record" feature, tap on the ⏵ icon. The "Play" icon to the right of the red message status text will be replaced with a "Pause" icon and the red text status message will change to "Auto record mode is active". If the readings are stable, the first reading will automatically be recorded (Figure 61).
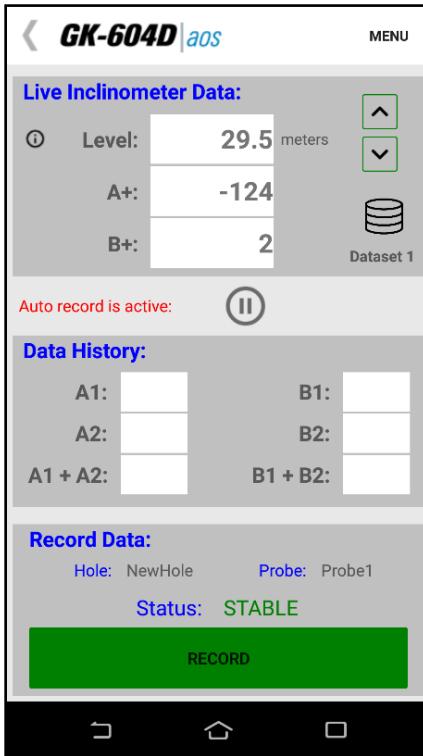
Figure 61 - Auto Record Active

The list of steps below (1-9) illustrates the proper way to utilize the "Auto Record" feature. For the purpose of this example, the following is assumed:

- The Android device is connected wirelessly to the Remote Module
- In System Configuration (Figure 54), the "Stable Indication" parameter is set to "Visual/Audible" and the "Auto Record Data" parameter is set to "On".
- At the start of an "Auto Record" sequence, the probe should be down the casing at the starting level, in the "A+" orientation.

NOTE: An "Auto Record" survey can be paused at any time and restarted as long as the probe is moved to the proper level reflected by the "Level:" display. When an Auto Record survey is paused, the data can still be recorded in the "normal" fashion by tapping on the "Record Data" buttons.

1) From the "APP" menu, tapping on the "Live Readings" menu item displays the screen shown in Figure 60).

2) As in the normal operation, readings are continuously updated from the remote. The data set always starts with 'Dataset 1' (can be switched at any time to 'Dataset 2'). At the start, the "Level" is set to the "Starting Level", previously set in the Hole Settings screen (Section 4.1, Hole Configuration, Figure 84).

3) Tap on the ⊙ icon to activate the "Auto Record" feature. The red status text message will change to "Auto record is active" and the "Play" icon will change to the "Pause" icon. If the readings are stable, the initial A & B readings will be taken and a "beep" sound should be heard, confirming that the readings have been stored (see Figure 61). If no beep is heard, tap the "volume" control at the top of the screen and adjust the volume.

4) By pulling on the inclinometer cable, move the probe to the next level, ensuring that the cable marker/ferrule sits just above the cable grips in the pulley assembly, (or securely in the cable hold if one is used). Approximately one second after moving the probe, the system will determine that the readings are no longer stable. Instability will be indicated by the "Record" button turning red and the "Unstable" sound selected in the "System Configuration" screen (see Figure 54) will be played.

5) Approximately two seconds after the cable marker/ferrule is locked in the cable grips, (or cable hold), the system will determine that the readings are again stable and respond by indicating stability ("Record" button goes green) and the "Stable" sound selected in the "System Configuration" screen (see Figure 54) will be played. Immediately following the stable sound, the current readings are stored, the record "beep" is heard, and the level is decremented by the preselected interval.

6) Repeat steps four and five until all the "A+" readings have been taken.

7) Tap the "Dataset 1" icon and observe that the red status text message will change to "Auto record is paused" and the "Pause" icon will change to the "Play" icon while "Dataset 1" becomes "Dataset 2" (Figure 62).
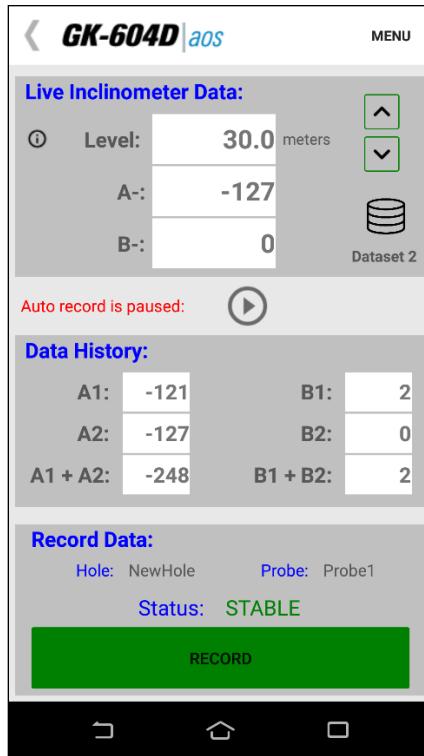
Figure 62 - Auto Record Paused, Dataset Two Selected

8) After rotating the probe 180 degrees, lower it back to the "Starting Level" appropriate for this hole. Repeat step three.

9) Repeat steps four and five until all the "A-" readings have been taken.

10) When done taking readings, tap ‹ **GK-604D** aos to dismiss the Live Readings screen. The application will detect if readings have been recorded and if so, an opportunity to save the readings will be presented to the user (Figure 63)
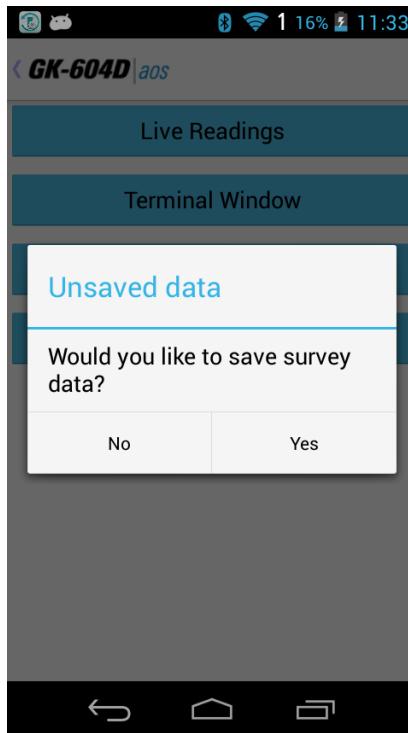
Figure 63 - Unsaved Data Prompt

- If "No" is selected from the Unsaved Data Prompt (Figure 63), the readings will be saved to a temporary database table and can be restored the next time "Live Readings" is entered (see Figure 64 and Figure 65).
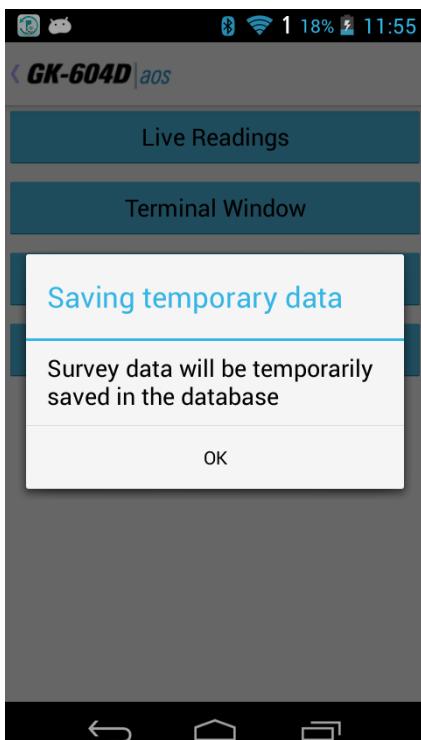
Figure 64 - Saving Temporary Data
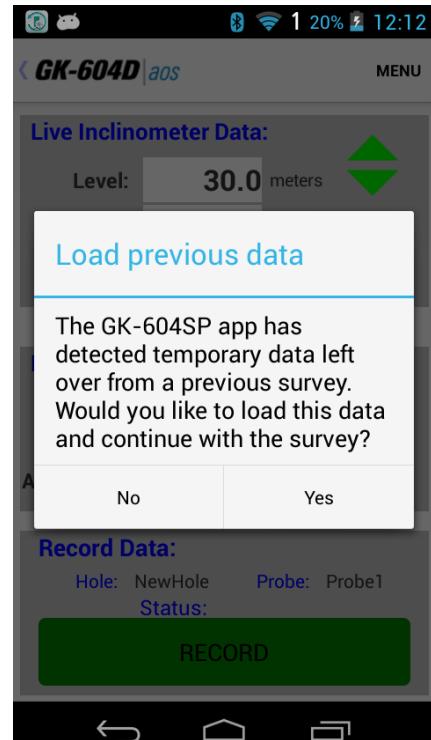
Figure 65 - Load Previous Data Prompt

- If "Yes" is selected from the Unsaved Data Prompt (see Figure 63), then the readings will be saved to the database and the survey will be saved with the name given to it in the Survey Metadata Settings (see Section 3.2.1.1, Survey Metadata topic). If no name was entered in the Survey Metadata Settings, the survey will be saved using a three-digit numerical suffix combined with the "Hole" name. For example, if there were four previous surveys saved for a hole with the name of "HL123_Dam75", the new survey would be named: "HL123_Dam75_005".

3.3 FILE Menu

The GK-604D|aos "FILE" Menu provides access to importing and exporting features along with data viewing and report generation. It also is used to fully delete previously "hidden" configuration elements. It is in the upper-right corner of the main window screen (see Figure 66). Tapping on the "FILE" menu causes the screen shown in Figure 67 to be displayed.
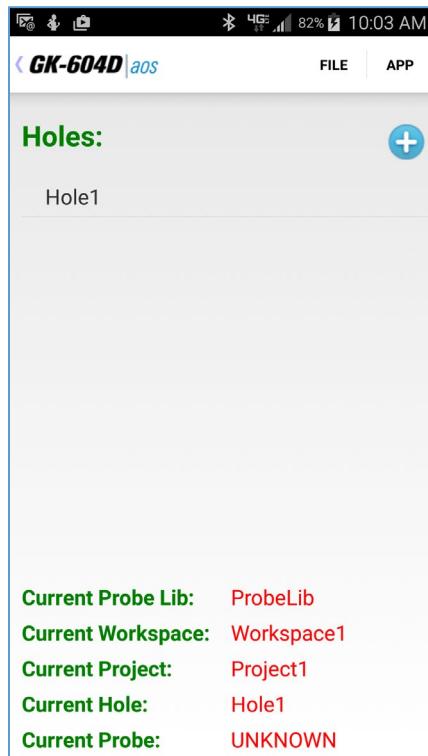
Figure 66 - Main Screen
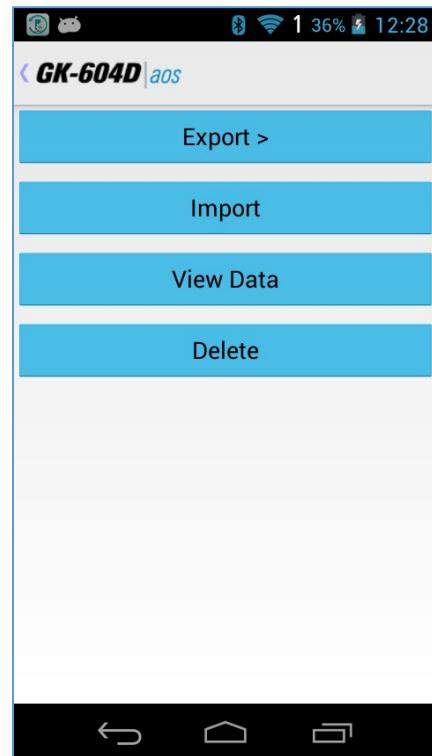
Figure 67 - File Menu

The FILE menu items are covered by the following sections:
EXPORT: Section 3.3.1
IMPORT: Section 3.3.2
VIEW DATA: Section 3.3.3
DELETE: Section 3.3.4

3.3.1 Export Menu

The Export menu is used to export hole data to a folder of the user's choosing. Hole data can also be exported as an email attachment. Figure 68 shows the export options and the subsections below describe them in more detail.
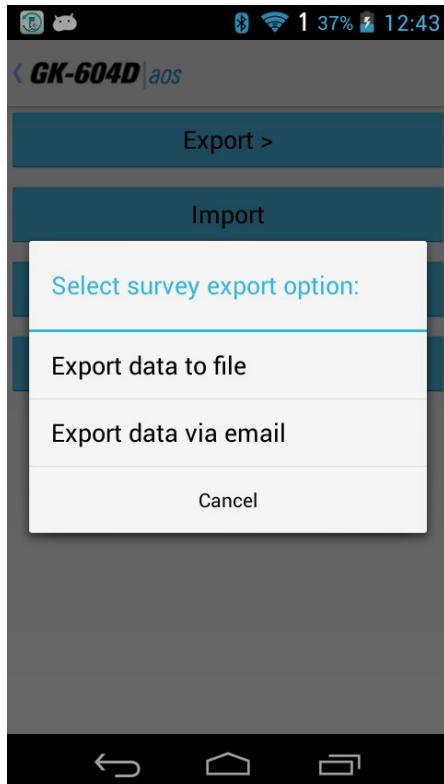
Figure 68 - Survey Export Options

3.3.1.1 Export Data to File

The "Export Data to File" menu allows exporting of data from the current hole (as listed in the status area) to a "raw" data file. Figure 69 shows the surveys available for hole "33". A survey is selected from the scrollable list by tapping on the survey name.

When a survey is selected the "Export Folder Selection" screen (see Figure 70) is displayed. Tap on a folder icon to navigate to subfolders. When the desired folder is selected, tap "Select" from the menu bar to export the survey data to a ".gkn" file containing the raw data from the survey. See Appendix B for more information regarding ".gkn" data file format.

