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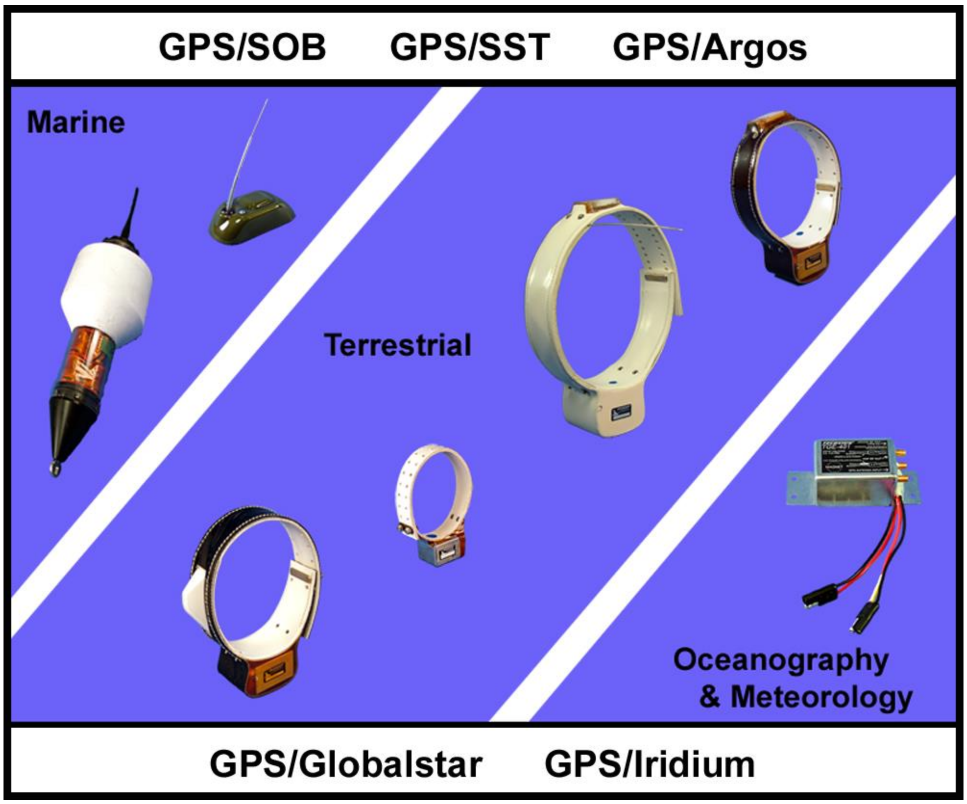
GEN4 GPS SYSTEMS MANUAL



GPS units are sophisticated systems that require correct handling by researchers if they are to perform as expected. Your research team must become familiar with this manual and the initialization procedures and should test the units thoroughly prior to deployment.

Note: This manual addresses numerous operational aspects of Gen4 systems. In addition, many topics are covered in much more detail in the appendices and in the help systems associated with Telonics Product Programmer (TPP) and Telonics Data Converter (TDC).

This document is available with color images on the Telonics website. Go to www.telonics.com and click manuals.

Please direct any procedural or operational questions to our factory before deploying units in the field.

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1 Introduction and Overview of Gen4 GPS Systems

Telonics, Inc. began a wide release of the fourth generation (Gen4) GPS technology to the field in April 2008. All Gen4 GPS systems are based on a single-board µGPSI electronics assembly (e.g., µGPSI-23, µGPSI-24, etc.) combining a GPS receiver, nonvolatile data log memory, various sensors, and an optional VHF beacon transmitter. Additionally, these systems allow the integration of a selected data-transfer component which allows researchers to receive data regularly throughout the study. All Gen4 GPS systems are designed to withstand shock, vibration, temperature, and pressure conditions found in animal tracking, inside oceanographic buoys, and onboard meteorological balloons.

Gen4 GPS systems have sophisticated firmware that controls the operation of the unit in the field. The role and mission of the unit can be modified by Telonics or the user by altering user-changeable parameters with a programming utility called Telonics Product Programmer (TPP).

The user can download data from Gen4 GPS systems log memory using Telonics Data Converter (TDC). TDC is also used to extract and process data from the various Gen4 data-transfer components. For example, data obtained from satellite networks, or from Telonics TSUR-400 Uplink Receivers, or from Telonics SST-901M Transceivers, are handled with TDC. TDC generates report files containing study data formatted as comma separated values (.csv files), which can be opened using Excel or imported into a user's database.

Based on the selection of a data-transfer component, five Gen4 GPS systems are offered:

- GPS-Store-on-Board (GPS-SOB) Systems
- GPS-Argos Systems
- GPS-Globalstar Systems
- GPS-Iridium Systems
- GPS-SST Systems

Each system is available in many models, with configuration options that cater to the application. Understanding, selecting, and using the proper technology from these system choices is critical to meeting the goals of the study design.

Models used for wildlife applications combine the µGPSI electronics with appropriate size battery packs and packaging. All models designed for deployment on wildlife are further configured with antennas and supplied with the appropriate attachment options (e.g., collars) for specific species.

Models designed for oceanographic and meteorological applications use the µGPSI in "electronics-only configurations". These models include the electronics in a waterproof package. Power supplies or battery pack, and antennas are typically purchased as separate items or provided by the user. These systems are then integrated into a user-provided external housing (e.g., buoy).

1.1 GPS-Store-on-Board (GPS-SOB) Systems

GPS-SOB systems combine a GPS receiver with a nonvolatile data log memory. Different models are equipped with various sensors for collecting data that can be associated with the GPS positions. A programmable VHF beacon transmitter is onboard for tracking and recovering the system. These units must be recovered in order to make a physical connection to download data as there is no other data-transfer component. Downloading data is achieved by connecting the unit to a PC or laptop and using Telonics Data Converter (TDC) software.

