



KILO User Manual

IRIDIUM SATELLITE BEACON WITH GPS LOCATION

Version 1.7
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Shipped From



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Version History

Version	Date	Description
1.0	May 2011	Base document
1.1	May 2011	Updated SBD messaging to KILO
1.2	Feb 2012	Updated specifications, included XO information
1.3	May 2012	Update specifications, included warranty
1.4	Aug 2014	Update specifications and formatting
1.5	Sep 2014	Added watch circle commands
1.6	Feb 2015	Updated watch circle commands and XO instructions
1.7	Jun 2015	New format and instructions

Overview

General Description

The KILO Watch Circle Subsurface Iridium Satellite Mooring Location Beacon continuously monitors for unplanned or accidental release of subsurface instrument moorings. The KILO makes use of the bi-directional, global, real time Iridium satellite Short Burst Data (SBD) network in combination with GPS position location. The KILO's sleek tubular design allows it to be easily retrofitted into subsurface flotation such as syntactic foam.

Inside the KILO is a stainless steel chamber, 9602 Iridium satellite Short Burst Data core radio transceiver, a specialized low power Xeos digital controller with GPS, Iridium antenna, GPS antenna, and water sense circuitry specially designed to measure changes in capacitance. The internal, customer replaceable AA battery pack, lasts over a year in deployment.

The KILO can establish a watch circle post-deployment and will notify users if it moves outside of the watch circle area.

KILO is intended for both surface and subsurface deployments. The KILO is rated for 2,500 m below sea level. Xeos Technologies Inc. manufactures other specific products for either surface or subsurface applications, up to 11,000 m below sea level.

See xeostech.com for details or call (902) 444-7650.

Theory of Operation

The KILO Watch Circle is intended for instantly and accurately locating and recovering high value, free drifting surface assets at sea. After being powered on, the KILO will begin to average its GPS location fixes for 48 hours. Then the KILO will create a circle using the 48 hour average as its center and a user definable radius (default radius of 100m). At default settings, the KILO will last for up to 1 Year.

If it travels outside of the watch circle, the KILO will enter an **Alarm Mode** and send 3 consecutive messages to the Iridium satellite. The first message is an Iridium check. The second message is a status change message. The third message contains the GPS position. The KILO will then transmit a position message every 10 minutes for 1 hour. After the first hour, the KILO will exit **Alarm Mode** and continue to transmit at its user configurable **Normal Mode** timings (default alarm mode timings are 3 hours)

Operators can communicate with the KILO via Iridium using email commands or [Xeos Online](#). Status information can be obtained, including the health of the GPS system and battery voltage. Timings are settable and should be changed within the first hour of power-up or surfacing. The default timings are 3 hours, thus the user will have to wait up to 3 hours for the KILO to receive any command messages once it has entered **Normal Mode**.

The KILO will continue to send position messages until it is manually turned off or the battery pack drops below the minimum voltage requirement of 7V.

Setting up your Iridium Account

The KILO makes use of the Iridium satellite system's (www.iridium.com) Short Burst Data (SBD) service for the 9602 transceiver. This service is a global, two-way, real-time, email-based data delivery service that has a maximum outbound (from beacon) message size of 340 bytes and a maximum inbound (to beacon) message size of 270 bytes.

KILO end users must set up an approved data delivery account with their preferred service provider. This can only be done once Xeos has provided the user with an International Mobile Equipment Identity (IMEI) number. Each 9602 has a unique IMEI number that must be registered with the preferred service provider. For a list of service providers in your area please contact Iridium for recommendations. Xeos Technologies is also able to provide Iridium SBD data service and accounts. Please contact activations@xeostech.com for more information or use the online form on our website: xeostech.com

Each IMEI number is capable of being associated with up to five (5) unique email addresses. This may vary between service providers. When registering your IMEI number, please provide the service provider with a temporary Xeos testing account email address.

This account is: xeosbeaconb@gmail.com

This temporary email testing account can be deleted or replaced at any time after delivery of the KILO. Once the SBD account has been activated, please contact your Xeos representative and confirm this.

The KILO makes use of a simple and robust, text-based email protocol. Any email application can be used to send and receive messages to the KILO. Command files are found on the Xeos Technologies website (www.xeostech.com), or can be emailed directly by contacting sales@xeostech.com. Once downloaded to the PC, unzip the file, which contains four (4) command files that have ".sbd" extensions used to communicate with the KILO. You are now ready to test the KILO beacon and prepare it for deployment.

On/Off Modes

Using the Magnet

The KILO beacon is turned ON and OFF through the use of an external magnet near an internal magnetic reed switch, and operation can be identified by viewing the LED through the top of the KILO

To turn the KILO, begin swiping the magnet quickly up and down at the location of the reed switch. The reed switch is located directly behind the Xeos Technologies Logo.

Note: If the initial color of the LED is Green that means that the KILO is already operational.



Figure 1: Reed switch location

A flashing green LED indicates the device is in the process of powering up, continue to swipe the magnet until you see a solid green LED. A solid green LED indicates that the device is powered and operational.

To turn the KILO OFF, repeat the above procedure with the magnet and watch the LED change from green to red. A red flashing LED indicates the device is powering down, continue to swipe the magnet until you see a solid red LED. A solid red LED indicates that the device is turned OFF.

At any time the magnet can be placed against the location of the reed switch once to see which mode the beacon is currently in. A red LED indicates the device is turned OFF. A green LED indicates the device is turned ON.

LED Notes

- **It is important to let all LED's stop illuminating before initiating another action**
- **Cycling power for any reason, for example by using the switch to turn OFF/ON or by removing battery power, will start the Startup Alarm Mode**
- **It is important that the beacon has a good view of the sky during any test, so it is necessary to test the beacon outside of a building**

Communicating with the KILO

Special email commands are used to communicate with the KILO when it is above water. These commands are sent as email attachments. Commands can configure the KILO before deployment and can also be used to remotely reconfigure or update status with KILO. There are four attachment files that serve separate functions. All commands are given "over the air" and the KILO must have a good view of the sky to receive these commands.