Figure 69 - Survey List
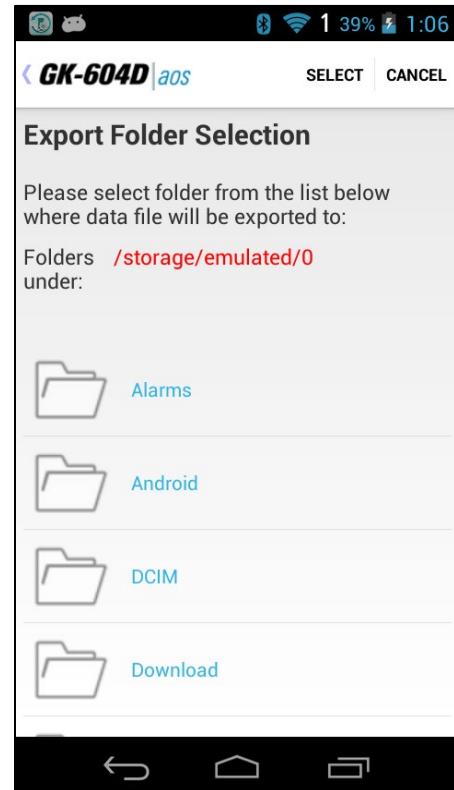
Figure 70 - Export Folder Selection

3.3.1.2 Export Data Via Email

The "Export Data Via Email" menu allows exporting of survey data from the current hole (as listed in the status area) as a "raw" (.gkn) data file. This file (or files in the case of an enabled digital compass) is compressed into a "zip" file and becomes the email attachment. The name of the attached zipped file is the Hole name along with any numeric suffix followed by a ".zip" file extension. Figure 69 shows the surveys available for hole "33". A survey is selected from the scrollable list by tapping on the survey name.

When a survey is selected the "Share Via" screen (see Figure 71) is displayed. Tap on the "Email" icon to begin the export process and to display the email message screen shown in Figure 72. Note that the hole survey file (.gkn) has been compressed, renamed and attached to the email, a default message has been included and the email is preaddressed to the email recipient that was entered for the System Configuration Email Address parameter (see Section 3.2.4.7 for more information regarding the setting of this parameter). The email (with attachment) can be sent at this point.

Note: Since the Android device typically remembers which application it used to send email, the "Share Via" screen (Figure 71) may not be displayed after the first email (and attachment) is sent.

See Appendix B for more information regarding ".gkn" data file format.
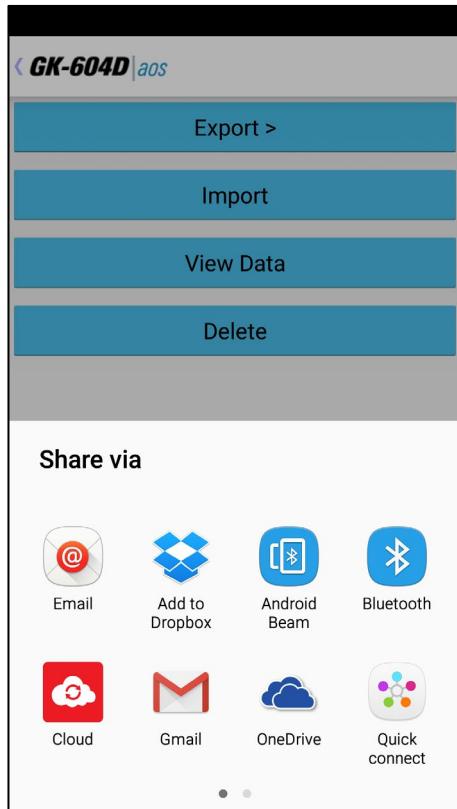
Figure 71 - Share Via Screen
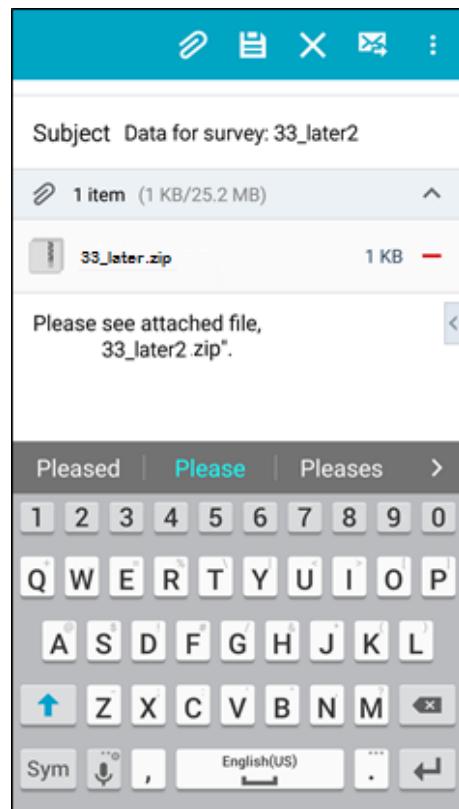
Figure 72 - Email Message Screen

NOTE: Sending data files as an email attachment requires an active data plan or access to a WIFI connection.

3.3.2 Import Menu

The Import Menu is used to import configuration element settings that were previously exported using the Windows Mobile version of the GK-604D Inclinometer Readout Application.

Tapping on "Import" from the "File Menu" (see Figure 67) causes the "Import File Selection" screen to be displayed (Figure 73). As with the "Export Folder Selection" screen, the "Import File Selection" screen is initially displayed showing the Android device's "External Storage Directory". This directory varies from device to device and between different Android versions but is generally considered to point to the "SD Card".

Unlike the "Export Folder Selection" screen, the "Import File Selection" screen's list may contain both files and folders. Tapping on a folder icon will cause that folder's contents to be displayed in the next screen. There are four types of files that are importable: Hole Export files (.lvhe), Project Export files (.lvpe), Probe Export files (.gkpe) and Probe Library Export files (.gple). Selecting any one of these four types of files will cause the "Importing…" screen (Figure 74) to be displayed along with all of the configuration element types that were found in the selected file. Tap "Start Import" to begin importing. The subsections below describe each file type in detail.
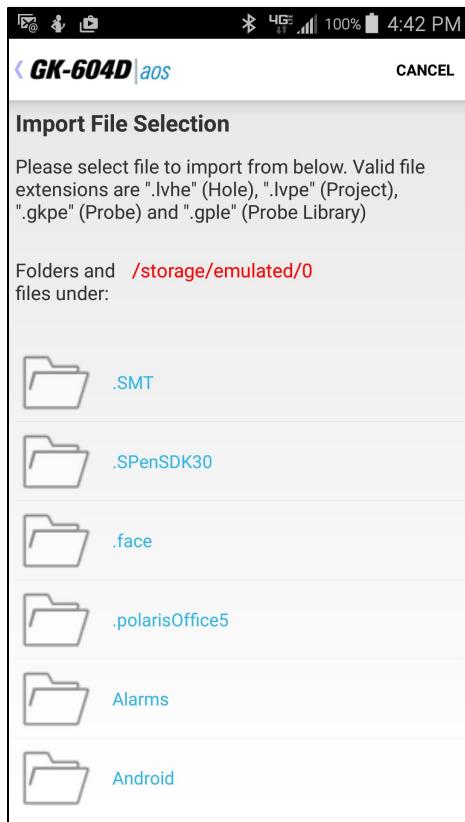
Figure 73 - Import File Selection
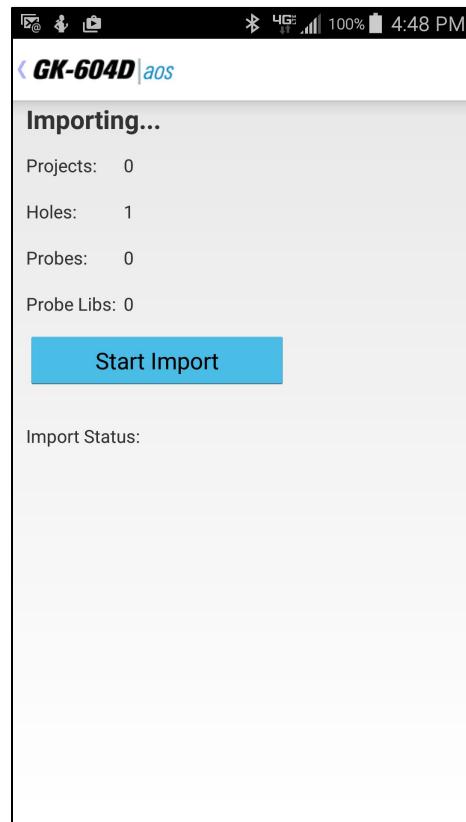
Figure 74 - Importing Screen

3.3.2.1 Hole Export File (.lvhe)

A Hole Export File contains all configuration parameters for a given hole as well as all survey data from all previously taken surveys. After the import is complete, a new "Hole" will be created in the currently selected project. If a hole with the same name already exists in the currently selected project a message will be displayed, and the hole import will be cancelled.

3.3.2.2 Project Export File (.lvpe)

A Project Export File contains all configuration parameters for a given project along with all holes that were associated with this project **and** their survey data. After the import is complete, a new "Project" will be created in the currently selected workspace. New "Holes" will also be created as necessary. If a project with the same name already exists in the currently selected workspace, a message will be displayed, and the project import will be cancelled.

3.3.2.3 Probe Export File (.gkpe)

A Probe Export File contains all configuration parameters for a given probe. After the import is complete, a new "Probe" will be created in the currently selected probe library. If a probe with the same name already exists in the currently selected probe library, a message will be displayed, and the probe import will be cancelled.

3.3.2.4 Probe Library Export File (.gple)

A Probe Library Export File contains all configuration parameters for a given probe library along with all probes that were associated with this probe library. After the import is complete, a new "Probe Library" will be created. New "Probes" will also be created as necessary. If a probe library with the same name already exists, a message will be displayed, and the probe library import will be cancelled.

3.3.3 View Data

When the View Data Menu is clicked the screen displayed in Figure 75 is shown. The Select View Options screen is used to select a report type (see Figure 76), survey and report options to view as a graphical or tabular report.
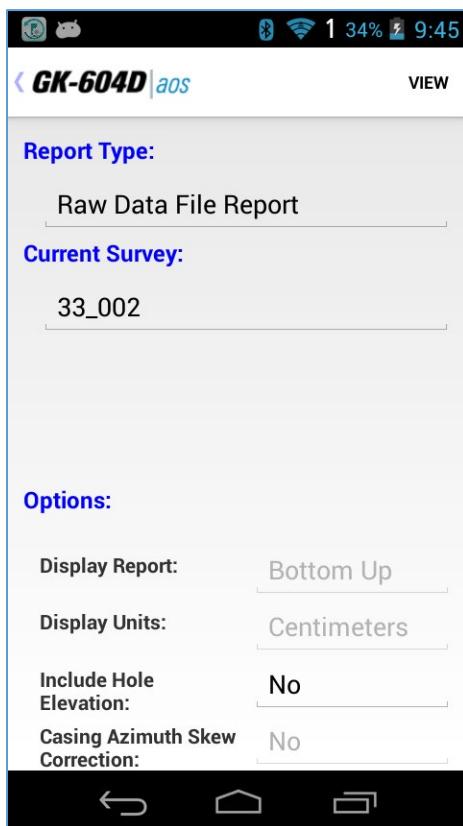
Figure 75 - Select View Options Screen

The survey or surveys are selected from rolling lists (similar to the report type in Figure 76) and, depending on the report type selected, requires the selection of one or two surveys. Deflection reports or plots require two surveys to generate the report or plot (see Figure 77).

The available report or plot options are shown in the subsections below.
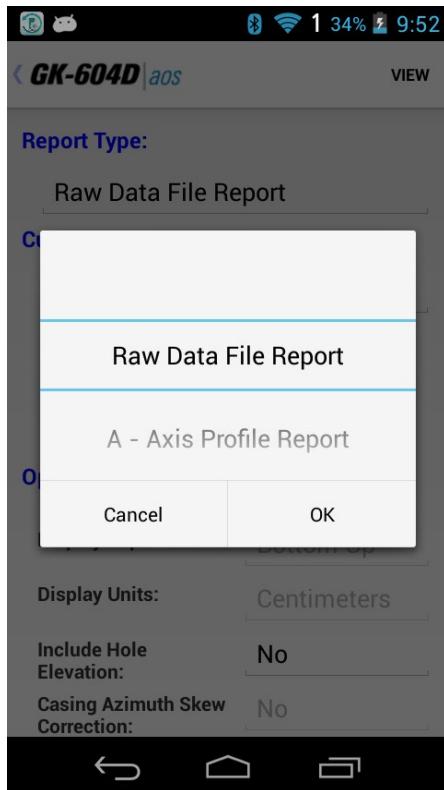
Figure 76 - Report Type List   **Figure 77 - View Options Screen (Selecting 2 Surveys)**
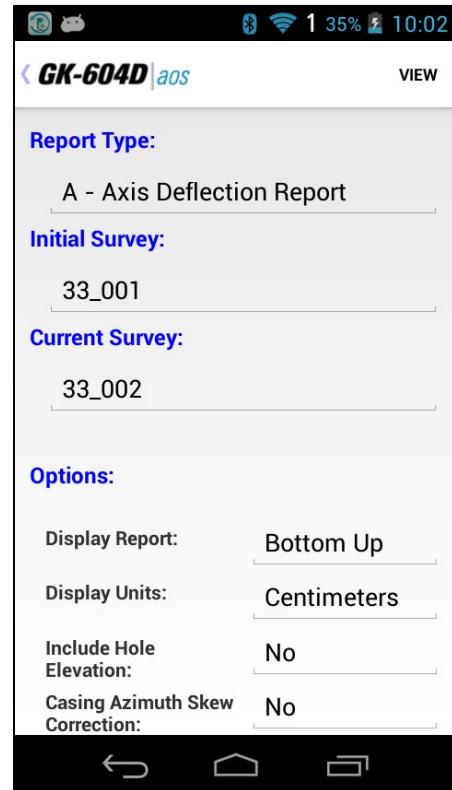
3.3.3.1 Raw Data File Report

This selection will cause the selected "hole" raw data to be displayed in tabular form. Figure 78 shows the report as viewed on an Android device. The column and row data will scroll left and right and up and down so that all rows and columns can be seen.

Figure 78 - Raw Data Report

3.3.3.2 Axis Profile Report

Selecting this option allows viewing or saving hole profile data for the A or B-axis. The profile is calculated from the magnitude of the readings at each level (see Figure 79). This report lists the profile of the casing as calculated from the bottom of the casing upward or from the top down (see the Options Screen in Figure 77). See Appendix C for an example of a profile report saved in text form.

When the app displays the profile report, the display is changed from Portrait mode to Landscape mode so that all columns will be visible. As initially displayed, the header portion of the report is visible but is not shown in Figure 79. The header can be seen be scrolling up or additional rows can be seen by scrolling down. This report may also be saved in comma-separated value (.csv) format.