Attaching Email Command Files

All command messages must be sent to the following email address:
data@sbd.iridium.com

- Messages must have only the unique IMEI number of the KILO in the subject line
- Command files must be sent to KILO as an attachment to a regular email message
- Text in the body of the message will be ignored

Your message is sent to the Iridium Gateway in Arizona, USA

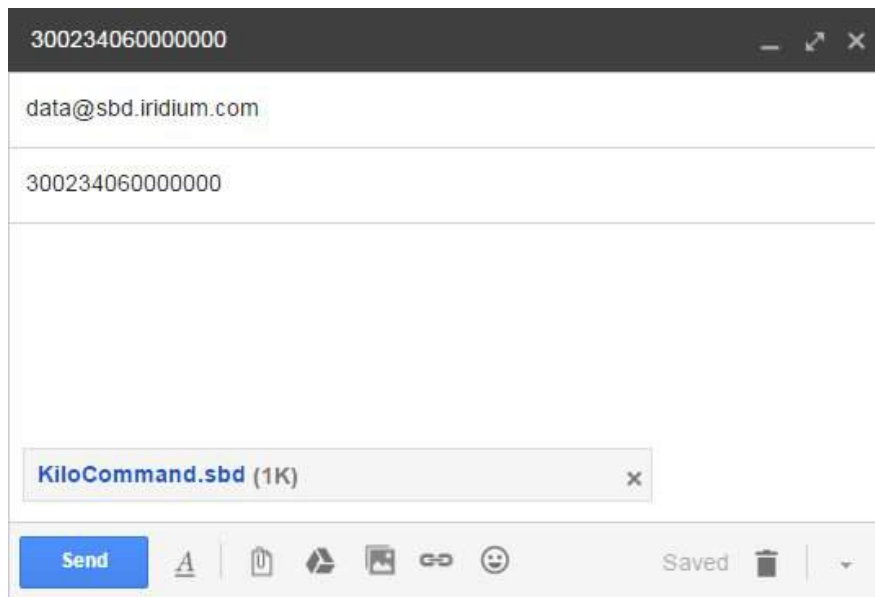


Figure 2: Sample SBD Email

A confirmation is immediately returned from the Gateway to let you know that your message has been received and is in the queue. This message is received from the address:

sbdservice@sbd.iridium.com

Note that the Iridium gateway uses separate email address for commands and responses

Received Messages

Messages received from KILO such as GPS messages or responses to Status requests arrive as email attachments to all of the email accounts that the KILO was setup with. When the unit is first turned on it will send out two messages (pictured below) and will enter startup mode.

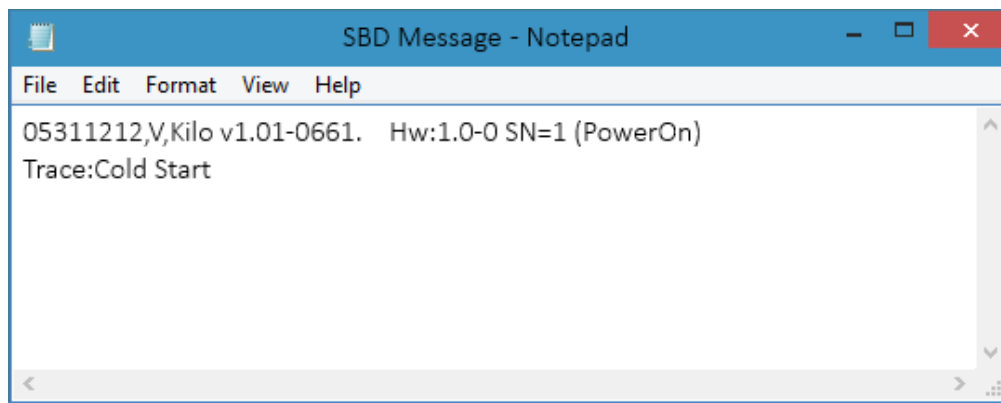


Figure 3: Startup Message

The first you will receive simply indicates the Firmware Version. The letter 'V' in the message indicates that this is a version message.

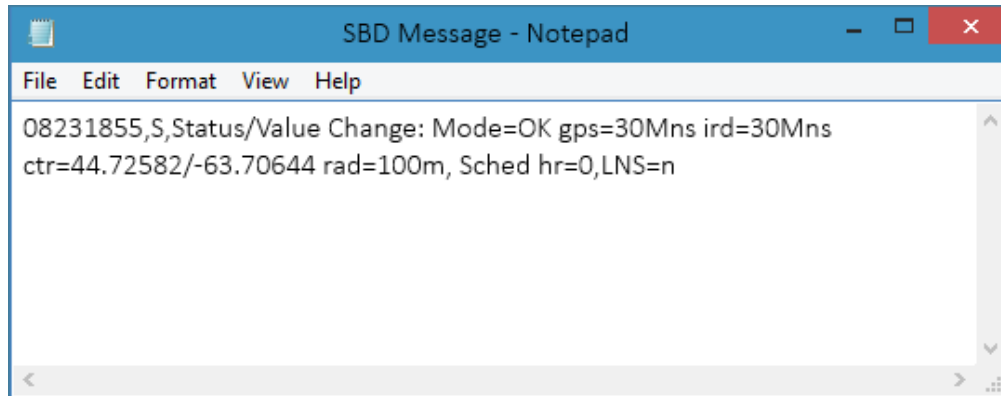


Figure 4: Status Message

The next message that the KILO will send will be a Status message. It will display the current normal timings, the center of the watch circle (ex. ctr=44.72582/-63.70644), and the radius of the circle (ex. rad=100m).

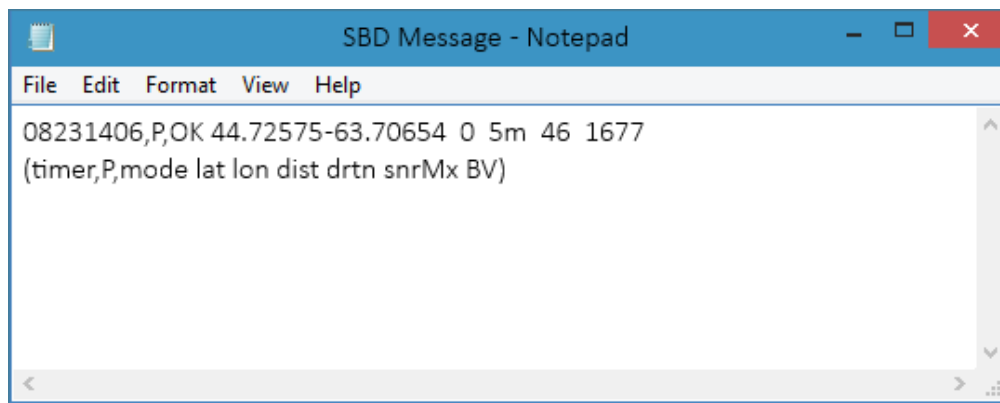


Figure 5: Position Message

The third message is a position message. The letter 'P' in the message indicates that this is a position message.