Figure 79 - Axis Profile Report

3.3.3.3 Axis Deflection Report

Selecting this option allows viewing or saving hole deflection data for the A or B-axis. Deflection is determined from the accumulated change in deflection between the two selected data files at each level. This report lists the deflection of the casing as accumulated from the bottom of the casing upward or from the top down (see Figure 80). See Appendix C for an example of a deflection report saved in text form.

When the app displays the deflection report, the display is changed from Portrait mode to Landscape mode so that all columns will be visible. As initially displayed, the header portion of the report is visible but is not shown in Figure 80. The header can be seen be scrolling up or additional rows can be seen by scrolling down. This report may also be saved in comma-separated value (.csv) format.

Figure 80 - Axis Deflection Report

3.3.3.4 Axis Profile Plot

Selecting this option allows a graphical view of hole profile data and is useful for visualizing the actual installed characteristics (inclination, couplings, anomalies, etc.) of the casing. Figure 81 shows a typical profile plot. "Screenshots" of plots may be saved in ".jpg" format.
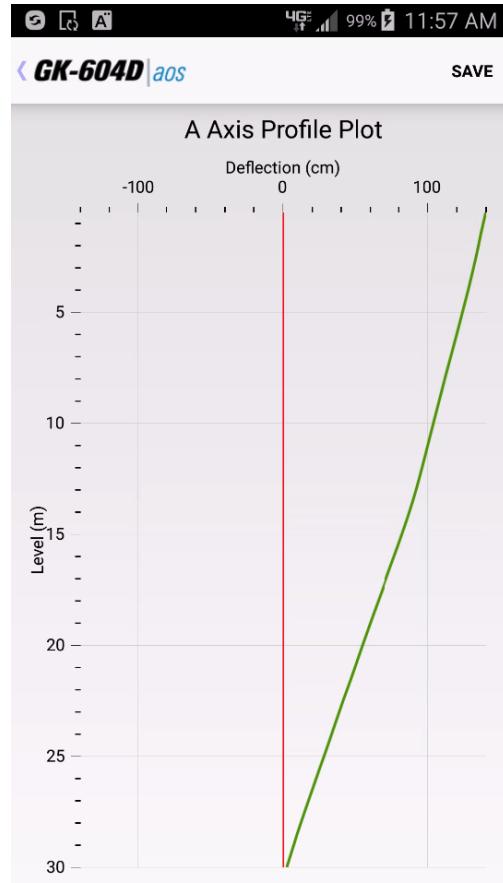
Figure 81 - Axis Profile Plot

3.3.3.5 Axis Deflection Plot

Selecting this option allows a graphical view of hole deflection data for either axis and is useful for visualizing magnitude and direction of any movement of the borehole (see Figure 82). "Screenshots" of graphical reports may be saved in ".jpg" format".
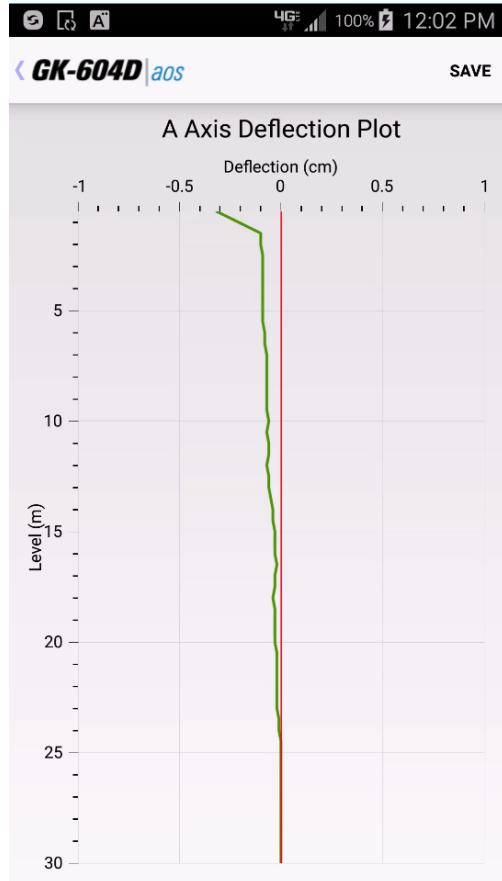
Figure 82 - Axis Deflection Plot

In addition to saving reports and plots to the Android file system, each report or plot can also be emailed as attachment to the email address specified in Section 3.2.4.7. Much like when exporting data via email, the plot or CSV file is compressed into a "zip" file and then sent via email as an attachment (see Figure 72 in Section 3.3.1.2).

3.3.4 Delete

This menu item allows configuration elements to be permanently deleted from the system database. Tapping "Delete" acts on the currently selected item from the configuration element screen that was displayed before pressing "File". For example, if the "Holes" screen was displayed when the "File" menu button was tapped, the only candidate for deletion will be the currently selected hole. As can be seen in Figure 83, a warning prompt is displayed before an element is deleted.

WARNING: Selecting "Delete" will permanently delete the selected element and later restoration will **NOT** be possible.
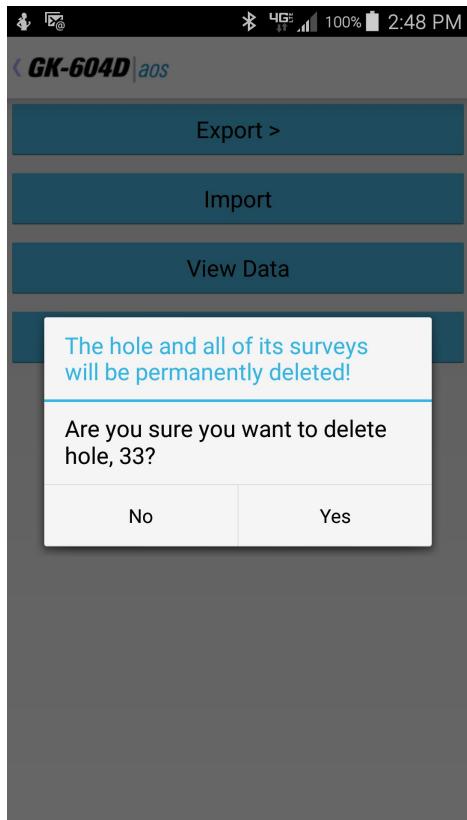
Figure 83 - Delete Warning Message

4. CONFIGURATION ELEMENTS

Each configuration element has settings that can be entered/modified. For some, like Workspace, Probe Library and Project the settings consist only of a name and description. Elements such as Holes and Probes require more configuration parameters such as English/metric units, initial level, and gauge factors. These settings can be adjusted to meet the user's needs and the specifications of the probe. The software currently supports two different probe types and as many probe and hole configurations as the Android device can store in memory. All these can be adjusted using the Edit Settings option from the configuration element context menu.

4.1 Hole Configuration

Figure 84 and Figure 85 depict the Hole Parameters screen. The available parameters are described below. When done editing, the settings can be saved by tapping the "<" beside the application title. Tapping "CANCEL" will exit the screen and return the parameters to their previously saved configuration.
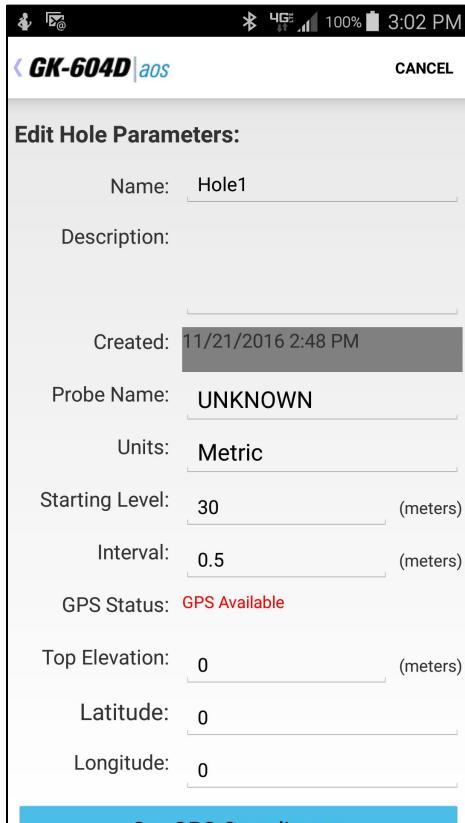
Figure 84 - Hole Parameters (Top Portion)
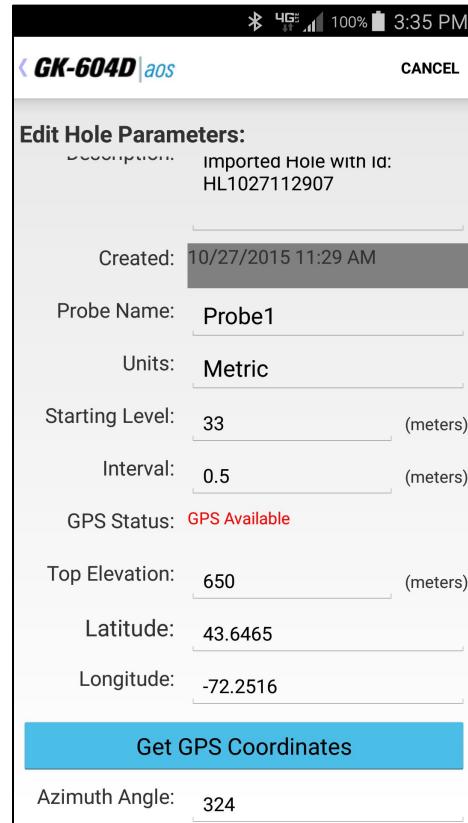
Figure 85 - Hole Parameters (Bottom)

Hole name: Tap on this parameter to bring up the on-screen keyboard. Use it to enter a unique and descriptive hole name.

Description: Optional parameter. Using the on-screen keyboard, enter a brief description pertaining to the hole's location and purpose.

Created On: Read-only date and time value, generated when the hole was created.

Probe Name: Select the Probe Name from the dropdown list. This associates a hole with a particular probe. Select "UNKNOWN" if the probe has not yet been "found" by the GK-604D|aos system.

Hole Units: The units for the hole level, interval and starting level. Select either meters or feet from the dropdown list (*must match probe!*).

Starting Level: Using the on-screen keyboard, enter a value for the initial level of the survey for this hole.

Interval: Enter an interval to be used for the survey. This value is dependent on Hole Units and is typically a half meter or two feet.

GPS Status: Gives a status of the Global Positioning Satellite hardware on board the Android device.

Top Elevation: This optional parameter corresponds to the elevation at the top of the hole.

Latitude: Double floating-point value corresponding to the "Y" location of the hole to be surveyed. This parameter can be entered directly if the GPS hardware is disabled or unavailable.

Longitude: Double floating-point value corresponding to the "X" location of the hole to be surveyed. This parameter can be entered directly if the GPS hardware is disabled or unavailable.

Get GPS Coordinates: This parameter may be "hidden" below the screen of the Android device. Scroll up to expose the last two parameters (see Figure 85). This button is enabled if the "GPS Status" (above) displays "GPS Available". If the button is enabled, tapping it will cause the application to access the GPS hardware, read the current location and populate the Latitude and Longitude parameters (described above).

Azimuth Angle: This optional parameter allows correction of any casing deviation from the appropriate A+ direction (see Figure 85).

4.2 Probe Configuration

The Probe parameters (see Figure 86) identify and configure the analog or digital probe that is connected to the Remote Module. These parameters are described below. When done editing, the settings can be saved by tapping the "<" beside the application title. Tapping "CANCEL" will exit the screen and return the parameters to their previously saved configuration.
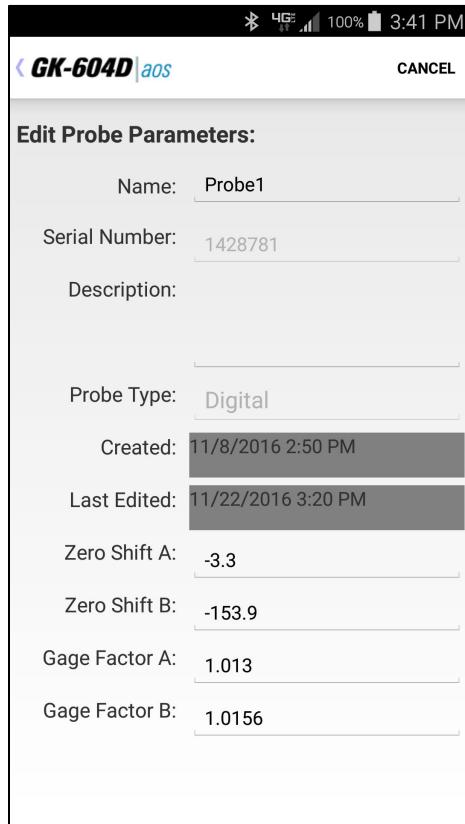
Figure 86 - Probe Parameters Screen

Probe name: Use the on-screen keyboard to enter a unique and meaningful name for the probe. This name will be used to associate the hole to the probe.

Serial number: Read-only parameter for digital inclinometer probes, read/write parameter for analog inclinometer probes.

Description: Optional parameter. Enter a brief description pertaining to the probe.

Probe type: Select a probe type from dropdown list. Choices are: Analog and Digital.

Date created: Read-only date and time value, generated when the probe was created.

Last edited: Read-only data and time value, updated whenever the probe settings are modified.

A and B Channel Zero Shift: To compensate for any offset at zero enter appropriate values for the Zero Shift values (see the Inclinometer Probe manual and Calibration sheet for more information). Digital probes will likely have these values programmed at the factory.

A and B Channel Gauge Factors: Using the on-screen keyboard, enter appropriate numbers for the two gauge factors (see the Inclinometer Probe manual and Calibration sheet for more information). Digital probes will likely have these values programmed at the factory.