- Time and date are displayed in UTC (05311209 would be May 31st at 12:09 UTC)
- The most recent GPS position obtained by the KILO is also displayed in the position message as well as the highest GPS signal level during the most recent GPS fix (snrMx)
- The distance from the center of the circle is displayed in meters
- The battery voltage is displayed in hundredths of a volt (ie. If BV = 2850, that means 28.50V on the battery)

It is recommended that KILO users consider using a back-up email service (such as Gmail) as well as their primary provider.

IMEI Targets

Each KILO IMEI account can be set up by an Iridium SBD service provider usually with up to five (5) email addresses. Web-based email providers such as Gmail offer a free service and plenty of memory storage to act as a backup in case your primary address is not accessible. Web-based services are also not subject to commercial or government mail server firewalls that may, at times, prevent email attachments from arriving.

Navigating Xeos Online

Log in to Xeos Online at www.xeosonline.com.

The image shows the Xeos Online login interface. At the top left is a logo consisting of a blue sphere with a black swoosh and the word "Xeos" in a light blue font, with "ONLINE" in a smaller black font to its right. Below the logo are two input fields: "Email" with the text "user@xeostech.com" and "Password" with a masked password ".....". Below these fields are two checkboxes, both of which are checked: "Remember my email address" and "Keep me logged in this session". A "Login" button with a checkmark icon is located at the bottom right of the form.

Figure 6: Xeos Online Login

Find your organization in the organization dropdown menu.

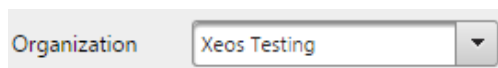
The image shows a dropdown menu for selecting an organization. The label "Organization" is on the left. The dropdown box contains the text "Xeos Testing" and a downward-pointing arrow on the right side.

Figure 7: Organization Menu

The left panel will display a list of your devices, your KILO will appear on this list.

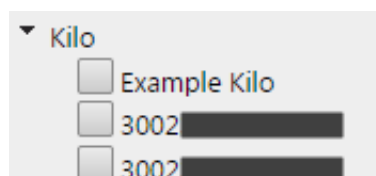
The image shows a list of devices under a collapsed "Kilo" category. The "Kilo" category is indicated by a small downward arrow and the word "Kilo". Below it are three items, each with a checkbox and a label: "Example Kilo", "3002", and "3002". The labels "3002" are followed by redacted information represented by black bars.

Figure 8: Device List

Issuing a Command

Click on the options button at the top of the page. Select **Send Manual SBD**.



Figure 9: Options Menu

Select the device from the list of possible targets and move it to the right-hand panel using the arrow buttons.



Figure 10: Target Dialog

Type in a command using the same syntax as email SBD messages.



Figure 11: Send Command

Commands

There are five (5) commands that are sent to the KILO over the Iridium network when the KILO is above water

1. **Set Timing**
2. **Status**
3. **Get Position**
4. **Reset**
5. **Set Watch Circle**

The commands are always sent as an email attachment. Command attachment files can easily be created using a plain text editor such as Notepad. Simply open a new Notepad and type in the command exactly how it is displayed in this manual. Save the Notepad with a name that corresponds to the command. Save the file's extension name as '.sbd'. It is recommended that all command files are saved in one location for ease of access.

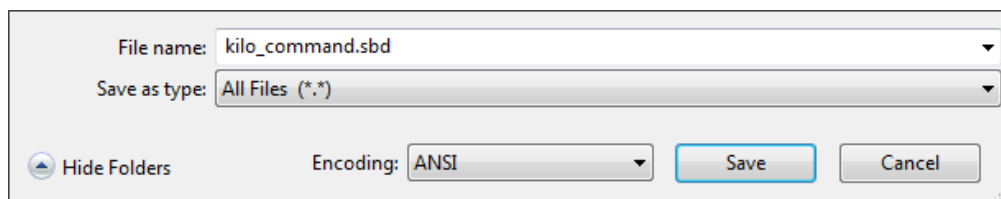


Figure 12: Saving an SBD File

Set Timing

The **\$settiming** command is used to set both timers (Iridium check and GPS acquisition) for the KILO. The timing value is stored in minutes. The set timing file should be set up like the file below. The default timing settings are 180 minutes (3 hours).

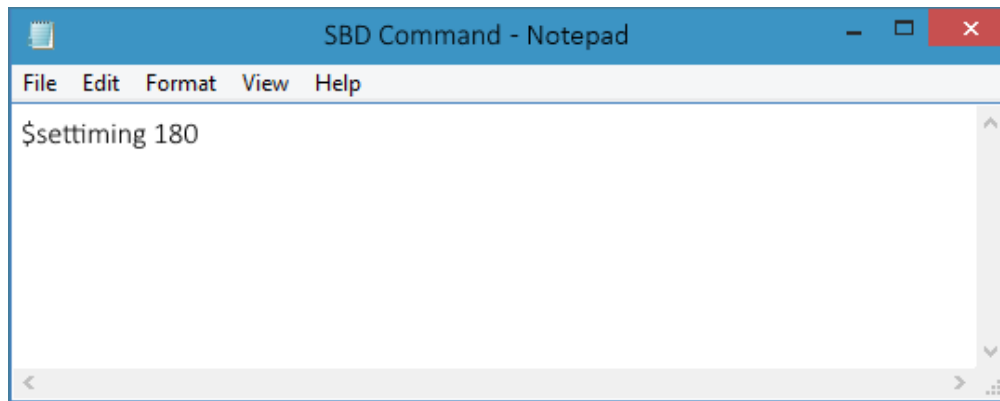


Figure 13: Set Timing Command

Things to Note:

- The default timer is 180 minutes (3 hours)
- The minimum/maximum intervals are 10/1440 minutes
- Values beyond the minimum/maximum will be set to the minimum/maximum
- Settings will persist between power cycles and resets
- All timings are relative to 00:00 UTC

Once an SBD command has been sent to the Iridium gateway and queued for delivery, the KILO will receive the command on its next scheduled Iridium check. Upon receiving and processing a **\$settiming** command, the KILO will send back a status message containing its new timings.