If connected to a digital Remote Module and digital probe, Zero Shift and Gauge Factor changes can be uploaded to the probe by answering "Yes" to the prompt that's displayed when exiting the probe parameters screen (see Figure 87).
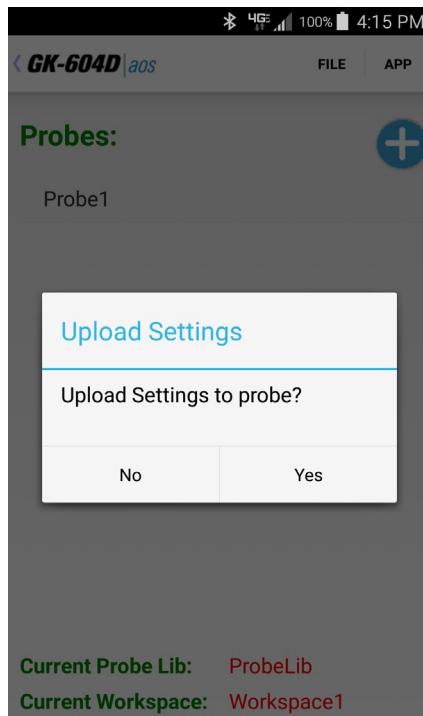
Figure 87 - Upload Settings

4.3 Project Configuration

The Project parameters (see Figure 88) identify the Project element. These parameters are described below. When done editing, the settings can be saved by tapping the "<" beside the application title. Tapping "CANCEL" will exit without saving.

Project Name: Use the on-screen keyboard to enter a unique and descriptive project name.

Description: Optional parameter. Use the on-screen keyboard to enter a brief description pertaining to the project.

Created On: Read-only date and time value, generated when the project was created.
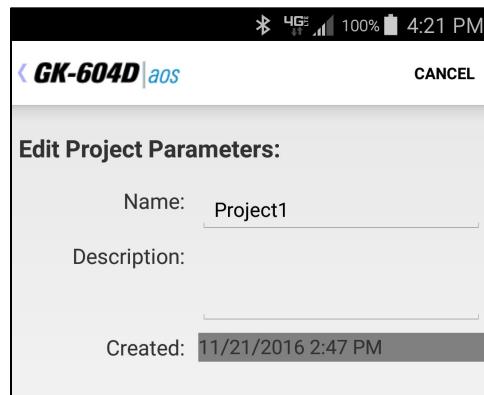
Figure 88 - Project Parameters Screen

5. FILES, FOLDERS AND TRANSFERRING DATA

The GK-604D|aos uses several types of files and dedicated folder locations to keep track of element configuration files as well as various repositories for reports and plots. The default locations and names for most of these appear in Table 1. (**PLEASE NOTE:** Manual editing of any files or renaming folders may result in data loss or unexplained operation and is strongly discouraged!)

Purpose	Default Folder	Filename
GK-604D|aos backup database	Device storage/IncloData	IncloSQLite.db3
File system report storage	Device storage/IncloData/Reports	*.csv, *.jpg
Imported data repository	Device storage/IncloData/Import	*.lvhe, *.lvpe, *.gkpe, *.gple
Metadata picture repository	Device storage/Pictures	*.jpg

Table 1 - Folder Paths and File Names

5.1 File Transfer

In general, the only files generated by the GK-604D|aos that might have to be transferred are the "hole" data files and/or reports. Connecting the Android device to a desktop or laptop PC using a USB cable (Type A to micro B) is straight forward and allows the user to view the Android devices storage as a flash drive on the desktop/laptop; you can then simply drag the files around to any folder on the desktop/laptop.

In general, the only setting required on the Android device has to do with how the USB connection is used. Typically, selecting "File Transfer" for this setting allows files to be shared in both directions with a Windows PC.

6. MAINTENANCE

The inclinometer probe is a totally sealed unit and, as such, field adjustments are not required.

6.1 O-ring

Maintenance of the 'O' ring on the connector requires that it be kept clean, as well as free of cuts and nicks. Periodic greasing with 'O' lube is recommended. A worn or damaged 'O' ring should be replaced with a new one (five 'O' rings are supplied with each new probe).

6.2 Wheel assemblies

Wheel assemblies should be kept dry when in storage. They should be kept free of dirt by using a compressed air gun to blow away grit. **After every survey, spray the springs, pivots and axles with light oil**. <u>**This is very important and should not be neglected.**</u>

Geokon **recommends lubricating the wheel bearings after each use with waterproof grease** as shown below. This practice forces out any water or contaminates that may be present thus extending the service life.

Figure 89 - Wheel Lubricant (ADH-106 Belray Waterproof Grease Type 99540)
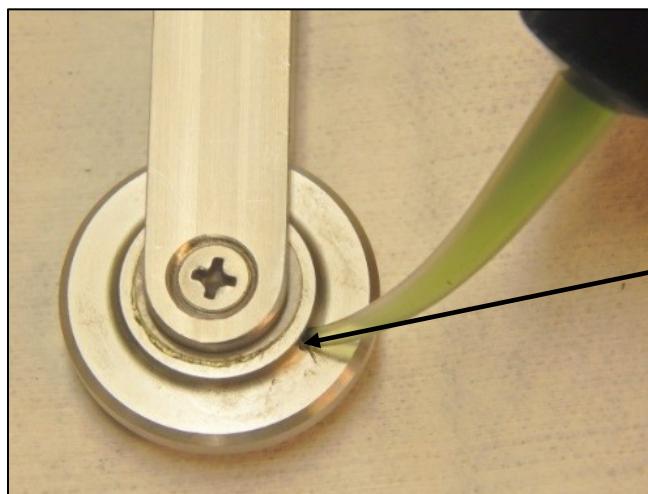
Grease wheels through the grease port in the wheel hub **after each use**.

Figure 90 - Greasing Wheels

6.3 Water Entry

One of the main problems encountered is failure to keep the cable and probe connectors dry. Often this is caused by failure to fully tighten the cable connector to the probe connector. This connection must be made up tight in order to compress the O-ring in the end of the probe connector. Periodically the pins of the probe connector **must** be sprayed with DEOXIT #DN5 spray contact cleaner and rejuvenator. A small spray can of this is supplied with each inclinometer probe. After each daily use, always make sure that the connectors are completely dry before replacing the protective caps. Otherwise, corrosion could result.

6.4 Zero Shift Changes

If the zero shift changes due to aging or rough handling this will not affect the quality or accuracy of the readings because the shift is removed by taking two sets of readings in the A+ and A− directions. However, if the zero shift changes by more than 5000 digits then the probe should be returned to the factory for repairs. Zero shift can be set to zero at any time using the software inside the GK-604 readout instrument (see Section 4.2).

6.5 Self Calibration Check

It is good practice to have a piece of inclinometer casing permanently fastened to a fixed immovable structure in the laboratory. This casing is used as a periodic check on the calibration of the probe. Placing the probe in the casing should give a reading that does not change with time.

7. TROUBLESHOOTING

The sections below contain basic troubleshooting information and are an attempt to solve the more common problems that may occur.

7.1 Probe Connection Failure

Because this is the most common problem that will likely occur, this potential error deserves a section all to itself. When the GK-604D|aos is unable to establish connection to the probe (or the Remote Module) the error dialog shown in Figure 91 is displayed.
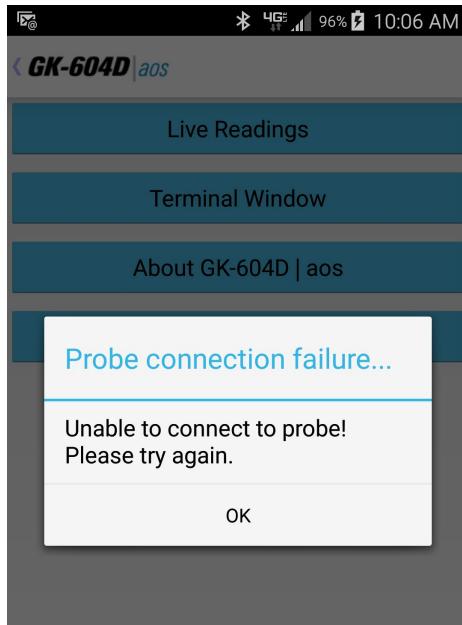
Figure 91 - Probe Connection Failure

If this error occurs, it's very likely that the problem lies with one of the following causes:

1) Bluetooth may not be turned on in the Android device settings. See Section 2.2, Establishing Contact with the Remote Module (step one), of this manual

2) The blue light on the Remote Module isn't blinking. (Attach Remote Module charger for two hours, then try again.)

3) The Bluetooth pairing is incorrectly selected in the System Configuration (see Section 3.2.4.6, Bluetooth Connection)

4) The probe is disconnected from the Remote Module cable.

5) The probe or cable may be damaged.

If the connection attempt fails multiple times after verifying the above steps, perform a full power down and restart of the Android device and attempt to connect again through the GK-604D|aos application.

7.2 Common Troubleshooting Solutions

PROBLEM	SOLUTION
Android device does not power up	Attach device charger for one hour then try again.
When launched, the GK-604D|aos app displays the Probe Library and Workspaces screen	Please refer to Section 2.4, Starting the GK-604D|aos for the first time.
When adding a "Hole," "UNKNOWN" is the only choice for "Probe name."	The "GK-604D|aos" app has not yet "discovered" the new probe, or the probe was deleted from the probe library. Please refer to Section 2.1, step five.
The blue indicator light does not blink when the "POWER ON/OFF" button is pressed on the Remote Module.	Attach Remote Module charger for two hours, then try again.
After tapping on "Live Readings" in the "APP" menu, the blue light never goes solid blue and a "Probe connection failure" screen is displayed.	Please refer to the previous section as well as Section 2.2.
The GK-604D|aos appears to be "hung" or "frozen" and will not respond to any key press.	This is highly unusual and may require that the Android device be powered down and/or a call to Geokon.
Blue light on Remote Module does not go off after Live Readings windows has been exited.	Press the "POWER ON/OFF" button on the Remote Module.

APPENDIX A. INCLINOMETER THEORY

A.1 Inclinometer Theory

In the geotechnical field inclinometers are used primarily to measure ground movements such as might occur in unstable slopes (landslides) or in the lateral movement of ground around ongoing excavations. They are also used to monitor the stability of embankments, slurry walls, the disposition, and deviation of driven piles or drilled boreholes and the settlement of ground in fills, embankments, and beneath storage tanks.

In all these situations it is normal to either install a casing in a borehole drilled in the ground, to cast it inside a concrete structure, to bury it beneath an embankment, or the like. The inclinometer casing has four orthogonal grooves (Figure 92) designed to fit the wheels of a portable inclinometer probe (Figure 93). This probe, suspended on the end of a cable connected to a readout device, is used to survey the inclination of the casing with respect to vertical (or horizontal) and in this way to detect any changes in inclination caused by ground movements.
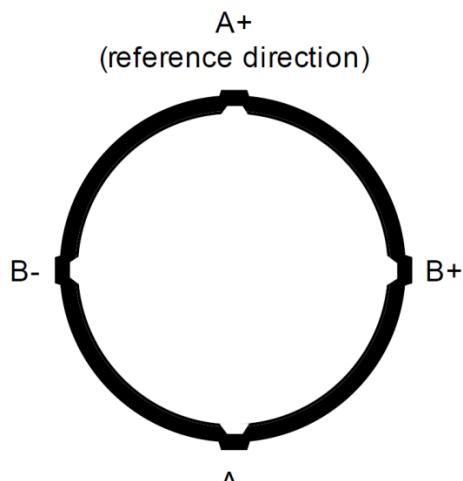
Figure 92 - Inclinometer Casing (End View)
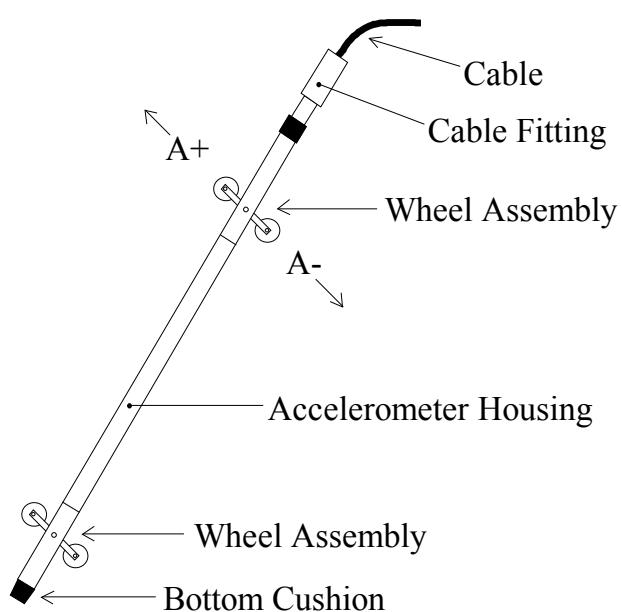
Figure 93 - Inclinometer Probe

The probe itself contains two MEMS, (Micro Electro-Mechanical Sensor), accelerometers, which flex when acted on by the force of gravity. Since the output voltage is proportional to the sine of the angle of inclination, the output is also proportional to horizontal deviation of the borehole (or the vertical deviation of a horizontal borehole).

In order to obtain a complete survey of the ground around the installed inclinometer casing it is necessary to take a series of tilt measurements along the casing. Typically, an inclinometer probe has two sets of wheels separated by a distance of two feet (English system) or half meter (Metric system). A casing survey would begin by lowering the probe to the bottom of the casing and taking a reading. The probe would then be raised at two-foot (English system) or half meter (Metric system) intervals and a reading taken at each interval until the top of the casing is reached. The set of readings thus generated is called the A+ readings. Marks on the cable at two-foot (English) or half meter (Metric) spacing facilitate the process. The probe is then removed from the casing, rotated through 180°, replaced in the casing, lowered to the bottom of the borehole and a second set of readings (the A− set) obtained as the probe is raised at the reading interval.

Inclinometer probes usually contain two accelerometers with their axes oriented at 90° to each other. The A-axis is in line with the wheels (Figure 93 illustrates) with the B-axis orthogonal to it. Thus, during the survey, as the A+, A− readings are obtained, the B+, B− readings are also recorded.

During the data reduction, these two sets of readings (A+, A− and B+, B−) are combined (by subtracting one set of readings from the other) in such a way that the effect of any zero offset of the force balance accelerometer is eliminated. [This zero offset is the reading obtained from the inclinometer probe when it hangs vertical. Ideally, the offset (or bias) would be zero, but usually there is a zero offset, which can change during the life of the probe. This change is most likely due to a sudden shock to the transducer caused by dropping or allowing it to hit too hard against the bottom of an installed inclinometer casing, but it can also be due to drift of the transducer or wear and damage of the wheels.