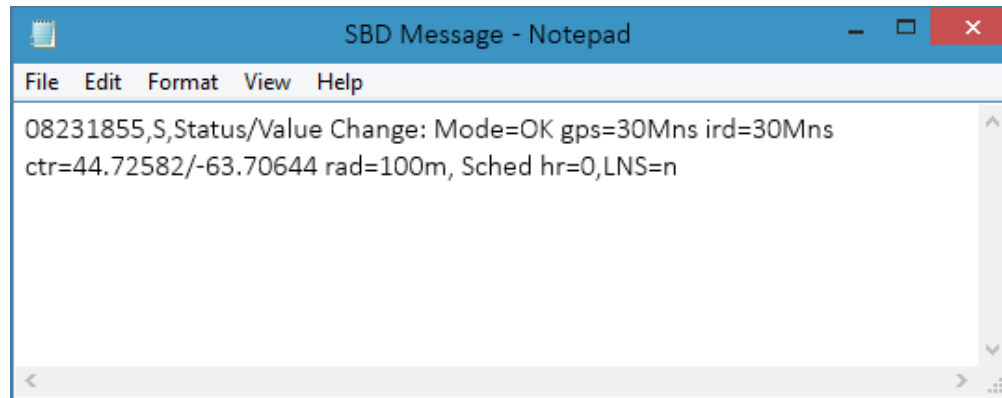


Figure 14: Status Message Response

Status

The **\$scm** command is used to retrieve KILO's current settings and beacon status. There is no need to configure this message. The Status command message file should look like the one below.

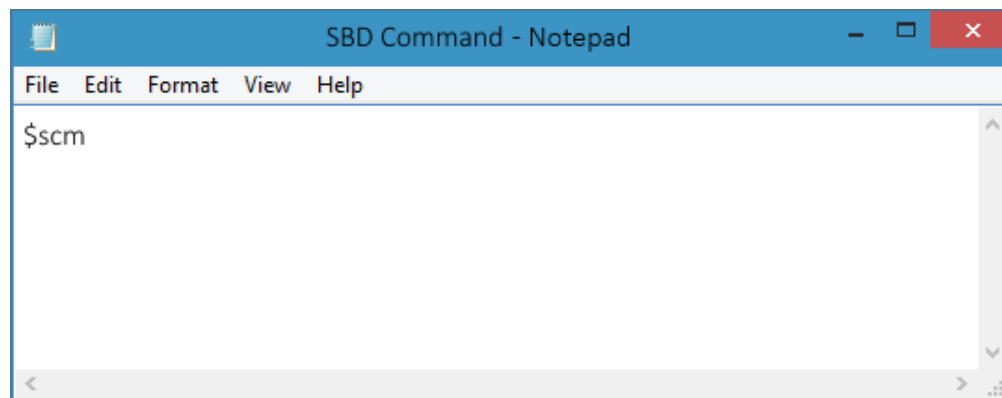


Figure 15: Status Command

The KILO will send a response message containing the following information

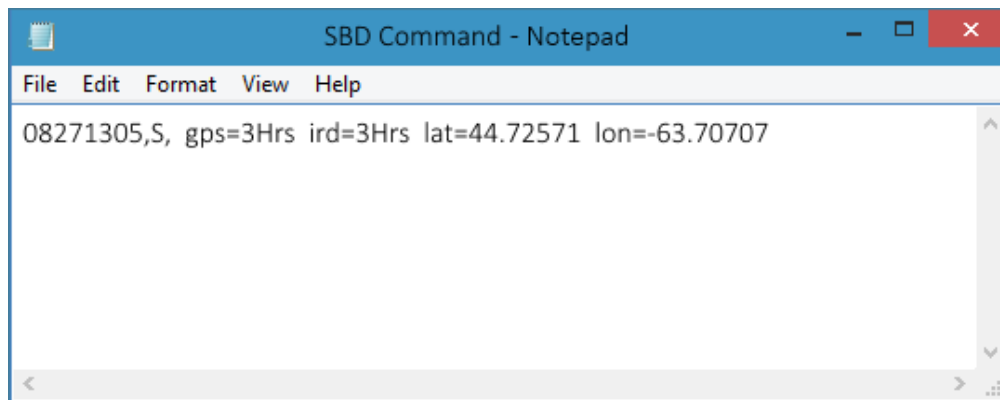


Figure 16: Status Response

The example above contains the following information:

08271305	This is the date and time of the most recent GPS fix. (UTC) in MMDDhhmm (M=Month, D= Day, h= hour, m=min)
S	This means the message is a 'Status Message'
gps=3Hrs	Checks the GPS position every 3 hours (this is the default)
ird=3Hrs	Checks the Iridium Gateway every 3 hours (default). This is when the unit receives commands and sends messages
lat=44.72571	Indicates GPS latitude position of unit, according to most recent GPS fix, and is expressed in decimal degrees
lon=-63.70707	Indicates GPS longitude position of unit, according to most recent GPS fix, and is expressed in decimal degrees

Get Position

The **\$getpos** command is a request for an immediate GPS location, which is answered by the KILO on its next Iridium Message Check. The position command message should look like the one below:

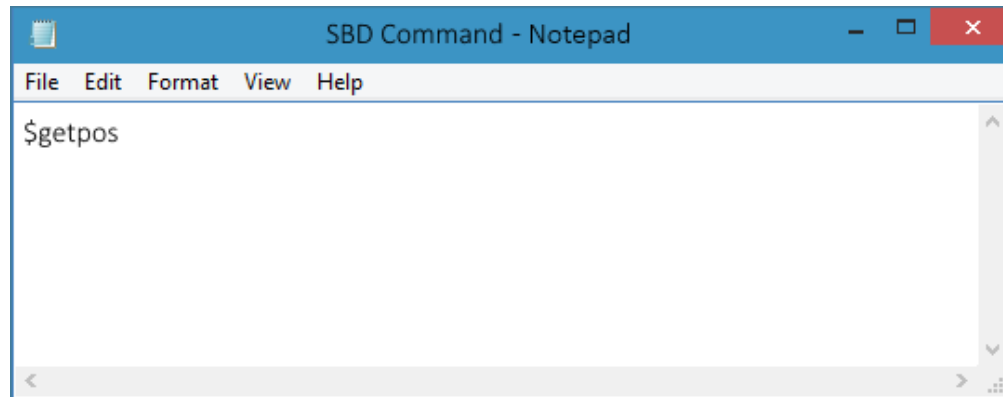


Figure 17: Get Position Command

Once the KILO has received the command, it will return a GPS position message, like the one below:

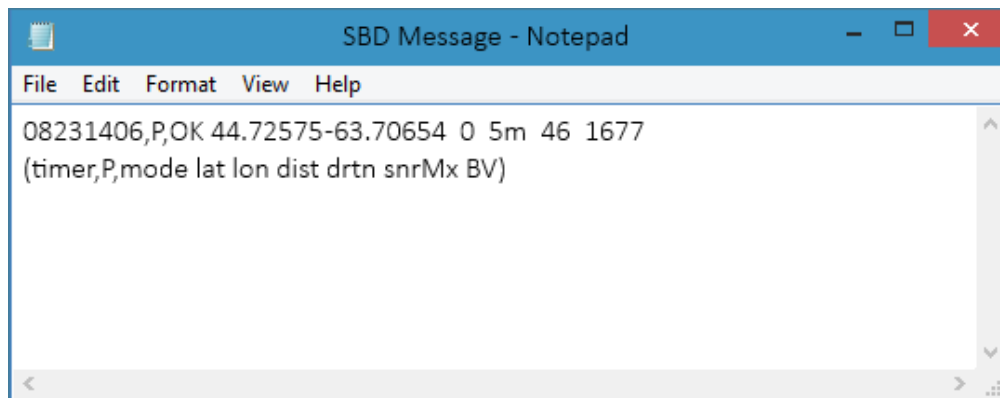


Figure 18: Position Response

Reset

The **\$resetnow** command does a full software reset of the KILO. This will effectively power the beacon OFF and then ON. The KILO's timers and settings will **not** be reset. This command should only be used on the advice of Xeos Technologies Inc. The reset command file should look like the one below:

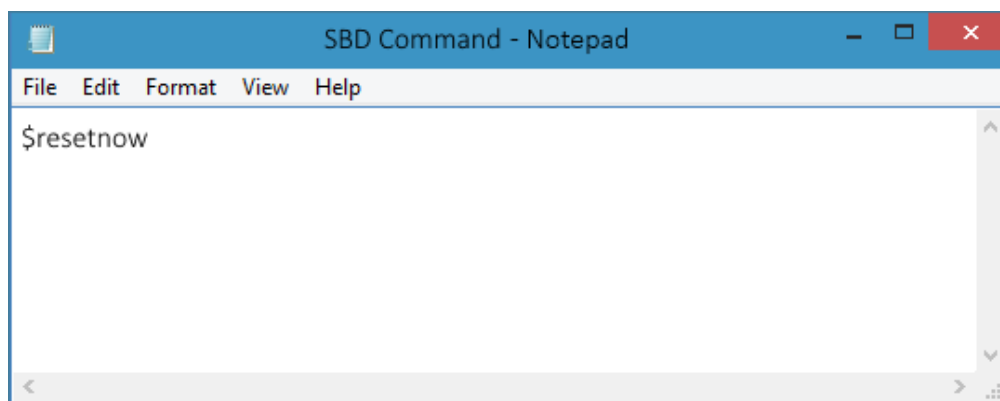


Figure 19: Reset Command

Enable Watch Circle

This command is used to enable or disable the watch circle.

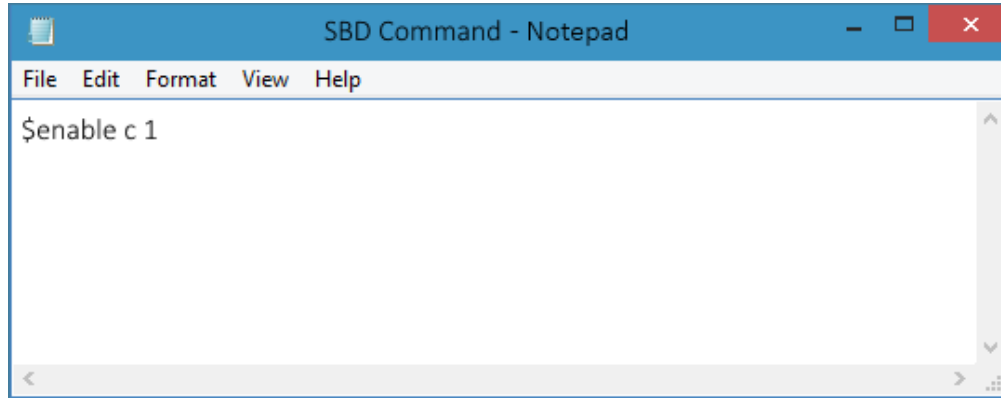


Figure 20: Enable Watch Circle Command

The enable watch circle command uses the following syntax:

\$enable c 1	Enables the KILO's watch circle
\$enable c 0	Disables the watch circle

Note: At factory settings watch circle functionality cannot be enabled on KILO units. To allow this feature, please contact Xeos customer support.

Set Watch Circle

The **\$setcircle** command is used to set the location and radius of the watch circle. If the watch circle is not set, the KILO will automatically set the center of the circle based on averaging the GPS readings from the first 48 hours of operation. The factory default radius of the watch circle is set to 100 meters. The KILO will remember new settings to the radius if the unit is powered off.

The format of the command is **\$setcircle latitude longitude radius**. In the example above:

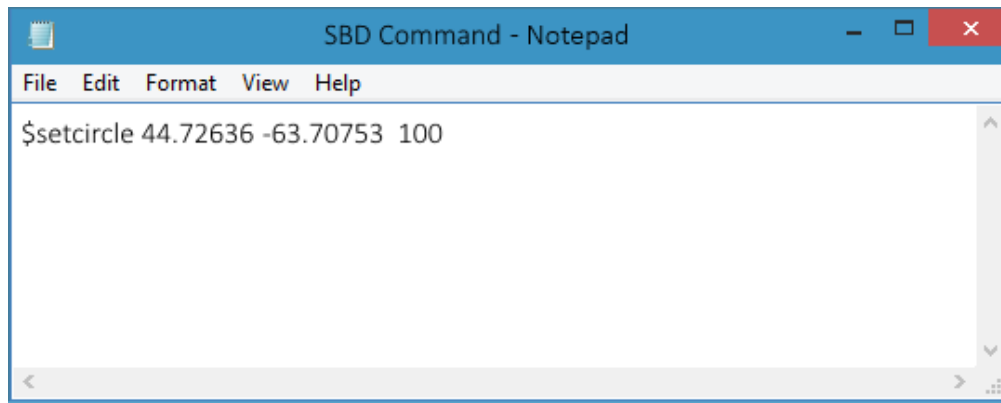


Figure 21: Set Watch Circle Command

The Command	\$setcircle
Latitude	44.72636
Longitude	-63.70753
Radius (in m)	100

The longitude and latitude values are used to manually specify the center of the watch circle. The radius (specified in meters) value is used to set the radius of the watch circle. The maximum radius for the watch circle is 5000 meters.