Subsequent surveys of the inclinometer casing, when compared with the original survey, will reveal any changes of inclination of the casing and locations at which these changes are taking place. Analysis of the change of inclination is best performed by computing the horizontal offset of the upper wheels relative to the lower wheels which has produced the tilting (θ) over the reading interval (L) of the survey (usually the wheel base of the probe, two-feet for English systems, half meter for Metric). At each position of the inclinometer, the two readings taken on each axis (A+, A− and B+, B−) are subtracted from each other leaving a measure of sineθ. This value is then multiplied by the reading interval (L) and the appropriate factor to output horizontal deflection in engineering units (inches for English, centimeters, or millimeters for Metric) (see Figure 94).
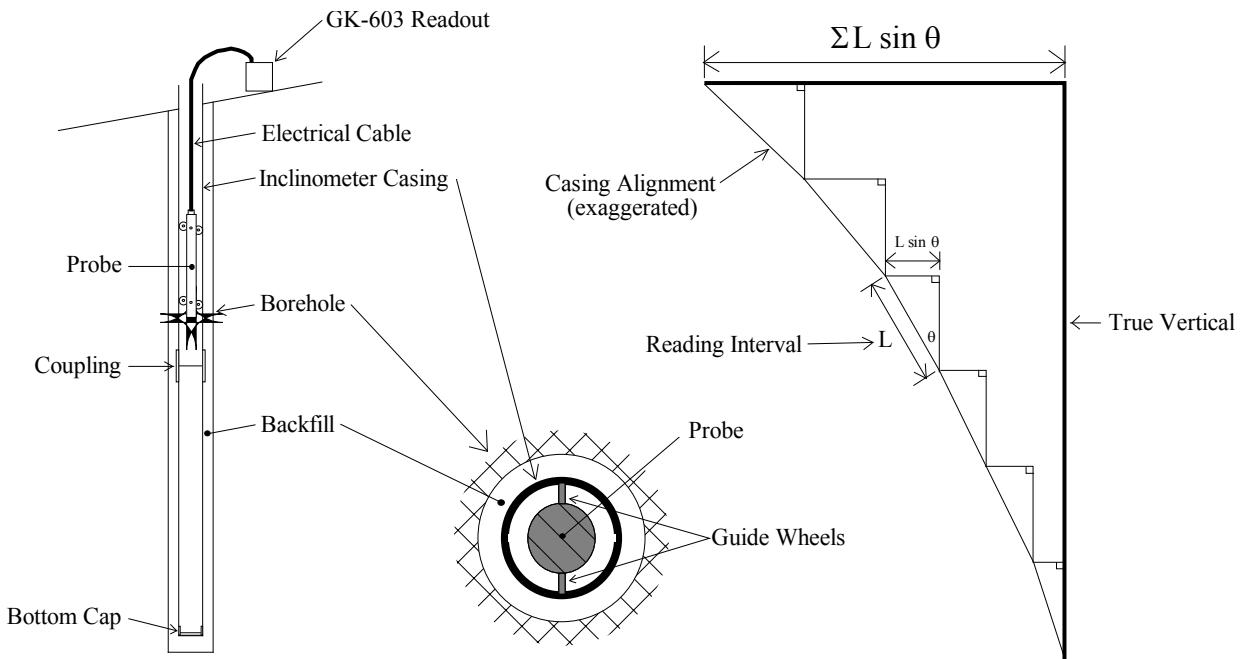
Figure 94 - Inclinometer Survey Description

When all these incremental horizontal deflections are accumulated and plotted, beginning at the bottom of the borehole, the net result is to produce a plot of the change in horizontal deflection between the time of the initial survey and the time of any subsequent survey. From such a deflection plot, it is easy to see at which depth the movement is occurring and its magnitude (Figure 95).
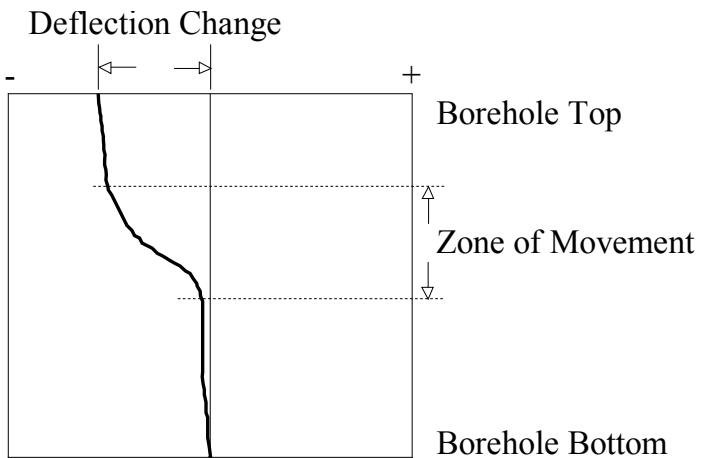
Figure 95 - Plot of Borehole Deflection

Other methods of analysis can be used but generally add little to the overall understanding of the situation. For example, using a single set of data, a profile of the borehole can be created. In addition, a plot can be made of the actual change in reading (inclination) at each measurement depth increment. A plot of this nature reveals the depths at which movement is occurring. This information can be obtained from the change in deflection curve with little difficulty.

One other analysis is the Check Sum (or Instrument Check) which can be used to measure the quality of the survey data.

The quality of the data can be impaired by any or all of the following:
- Skipping over or duplicating a reading.
- Not allowing the inclinometer sufficient time to come to rest before taking a reading.
- Not allowing sufficient time to allow the probe to reach temperature equilibrium before commencing the survey.
- Malfunction of the probe, cable, or readout device. This may be the result of shock, moisture, low battery conditions, opens or shorts in the cable or probe, etc.
- Carelessness when positioning the wheels so that the probe wheels do not rest on the same part of the casing from one survey to the next.
- Positioning the wheels so that they fall right on top of a casing joint, causing the reading to be unstable or simply erroneous.

The Check Sum analysis is performed by adding the A+, A- readings and the B+, B- readings. When this is done, the part of the reading due to the tilt is eliminated, leaving only a value that is equivalent to twice the zero offset of the inclinometer transducer.

A.2 Conducting the Survey

The following is a synopsis of the steps involved in taking a survey:

1) Attach the cable to the probe making sure that the connector is clean and the O-ring undamaged. Tighten the connector to ensure that the O-ring is compressed and watertight.

2) Twist the probe so that the uppermost wheel fits into the casing groove that faces the direction of the anticipated movement, (In the case of a slope this would be downhill, or, in the case of a foundation wall in the direction of the opening. This guarantees that the measured deflections will be positive. Lower the inclinometer probe to the bottom of the casing. To avoid damage to the probe be careful not to let the probe strike hard against the bottom of the hole.

3) Select the size of pulley assembly, (or cable hold), that matches the inclinometer casing and place it inside the top of the casing. Lift the inclinometer until the first cable marker passes the clamps on the pulley assembly (or sits in the cable hold if a cable hold is being used)

4) Turn on the Android device, turn on the Remote Module (blue light blinking) then launch the GK-604D|aos application. Tap on the "Live Readings" button (from the APP menu) and verify that the Android unit has connected to the probe. The Live Readings screen should be displayed (Figure 96) and inclinometer readings can be observed. Wait until the probe temperature has stabilized and the reading doesn't change.
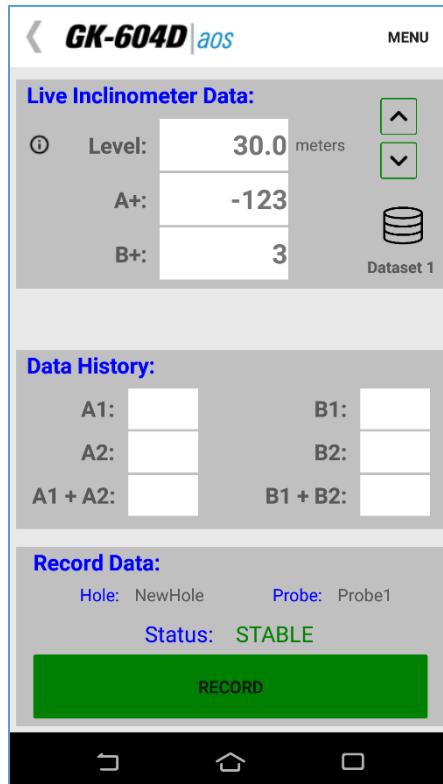
Figure 96 - Live Readings Screen

5) Make sure that the dataset indicator in the Live Readings screen (Figure 96) is "Dataset 1". Take the first reading, pull up on the cable until the next cable marker sits just above the cable grips on the pulley assembly, (or in the cable hold), and, after a short pause, take another reading.

6) Continue in this way until the top marker is reached, then remove the pulley assembly, (or cable hold), and pull the inclinometer out of the hole.

7) Twist the probe through 180 degrees then lower it to the bottom of the hole. Tap the "Dataset 1" button to select dataset two.

8) Repeat steps three through six.

9) Tap on the "<" icon to the left of the title to save the data.

A.3 Checksums and "Face Errors" on Inclinometer Probes

Many users have expressed concern about **checksums or "face errors"** on inclinometer probes. They are concerned with the effect of the "face error" on the accuracy of the readings. The purpose of this section is to show that under normal circumstances the effect of the "face error" or checksum is negligible even with checksums as large as 2000. **The only time a problem would arise is if the face error or checksum was to change between the two halves of a survey**. **This is why it is extremely important not to bang the probe on the bottom of the borehole between survey halves, and not to handle the probe roughly while out of the hole.** The term "face error" comes from surveying terminology. It is normal for all theodolites to have a "face error" which is caused by imperfections of alignment of the collimation axis and other misalignments. These "face errors" are removed routinely by taking two readings of the theodolite: one angle is measured with the face of the vertical scale on the left of the theodolite and another with the face of the vertical scale on the right of the theodolite. The average of the two readings "face right" and "face left" gives the **true angle since the "face error" cancels out.**

Similarly, with the inclinometer probe: the "face error" arises from the fact that the axis of the inclinometer probe is not parallel with the electrical axis of the internal, force-balance, servo-accelerometer transducer. Once again, the "face error" is eliminated by taking two surveys of inclinometer readings one with the wheels of the inclinometer probe pointing in one direction and another with the wheels of the probe at 180° to the first direction. If the first set of readings are all too <u>large</u> by the amount of the "face error", then the second set of readings will be too <u>small</u> by the amount of the "face error". Thus, the average (or sum) of the two readings will be a measure of the true inclination, since the effect of the face error will be eliminated.

A.3.1 Effect of "Face Error" on Reading Accuracy

The "face error" or checksum can only affect the accuracy of the readings if it affects the calibration of the probe. This is possible because the output of the probe transducer is proportional to the sine of the inclination from the vertical and the sine function is nonlinear.

Imagine, for a moment, that the electrical axis of the transducer is five degrees away from being parallel with the axis of the inclinometer. This would give rise to a "face error" of 01743. (The inclinometer reader displays $20{,}000 \sin \varnothing$). This would cause one set of readings would be all too large by this amount and the other set of readings from a normal inclinometer survey would be too small by this amount, but the sum of the two readings would be accurate, the "face errors" having canceled out. However, if we assume that the hole is almost vertical then the transducer will be tilted at an angle of 5°. The difference in the slope of the sine function at any point is equal to the cosine of the angle at that point. The cosine of 0 ° is 1.0000 the cosine of 5° is 0.996 so that the effect of this "face error" on the calibration of the probe is to increase it by a factor of $1/0.996 = 1.004$.

The practical implication of this would mean that if the apparent deflection of a borehole was 100 mm, the true deflection would be 100.4 mm. For practically all applications in the real world, the difference is insignificant and is a lot less than the differences that normally occur from survey to survey, i.e., a lot less than the <u>precision</u> of the inclinometer probe survey. (Lack of precision is caused by a failure to position the wheels of the probe in exactly the same place from survey to survey; failure to wait sufficiently long to allow the probe transducer to come to rest before reading; and random dirt in the inclinometer casing).

Note that the normal system accuracy of an inclinometer probe is ±3 mm in 30 meters. By comparison, it can be seen that the normal system accuracy or precision is very much larger than the calibration error caused by the "face error" and that for all practical purposes the "face error" is of no consequence and can be completely discounted if it is less than 2000 digits.

(As another example, supposing the checksum was as large as 5000 digits. This is equivalent to a gross angular error of misalignment of almost 15 degrees. The effect on the calibration would be a little over 3 % so that the apparent deflection of 100 mm would be out by 3 mm, which again is smaller than the normal data spread due to imprecision).

A.3.2 Measurement of "Face Error"

The "face error" is the reading shown by the inclinometer probe when it is perfectly vertical. In practice, the easiest way to obtain the "face error" is to run a normal inclinometer survey, with the two sets of readings at 180°, and then to run a profile or deflection report (see Appendixes C.2 and C.3, the column labeled "Diff"). Examination of the data will reveal **the average checksum, which is equal to twice the "face error."**

A.3.3 Setting of the "Face Error" to Zero

There are three ways of setting the "face error" to zero. None of them is necessary from the point of view of improving accuracy. These methods are detailed in the subsections below.

A.3.3.1 Mechanically

At the time of manufacture, the electrical axis of the transducer is adjusted by means of shims etc., until it points parallel to the axis of the inclinometer probe. This method suffers from the disadvantage that if the "face error" changes due to wear and tear on the probe and rough handling, or shock loading of the transducer then the probe needs to be returned to the factory for dismantling and readjustment.

A.3.3.2 Electrically

Electronic circuitry can be included in the probe so that the output of the transducer can be adjusted to zero when the probe is vertical. The disadvantage of this method is that it introduces electronic components into the inside of the probe which may alter with time, temperature and humidity and which, if the "face error" changes due to wear and tear or rough handling, will require the probe to be dismantled and the electronic circuitry readjusted. In addition, this form of correction does not really remove the "face error", it only masks it, and if the "face error" is very large, the calibration will be affected.

A.3.3.3 By Software

The best way for setting the "face error" to zero is by applying an automatic correction to the measured readings using the software capabilities of the inclinometer readout box.

The procedure for setting the face error to zero is described in Section 4.2, which covers the subject of "Zero shifts", which are the same as "face errors". The advantage of this method lies in its simplicity and the ability to set the "face error" to zero at any time without dismantling the probe. This is the method chosen by Geokon.

Another advantage of this method is that it is possible by judicious choice of the "face error" entered into the software program to make one probe give exactly the same digits output as another probe. This is sometimes thought to be desirable where probes are switched, and unbroken continuity of the raw data is desired. It is not necessary for reason of accuracy as has already been explained.

The disadvantage of this method is that, if the probe is changed, the operator must remember to change the zero shift offset in the program to accommodate the "face error" of the new probe.

A.3.4 Conclusion

It has been shown that for most practical purposes checksums of less than 2000 digits are of no consequence and can be completely ignored providing the inclinometer survey is conducted in the normal way. (i.e., two sets of readings at 180°) It has further been shown that the best method by far, for setting the "face error" to zero, is by means of the software capabilities in the inclinometer reader. This is the method chosen by Geokon.

APPENDIX B. DATA FILE FORMAT

B.1 Hole Data GKN File Format

```
***
GK 604M(v1.0.1.0,01/13);2.0;FORMAT II
PROJECT  :myHoles
HOLE NO. :newHole
DATE     :01/02/13
TIME     :14:32:13
PROBE NO.:testProbe
FILE NAME:newHole_001.gkn
#READINGS:61
FLEVEL,    A+,    A-,    B+,     B-
  30.0,  1013, -1052,  -380,   320
  29.5,   945,  -985,  -377,   315
  29.0,   946,  -981,  -346,   290
  28.5,   945,  -978,  -331,   276
  28.0,   995, -1048,  -337,   278
  27.5,  1014, -1050,  -318,   263
  27.0,  1034, -1068,  -316,   265
  26.5,  1046, -1078,  -348,   288
  26.0,  1037, -1075,  -376,   326
  25.5,  1042, -1075,  -415,   366
  25.0,  1079, -1116,  -430,   366
  24.5,  1053, -1087,  -440,   378
  24.0,  1027, -1066,  -449,   385
  23.5,  1024, -1061,  -477,   413
  23.0,  1020, -1054,  -474,   422
  22.5,  1029, -1063,  -500,   448
  22.0,  1099, -1131,  -485,   437
  21.5,  1080, -1116,  -503,   439
  21.0,  1047, -1082,  -514,   462
  20.5,  1043, -1075,  -518,   454
  20.0,  1042, -1077,  -527,   469
  19.5,  1062, -1096,  -542,   480
  19.0,  1074, -1105,  -551,   487
  18.5,  1085, -1118,  -553,   490
  18.0,  1104, -1140,  -572,   513
  17.5,  1097, -1128,  -541,   483
  17.0,  1090, -1125,  -549,   500
  16.5,  1069, -1105,  -545,   493
  16.0,  1103, -1139,  -567,   497
  15.5,  1082, -1129,  -566,   506
  15.0,  1065, -1100,  -553,   495
  14.5,  1052, -1086,  -529,   467
  14.0,  1009, -1045,  -519,   452
  13.5,   956,  -991,  -534,   468
  13.0,   899,  -933,  -558,   492
  12.5,   841,  -874,  -557,   493
  12.0,   800,  -836,  -568,   499
  11.5,   778,  -808,  -547,   482
  11.0,   755,  -789,  -522,   464
  10.5,   752,  -785,  -489,   440
  10.0,   754,  -789,  -465,   409
   9.5,   766,  -802,  -433,   378
   9.0,   769,  -804,  -429,   371
   8.5,   765,  -800,  -435,   372
   8.0,   762,  -795,  -442,   379
   7.5,   785,  -819,  -441,   386
   7.0,   811,  -844,  -456,   388
   6.5,   809,  -842,  -450,   394
   6.0,   802,  -837,  -472,   414
   5.5,   786,  -817,  -464,   398
   5.0,   776,  -809,  -475,   412
```