Additional Features

Tilt Sensor

The KILO comes equipped with a tilt sensor which, when enabled, puts the KILO into a hibernation state when the device is tilted. The KILO will return to a normal state when the device is returned to its normal orientation.

The tilt axis defaults to the horizontal axis, meaning, if the KILO is standing upright it will operate normally. If the KILO crosses the horizontal axis, i.e. orientated upside down, it will go into hibernation.

The tilt sensor is not enabled by default. To enable the tilt sensor, a command must be sent to the KILO in the following format:

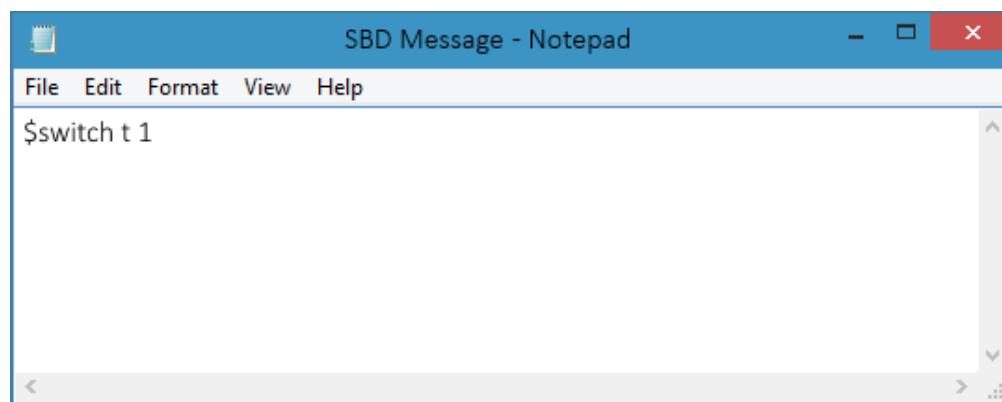


Figure 22: Tilt Enable Command

The enable tilt sensor command uses the following syntax:

\$switch t 1 Enables the KILO's tilt sensor
\$switch t 0 Disables the tilt sensor

It is possible to use the tilt sensor on other axis (Y,Z). For more information please contact Xeos Technologies at support@xeostech.com

Surfacing Alert

If the KILO detects a transition from underwater to surface. It will send an SBD message indicating that it has surfaced.

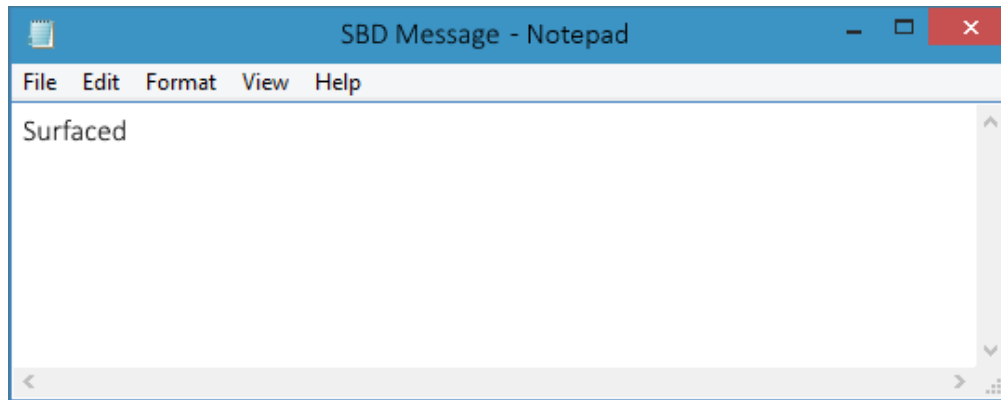


Figure 23: Surface Alert Message

There are two conditions which must be met before the KILO will detect that it is submerged:

1. The KILO must be fully submerged underwater
2. Iridium transmission must fail 3 consecutive sessions

After both conditions are met, which may take up to one hour, the KILO will send an alert if it surfaces.

Power Supply and Consumption

The KILO has an internal battery enclosure that holds 12 AA batteries. The batteries should be replaced whenever the KILO is recovered. The battery voltage can be monitored with the Status command.

Typical sleep current for the KILO is less than $200\mu\text{A}$. This is the amount of current the device will draw between GPS checks and Iridium transmissions. The device has a life time of 1 Year while submerged.

Choosing Batteries

The KILO's battery pack can hold and operate with any AA alkaline battery, however, only industrial grade batteries designed for harsh environments should be used. In particular, Duracell batteries **should not be used** as they are prone to leaking under some conditions.

Important Notes

- Xeos recommends the **Energizer EN91 AA** alkaline battery
- All new batteries should be used for each new deployment
- Each battery should be tested with a battery tester or voltmeter to ensure none of the cells are defective or discharged. Individual cells with a voltage measuring less than 1.5 V should be discarded

Maintenance and Installation

Opening the Housing

At the bottom of the KILO's acetyl housing is a screw-cap with an O-Ring (568-137 70A DURO BUNA). After removing the cap, you will be able to see where the black O-ring sits.

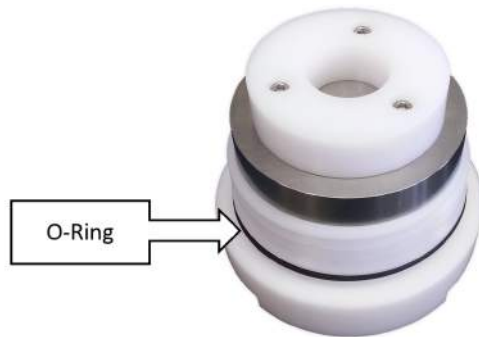


Figure 24: KILO Bottom

O-Rings

O-rings are critical to the waterproof nature of the KILO. The O-ring should be visually inspected to make sure that it is properly seated in the groove and to ensure there is no visible damage to the O-ring. If the O-ring fails visual inspection or the KILO has been deployed for longer than 2 months, the O-ring should be replaced prior to the next deployment.