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```
4.5,    788,   -818,   -468,    404
4.0,    777,   -808,   -447,    381
3.5,    707,   -757,   -435,    375
3.0,    707,   -739,   -408,    354
2.5,    686,   -721,   -407,    359
2.0,    647,   -680,   -413,    356
1.5,    608,   -643,   -412,    357
1.0,    559,   -599,   -359,    298
0.5,    564,   -600,   -361,    300
0.0,    565,   -600,   -359,    300
```

NOTE: The date value following the "DATE:" header in the data file above is displayed in the "Short date" format from Regional Settings of the Nautiz. The time value following the "Time:" header in the data file above is always displayed as "HH:mm:ss".

APPENDIX C. TEXT REPORTS

C.1 Axis Profile Data Report (.CSV)

Shown as displayed in Excel, for clarity.

Report: A-Axis Change in Digits and Deflection in (cm) (Bottom Up)

	Project Name:	Project1
	Hole Name:	33
	Top Elevation:	33
	Azimuth Angle:	324
	Hole Location:	Lat:	43.6465	Lon:	-72.2516

	Survey Name:	33_init1
	Reading Date:	10/27/2015
	Reading Time:	15:33:43
	Probe Name:	Probe1
	Picture Loc:	/storage/emulated/0/Android/data/com.geokon.GK_604Daos/files/Pictures/temp/IMG_20161123_092002.jpg

Level	A+	A-	Sum	Diff	Diff/2	Defl.
(m)	(dig)	(dig)	(dig)	(dig)	(dig)	(cm)
0	75	-211	-136	286	143	23.96
0.5	74	-211	-137	285	142.5	23.6
1	74	-211	-137	285	142.5	23.24
1.5	77	-211	-134	288	144	22.89
2	74	-209	-135	283	141.5	22.53
2.5	77	-209	-132	286	143	22.17
3	77	-210	-133	287	143.5	21.82
3.5	73	-208	-135	281	140.5	21.46
4	75	-208	-133	283	141.5	21.11
4.5	75	-211	-136	286	143	20.75
5	75	-211	-136	286	143	20.39
5.5	76	-211	-135	287	143.5	20.04
6	76	-208	-132	284	142	19.68
6.5	76	-208	-132	284	142	19.32
7	74	-211	-137	285	142.5	18.97
7.5	76	-212	-136	288	144	18.61
8	75	-212	-137	287	143.5	18.25
8.5	73	-211	-138	284	142	17.89
9	75	-208	-133	283	141.5	17.54
9.5	77	-212	-135	289	144.5	17.18
10	75	-212	-137	287	143.5	16.82
10.5	74	-212	-138	286	143	16.46
11	75	-211	-136	286	143	16.11

Figure 97 - Sample Axis Profile Data Report

C.2 Axis Deflection Data Report (.CSV)

Shown as displayed in Excel, for clarity.

Report: B-Axis Change in Digits and Deflection in (cm) (Bottom Up)								
--								
Project Name:			Project1					
Hole Name:			33					
Top Elevation:			33					
Azimuth Angle:			324					
Hole Location:			Lat:	43.6465	Lon:	-72.2516		
--								
			--Initial Data--		--Current Data--			
Survey Name:			33_init1		33_later2			
Reading Date:			10/27/2015		10/27/2015			
Reading Time:			15:33:43		15:38:11			
Probe Name:			Probe1		Probe1			
--								
Level	--Initial (digits)--			--Current (digits)--			Corr.	Defl.
(m)	B+	B-	Diff.	B+	B-	Diff.	Diff.	(cm)
--								
33	264	-200	464	-199	271	-470	-934	78.05
32.5	264	-197	461	-199	270	-469	-930	76.88
32	265	-197	462	-198	270	-468	-930	75.71
31.5	265	-199	464	-198	271	-469	-933	74.55
31	265	-201	466	-198	271	-469	-935	73.39
30.5	264	-198	462	-197	271	-468	-930	72.22
30	265	-199	464	-197	271	-468	-932	71.05
29.5	265	-196	461	-197	272	-469	-930	69.88
29	265	-198	463	-200	272	-472	-935	68.71
28.5	263	-199	462	-200	272	-472	-934	67.55
28	266	-197	463	-199	272	-471	-934	66.39
27.5	265	-197	462	-197	272	-469	-931	65.22
27	264	-197	461	-198	271	-469	-930	64.06
26.5	265	-197	462	-198	271	-469	-931	62.89
26	266	-197	463	-198	271	-469	-932	61.73
25.5	265	-197	462	-198	271	-469	-931	60.57
25	264	-199	463	-198	271	-469	-932	59.4
24.5	264	-200	464	-198	273	-471	-935	58.24
24	264	-198	462	-198	273	-471	-933	57.08
23.5	265	-198	463	-197	272	-469	-932	55.91
23	264	-198	462	-197	272	-469	-931	54.74
22.5	263	-200	463	-197	272	-469	-932	53.58
22	262	-198	460	-197	273	-470	-930	52.42

Figure 98 - Sample Axis Deflection Data Report

APPENDIX D. REMOTE MODULE COMMAND STRUCTURE

COMMAND	FUNCTION	SYNTAX	RETURN VALUE
0	TAKE VA READING	0	(+/-)#####
1	TAKE VB READING	1	(+/-)#####
2	TAKE BATTERY READING	2	\<sp>\<sp>+#.#
3	TAKE -12V READING [1]	3	\<sp>-12.0
4	FIRMWARE VERSION [4]	4	VER#.#
5	(see Note 2)	5	\<CR>
6	(see Note 2)	6	000\<sp>\<sp>\<sp>
7	TAKE +12V READING [1]	7	\<sp>+12.0
8	TAKE +5V REFERENCE READING	8	\<sp>\<sp>+#.#
9	TAKE 3.3V READING [1]	9	\<sp>\<sp>+3.3
D	LOAD PROBE DEFAULTS [3]	D	See Example D
G	DISPLAY GAUGE PARAMETERS [3]	G	See Example G2
G	ENTER GAUGE PARAMETERS [3]	G70A/(LorP)/#/#/# or G70B/(LorP)/#/#/# See example G below	See Example G1
T	PROBE TEMPERATURE (°C) [3]	T	(+/-)##.####
V	FIRMWARE VERSION (Remote Module) [3]	V	VER #.#
#	DISPLAY PROBE SERIAL # [3]	#	See example #
#sn	ENTER PROBE SERIAL # [3]	#sn (16 alphanumeric characters or symbols)	See example #sn

Table 2 - Remote Module Commands

Notes:

[1] These commands exist only for GK-604 analog systems and are included in the digital system for compatibility.

[2] Similar to Note 1, but are for internal use only.

[3] These commands exist only for GK-604D digital system.

[4] Firmware Version (Command 4) returns the Remote Module version for analog systems and the probe firmware version for digital systems.

Example 1: LOAD PROBE DEFAULTS

Loads probe default gauge parameters (calibration factors):
Command: D\<CR>
Response: GT:70A ZR:0.0000 GF:1.0000 GO:0.0000 GT:70B ZR:0.0000 GF:1.0000 GO:0.0000

Channels VA and VB: Linear Conversion
Zero Read Offset = 0
Gauge Factor = 1
Gauge Offset = 0

Results in digits display = 2500(Vout)

Example 2: ENTER GAUGE PARAMETERS

Enter and store gauge parameters for each axis:

<u>A-axis:</u> Linear conversion
Zero Read Offset = 0
Gauge Factor = .62
Gauge Offset = 0

<u>Command:</u> G70A/L/0/.62/0<CR>
<u>Response:</u> GT:70A ZR:0.0000 GF:0.6200 GO:0.0000 GT:70B ZR:0.0000 GF:1.0000 GO:0.0000

<u>B-axis:</u> Linear conversion
Zero Read Offset = 0
Gauge Factor = 1.005
Gauge Offset = 0

<u>Command:</u> G70B/L/0/1.005/0<CR>
<u>Response:</u> GT:70A ZR:0.0000 GF:0.6200 GO:0.0000 GT:70B ZR:0.0000 GF:1.005 GO:0.0000

Example 3: DISPLAY GAUGE PARAMETERS

Display gauge parameters stored in the probe:
<u>Command:</u> G<CR>
<u>Response:</u> GT:70A ZR:0.0000 GF:0.6200 GO:0.0000 GT:70B ZR:0.0000 GF:1.005 GO:0.0000

Example 4: DISPLAY PROBE SERIAL NUMBER

Display the serial number that is stored in the probe:
<u>Command:</u> #<CR>
<u>Response:</u> 6001-E,126543

Example 5: ENTER PROBE SERIAL NUMBER

NOTE: The GK-604D|aos application uses the serial number to determine the inclinometer probe units (metric or English) by reading the model number portion of the serial number string (the part to the left of the comma). If the model number does not contain an "-E" or a "–M" then unpredictable results may occur.

Enter and store probe serial number:
(Up to 16 alphanumeric characters and symbols may be stored.)

<u>Command:</u> #sn6001-E,126543<CR>
<u>Response:</u> 6001-E,126543

APPENDIX E. DATA REDUCTION FORMULAS

E.1 Deflection Calculation

Label	Description
ZZ	Correction Angle (usually 0°).
RINT	Absolute Reading Interval in feet or meters.
IA+,IA−	Initial A-axis Data in Digits ($2\sin\theta$=10000 @ 30°, $2.5\sin\theta$=12500 @ 30°).
PA+,PA−	Present A-axis Data in Digits ($2\sin\theta$=10000 @ 30°, $2.5\sin\theta$=12500 @ 30°).
IB+,IB−	Initial B-axis Data in Digits ($2\sin\theta$=10000 @ 30°, $2.5\sin\theta$=12500 @ 30°).
PB+,PB−	Present B-axis Data in Digits ($2\sin\theta$=10000 @ 30°, $2.5\sin\theta$=12500 @ 30°).
SA	Calculated Digit Change for A-axis.
SB	Calculated Digit Change for B-axis.
M	Multiplier, where: Geokon probe / Sinco Probe. Probe configuration $2\sin\theta$, $2.5\sin\theta$. Metric units, millimeters, 0.05 / 0.04. Metric units, centimeters, 0.005 / 0.004. Imperial units, inches 0.0006 / 0.00048
CA	Deflection A (in inches, English units, not corrected). Deflection A (in centimeters or millimeters, Metric units, not corrected).
CB	Deflection B (in inches, English units, not corrected). Deflection B (in centimeters or millimeters, Metric units, not corrected).
DA	Deflection A (in inches, English units, corrected for angle). Deflection A (in centimeters or millimeters, Metric units, corrected for angle).
DB	Deflection B (in inches, English units, corrected for angle). Deflection B (in centimeters or millimeters, Metric units, corrected for angle).
cos	Cosine function.
sin	Sine function.

Table 3 - Data Reduction Variables (Deflection)

$$SA = ((PA+)-(PA-))/2 - ((IA+)-(IA-))/2$$
$$SB = ((PB+)-(PB-))/2 - ((IB+)-(IB-))/2$$

Equation 1 - Change in Digits Calculation (Deflection)

$$CA = M \times RINT \times SA$$
$$CB = M \times RINT \times SB$$
$$DA = (CA \times \cos(ZZ))-(CB \times \sin(ZZ))$$
$$DB = (CA \times \sin(ZZ))+(CB \times \cos(ZZ))$$

Equation 2 - Deflection Calculation

NOTE: Accumulate (Σ) DA and DB results at each depth increment (from the bottom up or the top down) to obtain the deflection change (Figure 80).

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E.2 Profile Calculation

Label	Description
ZZ	Correction Angle (usually 0°).
RINT	Absolute Reading Interval in feet or meters.
A+, A−	A-axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).
B+, B−	B-axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).
SA	Calculated Digit Change for A-axis.
SB	Calculated Digit Change for B-axis.
M	Multiplier, where: Geokon probe Sinco Probe Probe configuration 2sinθ, 2.5sinθ. Metric units, millimeters, 0.05 0.04 Metric units, centimeters, 0.005 0.004. Imperial units, inches 0.0006 0.00048
CA	Deflection A (in inches, English units, not corrected). Deflection A (in centimeters or millimeters, Metric units, not corrected).
CB	Deflection B (in inches, English units, not corrected). Deflection B (in centimeters or millimeters, Metric units, not corrected).
DA	Deflection A (in inches, English units, corrected for angle). Deflection A (in centimeters or millimeters, Metric units, corrected for angle).
DB	Deflection B (in inches, English units, corrected for angle). Deflection B (in centimeters or millimeters, Metric units, corrected for angle).
cos	Cosine function.
sin	Sine function.

Table 4 - Data Reduction Variables (Profile)

$$SA = ((A+)-(A-))/2$$
$$SB = ((B+)-(B-))/2$$

Equation 3 - Change in Digits Calculation (Profile)

$$CA = M \times RINT \times SA$$
$$CB = M \times RINT \times SB$$
$$DA = (CA \times \cos(ZZ))-(CB \times \sin(ZZ))$$
$$DB = (CA \times \sin(ZZ))+(CB \times \cos(ZZ))$$

Equation 4 - Profile Calculation

NOTE: Accumulate (Σ) DA and DB results at each depth increment (from the bottom up or the top down) to obtain the profile.

E.3 GTILT Users

When using GTILT with the GK-604D|aos data files, use a Probe Constant of 10000 for both English and Metric "2.0sin" probes. For 2.5sin Units (Sinco) use a Probe Constant of 12500.

E.4 SiteMaster Users

When using SiteMaster with the GK-604D|aos, use a Probe Constant of 20000 for both English and Metric probes.

APPENDIX F. TECHNICAL SPECIFICATIONS

F.1 GK-604D Digital System Specifications

Standard Range:	± 30°
Sensors:	Two MEMS accelerometers
MEMS Output:	Differential ± 4 VDC
6100D Probe Output:	Digital Data Stream
Probe Resolution:	24-bit
System Resolution[1]:	± 0.025 mm/500 mm (± 0.0001 ft./2 ft.)
Accuracy:	± 0.05% Full Scale (F.S.)
Linearity:	± 0.02% F.S., up to ±10°
Repeatability:	± 1 mm/30 m
Total System Accuracy[2]:	± 3 mm/30 m (± 0.125 in/100 ft.)
Temperature Range (Probe):	-30°C to 85 °C
Temperature Range (Remote Module):	-30°C to 85 °C
Temperature Coefficient:	0.002% F.S./°C
Wheel Base:	0.5 m, 1 m or 2 ft.
Length x Diameter[3]:	700 x 25 mm, 1200 x 25 mm or 32 x 1 in.
Casing Size I.D.[4]:	48 to 89 mm (1.9 to 3.5 in)
Weight (with case):	7.5 kg (16 lb.)
Shock Survival[5]:	2000 g
Battery (Remote Module):	Li-Ion, 7.4 V, 2600 mAh; >40 hours continuous operation per charge
Maximum Probe-Reel Cable Length	500 m (1640 ft.)

Table 5 - GK-604D Specifications

NOTES:

[1] ± 10 arc seconds. This resolution is true only in the range of ± 5° from vertical. Beyond this, the resolution is diminished by the cosine of the angle from vertical.

[2] Within 3° of vertical. This takes into account the accumulation of the error inherent with each reading and normal placement errors in positioning the probe inside the casing; also the effect of debris in the casing or casing damage.

[3] The cable connector adds 150 mm to the length of the probe. The wheel diameter is 30 mm.

[4] The probe is designed for use in all standard inclinometer casing up to a maximum diameter of 89 mm (3.5 inches).

[5] **The Inclinometer Probe is a highly sensitive device and should be treated with great care at all times in order to maintain calibration. In particular, the probe should be prevented from impacting the bottom of the casing with any force.**

F.1.1 Compass Sensor Specifications

Table 6 contains specifications for the Digital Compass sensor embedded in digital inclinometer probes.

Compass Sensor:	Anisotropic Magneto-resistive
MEMS Output:	± 4 VDC
Compass Sensor Resolution:	12 bit
Remote Module Resolution:	16 bit
Compass Sensor Accuracy:	± 2 degrees
Operating Temperature:	−30°C to 85°C (−22° to 185°F)

Table 6 - Compass Sensor Specifications

F.2 Analog Probe System Specifications (Obsolete Model)

Table 7 contains specifications for the analog probe system, which is comprised of a probe (6100-1M or 6100-1E) and the Remote Module. The Remote Module can be either a GK-604-3 (reel system) or a GK-604-4 (probe interface).

Probe Range (100% F.S.):	$\pm$ 30°
Remote Module Input Range:	$\pm$ 8 VDC
Sensors:	2 MEMS accelerometers
MEMS Output[1]:	$\pm$ 4 VDC
Probe Resolution[2]:	.025 mm /500 mm (.0001 ft./ 2 ft.)
Remote Module Resolution:	16-bit
Repeatability[3]:	$\pm$ 1 mm/30 m ($\pm$ 0.05 in./100 ft.)
Total System Accuracy[4]:	$\pm$ 4 mm/ 30 m ($\pm$ 0.17 inch/ 100 ft.)
Remote Module Accuracy:	$\pm$ 0.1% F.S.
Probe Temperature Range:	−20°C to 50°C (−4° to 122°F)
Remote Module Temp. Range:	-30°C to 50°C
Temperature Coefficient:	<.0002% F.S./ °C (<.0002% F.S./ °F)
Wheel Base:	0.5 m or 1.0 m (2 ft.)
Casing Size I.D.[5]:	48 to 89 mm (1.9 to 3.5 in)
Probe Length x Diameter[6]:	700 × 25 mm dia. (32 × 1 in dia.)
GK-604-3 Dimensions:	*(L x W x H):* 380 x 280 x 490 mm
GK-604-4 Dimensions:	*(L x W x H):* 160 x 75 x 75 mm
Weight (with case) (GK-604-1):	7.5 kg (16 lb.)
Shock Survival:	2000 g
Battery (Remote Module):	Li-Ion, 7.4 V, 2600 mAh; >16 hours continuous operation per charge
Maximum Probe-Reel Cable Length	850 m (2790 ft.)

Table 7 - Analog Probe System Specifications

NOTES:

[1] The probe outputs ±4 volts at an inclination of ±30° to the vertical. These parameters are referred to as full scale. Operation beyond this inclination is not possible with a standard MEMS probe.

[2] The resolution shown in Table 7 is only true in the range of $\pm$ 5° from the vertical. Beyond this, the resolution is reduced by a factor equal to 1/cosine of the angle from the vertical. For instance, the resolution at 0 degrees from vertical is 10.3 arc seconds and the resolution at 15 degrees from the vertical is 10.3 x 1/0.966 = 10.7 arc seconds. The figures given assume that the readout box can detect a change of output of 0.0005 VDC.

[3] The figure shown applies to the use of a single probe used repeatedly over a short space of time in a single borehole.

[4] In practice, system accuracy is controlled mainly by the precision with which the inclinometer can be positioned at exactly the same depth in the casing from survey to survey. Factors such as debris in the casing or casing damage also have an effect. The stated accuracy assumes that the surveys are conducted over a period of time, in a proper manner, and that the casing is within five degrees of vertical. Accuracy is improved by allowing the probe to reach equilibrium at each depth before taking a reading.

[5] The probe is designed for use in all standard inclinometer casing up to a maximum diameter of 89 mm (3.5 inches).

[6] The wheel diameter is 30 mm. The cable connector adds 150 mm to the length of the probe.

F.3 Android Device Minimum Specifications

Operating System:	Jelly Bean, 4.2 or greater
Bluetooth:	Version 2.1 or greater
Wifi or Cell Phone capability:	Required if email export and/or saving is used
GPS Hardware:	Recommended
Camera:	Recommended
Protective Case:	Recommended

Table 8 - Android Device Minimum Specifications

APPENDIX G. COMPASS PROBE OPERATION

The GK-604D|aos supports Geokon's digital Inclinometer/Compass Probe (6100D - firmware Version V2.7 or higher), used with a Digital Reel System (GK-604D - firmware version of V2.7 or higher) as described in the sections that follow.

G.1 Inclinometer/Compass Probe (6100D)

As of probe firmware version V2.7, coupled with the GK-604D reel assembly (also V2.7), all digital inclinometer probes now include a three-axis, magneto-resistive, compass sensor survey (see Figure 99). The compass sensor coupled with two axes of MEMS, allow a spiral survey to be performed at the same time as the inclinometer survey.

Figure 99 - Digital Inclinometer/Compass Probe (6100D)

To perform a compass survey with the Digital Inclinometer/Compass Probe:

1) Connect the 6100D probe to the Remote Module and ensure that a wireless pairing exists between the Remote Module and the Android device. See Section 2.2 for more information regarding wireless pairing.

2) Launch the GK-604D|aos application.

3) If one does not already exist, create a hole to represent the physical hole, shaft or well where the inclinometer/compass survey is to be performed. If a probe configuration exists for the Inclinometer/Compass probe, then select the name of the probe to be assigned to this hole, otherwise set the "Probe" to "UNKNOWN". Set the "Azimuth Angle" parameter to "0" then save settings.

4) Press the "POWER ON" button on the reel and ensure that the blue light is blinking.

5) From the main screen (Figure 100), tap the "APP" menu (Figure 101) then "Live Readings". If the probe serial number matches a probe configuration serial number from the Probe Library, then the "Live Readings" screen (Figure 102) will be displayed. Proceed to step six.
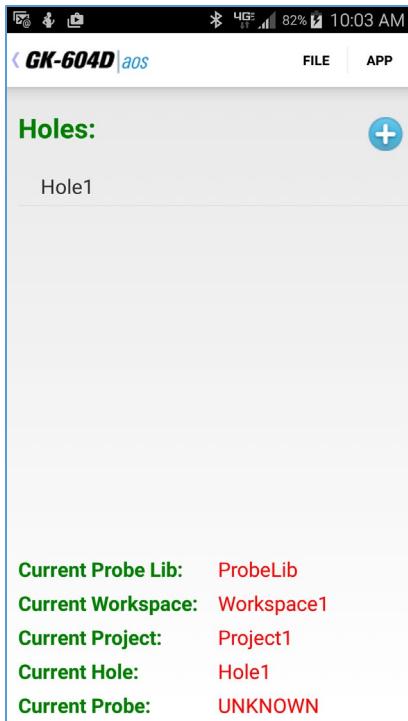
Figure 100 - Main Screen
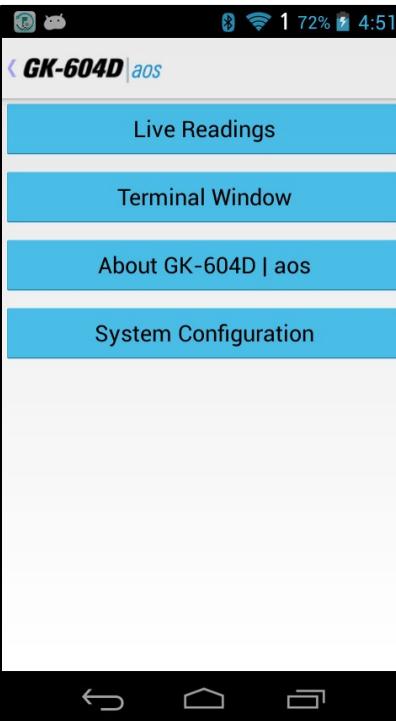
Figure 101 - App Menu
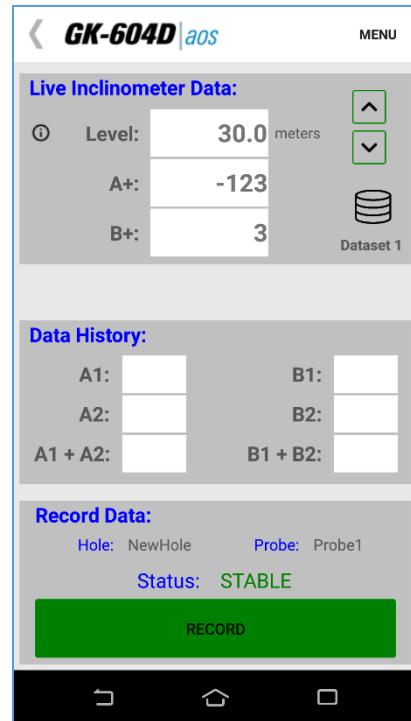
Figure 102 - Live Readings Screen

If the probe has never been detected before, a screen similar to the one in Figure 103 will be displayed. Tap "ok" to continue and the GK-604D|aos will display a probe editing screen to allow the probe to be named (Figure 104). After entering a name, tap the "<" to the left of the title. If the hole to be surveyed has an "UNKNOWN" probe assigned to it then the GK-604D|aos will ask if this newly discovered probe should be assigned to this hole (Figure 105). Selecting "Yes" will cause the "Live Readings" screen to be displayed Figure 102.
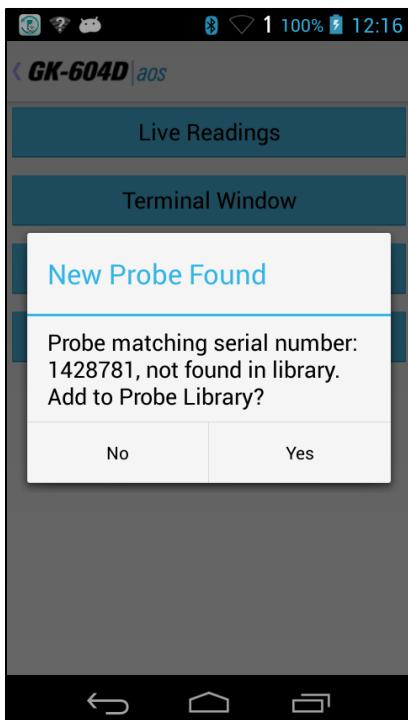

Figure 103 - New Probe Found
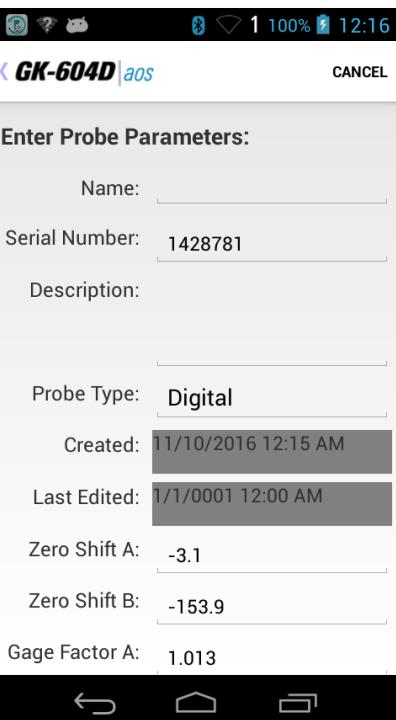

Figure 104 - Initial Probe Settings
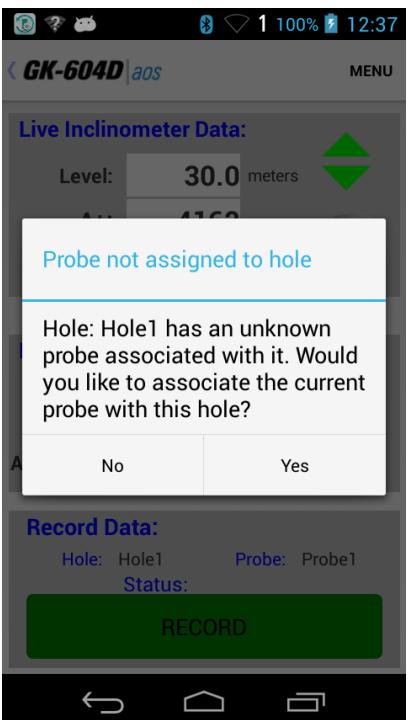
Figure 105 - No Probe Association

6) Tap "MENU" on the live reading screen to display the menu shown in Figure 106. Tapping "Enable Compass Survey", will enable the compass survey option and cause the message shown in Figure 107 to be displayed. An inclinometer survey with the compass enabled will take approximately 30% longer.
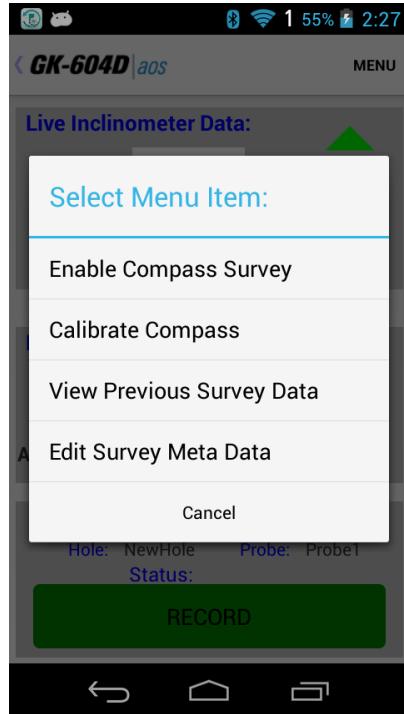

Figure 106 - Live Readings Menu Options
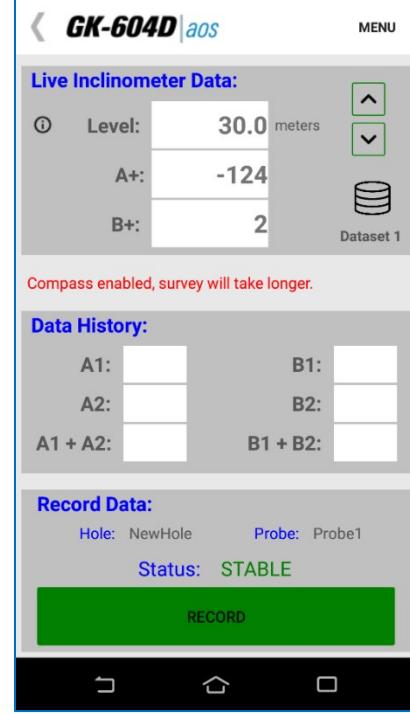
Figure 107 - Compass Enable Message

7) With the compass enabled, a survey is performed as normal (see Section 3.2.1) and the compass heading can be displayed at any level by tapping on "MENU->View Compass Data", displaying the screen shown in Figure 108.
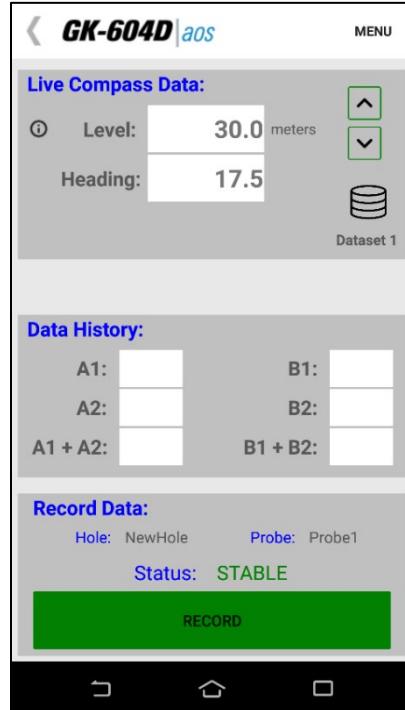

Figure 108 - Live Compass Data

8) While live compass data is being shown, "Live Inclinometer Data" can be redisplayed at any time by tapping on "MENU->View Inclinometer Data".

9) When done the survey, tap the "<" to the left of the title and the "Unsaved data" prompt (Figure 109) will be displayed. Tap "Yes" to save the inclinometer/compass survey data.
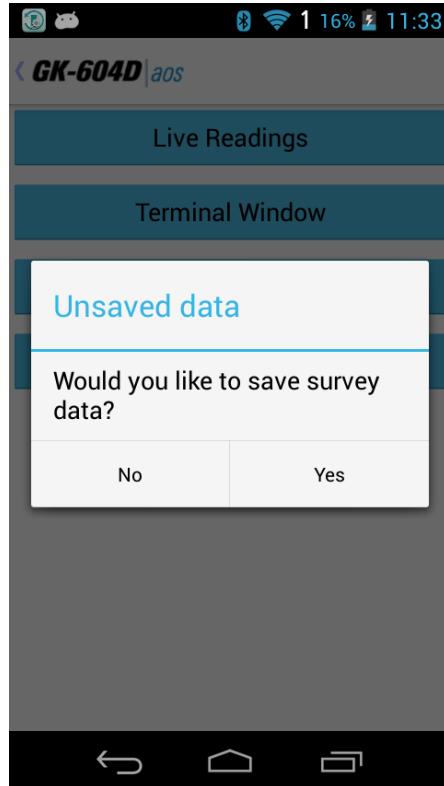

Figure 109 - Unsaved Data Prompt

10) When exporting inclinometer surveys, data is saved into a ".gkn" file as normal while the compass survey data is saved into a ".gks" file. The ".gks" file format is supported by SiteMaster inclinometer analysis software and is very similar to standard inclinometer survey data with the following exceptions:
   - **A+** data is always in degrees.
   - **A-** and **B-** are always zero (0)
   - **B+** data is always 90 degrees greater than **A+**

11) For surveys with the compass enabled, compass data is included in the "Raw Data Report" as an additional column of data labeled "Compass Hdg (deg)". Compass data can also be exported for later use in analysis using "FILE-> Export". See Section G.2 for an example ".gks" file.

G.1.1 Calibrate Compass

For optimum accuracy, the digital inclinometer/compass probe should be calibrated for each site. A compass survey does not need to be enabled to perform the calibration.

While the GK-604D|aos is connected to the probe and displaying the "Live Readings" screen, tap on "MENU" to open the menu shown in Figure 110.
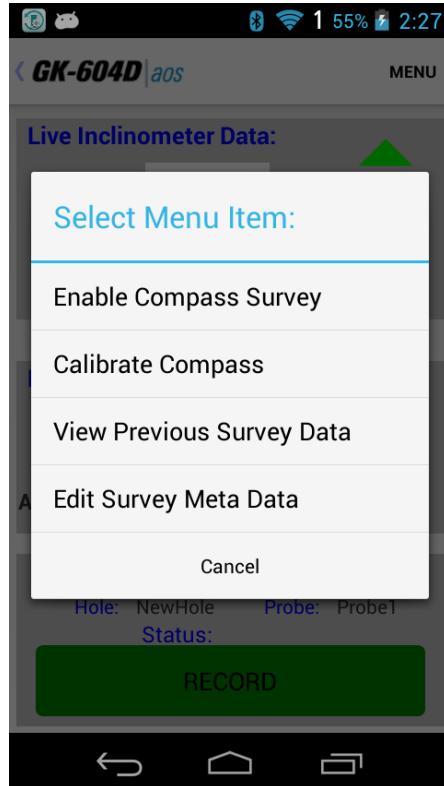

Figure 110 - Live Readings Menu

Next tap "Calibrate Compass" to display the initial calibration screen (Figure 111).
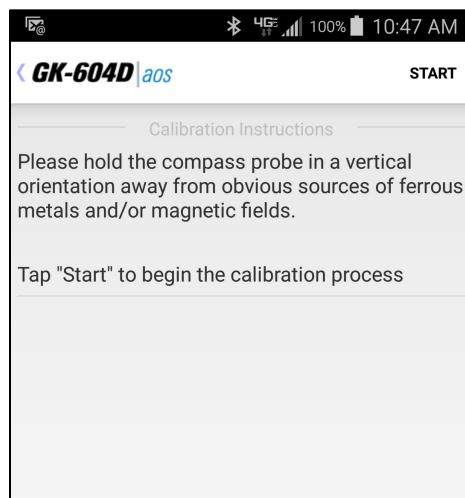
Figure 111 - Initial Calibration Screen

Tap "START" to begin the calibration process (Figure 112).
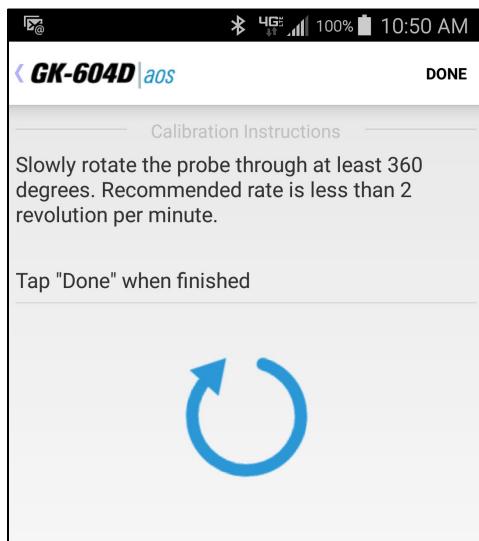
Figure 112 - Calibration Routine

As the instructions state, the probe should be held in an upright position and slowly rotated through at least 360 degrees. The large rotating blue "arrow" serves two purposes: 1) It indicates to the user that the probe should be turned. 2) It provides feedback that the calibration routine is still running. Tapping "DONE" sends a command to the probe that calibration is finished, and the Live Readings screen is redisplayed.

G.2 Compass Survey Data