- Remove the old O-ring, and clean all dirt away from the screw-cap and inner-housing using a lint free cloth, cleaning alcohol, and a soft-brush
- Thoroughly inspect the O-ring groove as well as the point of contact on the inside of the KILO enclosure, any scratches or dirt could compromise the O-ring seal
- Apply a thin layer of O-ring lube (Molykote 111 from Dow Corning) to the new O-ring and gently slide the new O-Ring down over the threads of the screw-cap and into the O-ring groove

Note: It is very important to be aware of where the O-ring is sitting on the screw cap. If the O-ring is not sitting perfectly in the O-ring groove, there will not be a perfect seal and could cause fatal damage to the unit.

Replacement of Batteries

After removing the screw-cap, you will be able to see a green, circular circuit board sitting loosely inside the main body of the KILO. Remove this board by turning the KILO right side up and letting the board fall onto a table or your hand.



Figure 25: KILO Battery Cap

After the Circuit board is removed, you will see a black battery pack with 6 slots that will hold 2 AA batteries each (12 batteries in total).

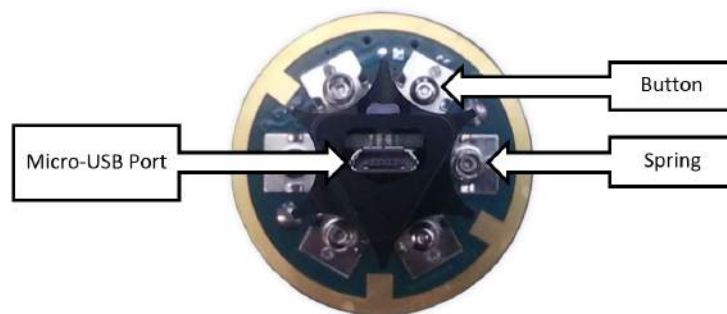


Figure 26: KILO Battery Slots

Drop the batteries into the Main body of the KILO. At the bottom of each slot, there is either a "spring" or a "button".

- For slots with buttons, drop the batteries with the negative end facing up
- For slots with springs, drop the batteries with the positive end facing up



Figure 27: KILO Battery Orientation

Once the batteries have been inserted, place the green circular circuit board back on top of the batteries with the springs and buttons of the board touching the batteries. Hand tighten the screw-cap back on until there is no space between the main body of the KILO and the screw cap.

The KILO is now ready for testing and/or deployment

Important Notes

- If the batteries are low, or if some of the batteries have been inserted incorrectly, the KILO will sound a quick intermittent beep and flash the red LED at the top for 5 minutes, or until the batteries have been corrected or replaced.
- The USB port located in the center of the triangle at the top of the battery pack is used for firmware updates.

Field Installation

The KILO is intended for use on marine flotation devices. It is important that the top of the KILO is located as high above the surface of the water as possible. Both the Iridium and GPS antennas are located at the top of the unit. It is recommended that users install KILO on a mast or superstructure at the top of their surface buoy or flotation device.

Care should be taken when installing to avoid putting metal bands close to the top of the unit where the antennas are located.

Appendix A: Updating Firmware

Introduction

If you have been notified that the firmware in your KILO needs to be updated, please use the instructions below. Please note, the KILO must be removed from the field.

Overview

1. Retrieve the unit from the field
2. Remove the KILO's Batteries
3. Update KILO Firmware
4. Test the KILO's ability to transmit
5. Once transmission has been confirmed, it is safe to redeploy the unit.
6. Notify Xeos of the successful update

What is Required

- Use of a computer running some version of Windows OS
- A USB to Micro-USB cable
- The UART to USB [device driver](#)
- A KILO Firmware Update Package
- The KILO unit
- tools for disassembly



Figure 28: USB Connector

Loading Firmware into the KILO

Connecting the KILO

1. Remove all batteries from the KILO. Warning: Failure to remove batteries may cause electrical damage to the KILO
2. Remove the end (battery) cap by unscrewing it. See [Opening the Housing](#)
3. Plug the Micro-USB connector into the KILO
4. Then connect the other end of the USB programmer to your computer.
5. Once it is plugged in, the KILO may begin beeping, this is no cause for alarm. This warning is given when the KILO detects incorrect battery orientation and can be ignored
6. The KILO's LED will also flash red, indicating a self-test fail due to a lack of batteries

Uploading Firmware

1. Navigate to the Device Manager from Windows Control Panel (or type "Device Manager" in the Windows Start Menu)

2. Note the COM port being used by the KILO's CP210x USB adapter



Figure 29: COM Port Entry

3. Download and extract the KIL0 firmware update package.
4. Navigate to the extracted folder and double click on the "kilo_updater.cmd" file
5. Type the COM port number and press Enter
6. The firmware will begin updating right away. Firmware update should take approximately 90 seconds. If the window closes immediately upon executing the file, the firmware update has failed

```
b060? >>>
Starting bootload

Found programmer: Id = "XBoot++"; type = S
    Software Version = 1.6; No Hardware Version given.
Programmer supports auto addr increment.
Programmer supports buffered memory access with buffersize=512 bytes.

Programmer supports the following devices:
    Device code: 0x7b

avrdude: devcode selected: 0x7b
avrdude: AVR device initialized and ready to accept instructions

Reading : ##### : 100% 0.00s

avrdude: Device signature = 0x1e9842
avrdude: reading input file "Kilo_681_1456.hex"
avrdude: input file Kilo_681_1456.hex auto detected as Intel Hex
avrdude: writing flash (188006 bytes):

Writing : ##### : 40% 15.05s
```

Figure 30: KIL0 Updater Screen

7. The KIL0's update progress will be shown in the command prompt window. When it has completed successfully it will say: "avr dude done. Thank You."
8. After programming has successfully completed, unplug the Micro-USB cable from the KIL0
9. Install batteries and reassemble the KIL0

Testing the KILO

1. Once the KILO firmware has been updated and the device reassembled, you must test its ability to transmit
2. Make sure the KILO has an active Iridium account. Xeos can setup an account for you if you do not currently have one. Make sure you have access to one of the email addresses to which messages are sent
3. Place the KILO outside in a location where it has a clear view of the sky
4. Turn the KILO on
5. Check the email account to see if a transmission has been received. If no message is received within 20 minutes, please check operating manual to make sure it is setup as required.
6. If no message is received, please contact Xeos for assistance in troubleshooting.
7. DO NOT redeploy the KILO until you have confirmed Iridium transmission.