```
***
GK 604M(v1.2.0.0,07/14);2.0;FORMAT II
PROJECT :testProj
HOLE NO. :testHole
DATE    :7/22/14
TIME    :11:30:57
PROBE NO.:incloCompass
FILE NAME:testHole_012_Compass.GKS
#READINGS:71
FLEVEL,  A+,  A-,  B+,  B-
 35.0,  164,   0,  254,   0
 34.5,  164,   0,  254,   0
 34.0,  168,   0,  258,   0
```

APPENDIX H. COMMONLY ASKED INCLINOMETER PROBE QUESTIONS

Can inclinometer probes be swapped freely to perform surveys in the same borehole?

Immediately after leaving the factory, probes may be swapped freely as they will meet the system accuracy specification, which is ±3 mm/30 m (±.125 in/100 ft.).

Can corrections be made to the data when instruments are swapped? Such as an offset or formula?

As time passes, correcting the output of one probe to match that of another probe becomes quite difficult, and would involve a tremendous amount of time and effort spent recording, calculating, and converting every data point for every level in every survey.

Unfortunately, there is not a universal formula, any simple corrections, or offsets that can be used to correct one probe to another.

We recently sent our probe in for calibration. After receiving it back from Geokon, the old surveys do not match up with the newly calibrated probe's surveys and are showing significant displacement. It is the same probe, so why don't the surveys match?

For the same reasons that two different probes will show differences in the same borehole, a newly calibrated probe will also show differences (from its old calibration) even though it is physically the same piece of equipment. Essentially, after a recalibration you are working with a "new" probe.

How can I compare my old data with my new data?

The recommended method to check compatibility between two sets of probes is to take at least three surveys with the new probe and compare them to the most recent survey taken with the old probe. If the resulting *cumulative displacement* plots performed with the new system overlay the latest survey from the old system, consider yourself lucky. However, if you see significant differences, we recommend the following method.

From the old series of surveys performed with the original system, create a final summary of cumulative displacement and a summary of displacement vs. time. Also, create a comparison of the final survey with the old system to the initial surveys taken with the new system. Then archive these summaries and data.

Next, use one of the three surveys obtained with the new system that you feel is most accurate. Use that survey to establish a new baseline survey and start a new series. This is the most accepted method in the long term.

The reason Geokon recommends this method is that you already know the magnitude and rate of movements you were detecting with the old system. This will be based on the final cumulative displacement plot and the displacement vs. time summaries created earlier. When movements occur, you will catch them with the new series based on the new system.