Appendix B: Technical Specification

Mechanical

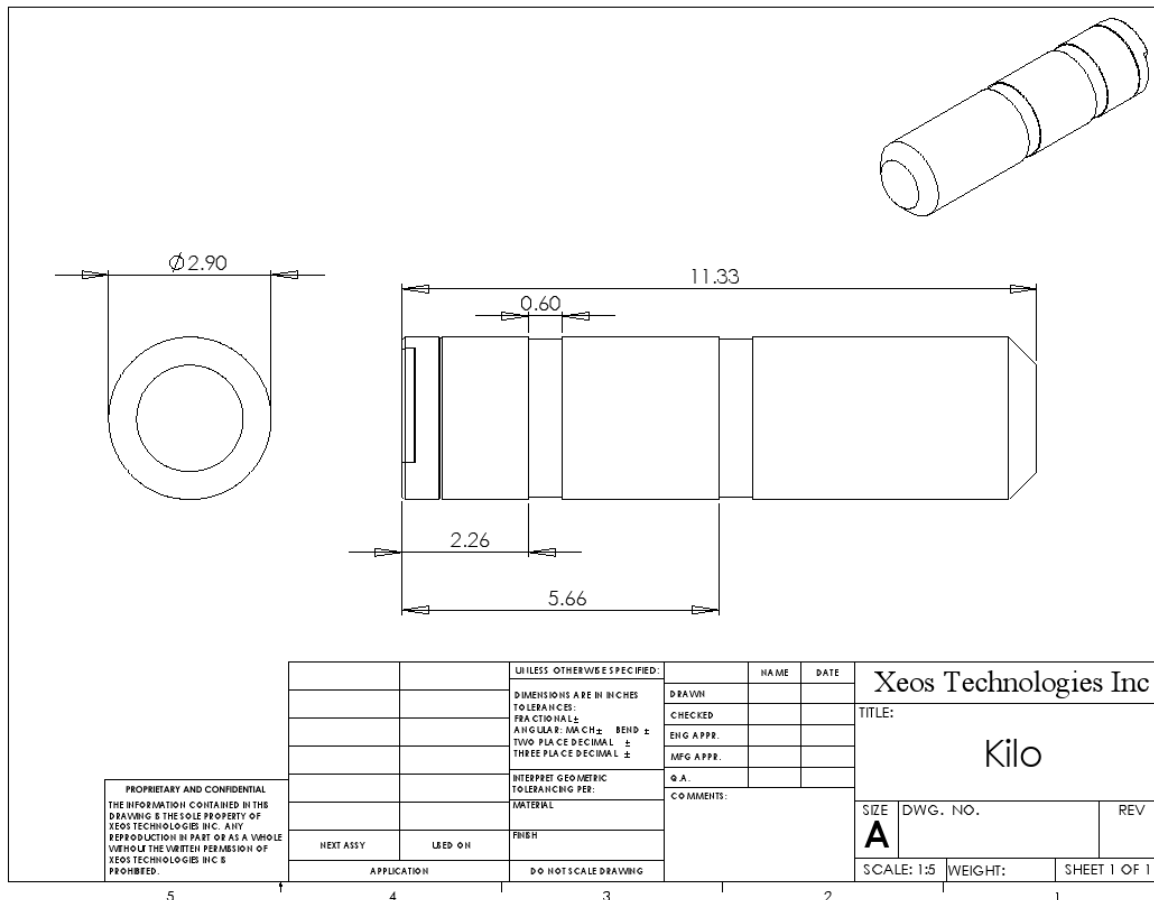
Material: Outside Housing: Delrin Case
Inside Chassis: Stainless Steel

Dimensions: 11.31" Long x 2.87" Diameter (287.5mm x 72.9mm)

Weight: 2.75 kg (Air), 1.55 kg (Water)

O-Rings: Bottom Screw-Plug: 568-137 70A DURO BUNA

O-Ring Lube: Molykote 111 from Dow Corning



Electrical

Power Supply

- Battery Supply:** 12 Alkaline AA cells (user replaceable)
- Voltage:** +18 Volts nominal
- Capacity:** 2.0 Amp Hours
- Life Expectancy:** 1 Year Subsurface followed by 90 days of outbound/inbound surface messages

Electronics

- Iridium Transceiver:** 9602
- Digital Controller:** Xeos IRDC3
- GPS Receiver:** 48 Channel SirFstarIV, GSD4e GPS chip

Environmental

- Operating Temperature:** -30° C to +60° C (-22° F to +140° F)

Warranty, Support, and Limited Liability

Xeos Technologies Inc. warrants the KILO Beacon to be free of defects in material or manufacturing for a period of one year following delivery. Liability is limited to repair or replacement of the defective part and will be done free of charge.

LIMITED WARRANTY: Xeos Technologies Inc. warrants that the product will perform substantially in accordance with the accompanying written materials for a period of one year from the date of receipt.

CUSTOMER REMEDIES: Xeos Technologies Inc. entire liability and your exclusive remedy shall be at Xeos Technologies Inc. option, either (a) return of the price paid or (b) repair or replacement of the product that does not meet Xeos Technologies Inc. Limited Warranty and that is returned to Xeos Technologies Inc. with a copy of your receipt. This Limited Warranty is void if failure of the product has resulted from accident, abuse, or misapplication. Any replacement product will be warranted for the remainder of the original warranty period or ninety (90) days, whichever is longer.

NO OTHER WARRANTIES: Xeos Technologies Inc. disclaims all other warranties, either express or implied, including but not limited to implied warranties of merchantability and fitness for a particular purpose, with respect to the product or the accompanying written materials. This limited warranty gives you specific legal rights. You may have others, which vary from state to state.

NO LIABILITY FOR CONSEQUENTIAL DAMAGES: In no event shall Xeos Technologies Inc. or its suppliers be liable for any damages whatsoever (including, without limitation, damages for loss of equipment, for loss of business profits, business interruption, loss of business information, or other pecuniary loss) arising out of the use of or inability to use this Xeos Technologies Inc. product, even if Xeos Technologies Inc. has been advised of the possibility of such damages.