1.2 GPS-Argos Systems

GPS-Argos systems combine a GPS receiver, nonvolatile data log memory, VHF beacon transmitter, and an Argos transmitter to relay data back to the user via the Argos Data Collection and Location System (DCLS). These systems use a satellite based data recovery technology. In addition, all GPS positions and other data collected are stored in nonvolatile memory which can be downloaded using TDC if the unit is recovered at the end of the study. Each model is equipped with various sensors for collecting associated data. Note: Use of the Argos system as a data recovery system requires approval of the CLS Group. Argos is not available to commercial applications but is chartered as a location and data collection system for environmental applications. The Argos transmitter is FCC certified through Argos certification.

1.3 GPS-Globalstar Systems

GPS-Globalstar systems combine a GPS receiver, nonvolatile data log memory, VHF beacon transmitter[1], and a Globalstar Simplex Transmitter to relay data back to the user via the Globalstar satellite network. In addition, all GPS positions and other data collected are stored in nonvolatile memory which can be downloaded using TDC if the unit is recovered at the end of the study. Each model is equipped with various sensors for collecting associated data. Users must work with a Globalstar service provider to activate and maintain service for each Globalstar transmitter. The system is FCC and IC certified and is available for use throughout the United States and Canada with no additional licensing.

1.4 GPS-Iridium Systems

GPS-Iridium systems combine a GPS receiver, nonvolatile data log memory, VHF beacon transmitter[2], and an Iridium transceiver to relay data back to the user via the Iridium satellite network. In addition, all GPS positions and other data collected are stored in nonvolatile memory which can be downloaded using TDC if the unit is recovered at the end of the study. Each model is equipped with various sensors for collecting associated data. Users must work with an Iridium service provider to activate and maintain service for each Iridium transceiver. The system is FCC and IC certified and is available for use throughout the United States and Canada with no additional licensing.

1.5 GPS-SST Systems

GPS-SST systems combine a GPS receiver, non-volatile data log memory, VHF beacon transmitter, and a Spread-Spectrum Transceiver (SST). Several models are available and are equipped with various sensors for collecting data that can be associated with GPS positions. All data collected are stored in non-volatile memory and are available for download physically using a TSC-7 cable or remotely through the two-way, high-speed SST radio link. Before a remote download can be performed, users must first approach the deployed GPS-SST system to within its operable communication range. This process is aided by monitoring the VHF beacon. The remote download is then accomplished using a laptop computer equipped with a Telonics SST-901M Spread-Spectrum modem and Telonics Data Converter (TDC) software. Telonics SST equipment communicates in the 902-928 MHz Industrial, Scientific, and Medical (ISM) band and is certified for use in the United States by the Federal Communications Commission (FCC) and in Canada by Industry Canada (IC). End users are not required to obtain a license to operate Telonics SST equipment.

[1] The VHF beacon transmitter associated with GPS-Globalstar systems operates under the control of an interlock device that keeps the VHF transmitter off whenever the Globalstar simplex transmitter is on. Because the two transmitters never operate simultaneously, they are not considered to be co-located under FCC regulations.

[2] The VHF beacon transmitter associated with GPS-Iridium systems operates under the control of an interlock device that keeps the VHF transmitter off whenever the Iridium transceiver is on. Because the VHF beacon transmitter and Iridium transceiver never operate simultaneously, they are not considered to be co-located under FCC regulations.

1.6 Handling Considerations

Gen4 systems contain electronic components that are subject to damage by electrostatic discharge (ESD) and improper handling. Please read this section carefully.

Gen4 systems are engineered to operate in the harsh environmental conditions associated with long-term animal-borne applications. However, researchers and other field personnel are responsible for proper care and handling of these systems before and after a deployment, as noted below.

1.6.1 Electrostatic Discharge (ESD)

All Gen4 systems employ special circuitry to actively protect against damage from electrostatic discharge (ESD) on all external electrical connections (antennas, saltwater sensor terminals, etc). This protection is adequate against most ESD events associated with animals and by extension with the human body. However, the protection may not be adequate to prevent damage from extremely high levels of static electricity that can be generated by machines.

Small aircraft are well known for building electrostatic charge. Airplane propellers and helicopter rotors can generate static electricity levels far beyond what Gen4 systems (or any portable electronic system) can tolerate. However, with proper handling, Gen4 systems may be transported by air without damage. Prior to boarding an aircraft with Gen4 systems, place them into metalized ESD shielding bags to protect them from the electrostatic charge build-up. Open the bag only after complete egress from the aircraft. Never transfer Gen4 systems to or from a helicopter while it is airborne.

In addition to the ESD considerations noted above for all Gen4 systems, special considerations apply to “electronics-only” systems and “bare-board” systems not yet packaged in protective housings. These units have additional vulnerabilities due to the exposure of electrical components normally protected from external access. Users who handle these systems must always observe standard ESD precautions including proper packaging during transportation and proper handling at approved static-free workstations.

1.6.2 Storage Guidelines

While Gen4 systems are not deployed or under test, be sure to keep the shutdown magnet applied. While the magnet is applied, the unit turns off to conserve energy. Only the onboard clock remains powered in order to keep time.

When storing Gen4 systems for longer than one month, be sure to observe the following guidelines to preserve the integrity of the battery system.

- Store at room temperature (20 degrees Celsius)
- Initialize collar once per month (see section 6, Initializing Gen4 GPS Systems, for procedure)

Before deploying a unit that has been stored for more than a month, consider the following programming issues. *Certain kinds of programming become obsolete during extended storage* as noted below:

- Review the TPF record to verify that season start and end dates inside sensor and transmitter schedules are still appropriate for the study. In particular, be sure schedules continue well beyond the desired deployment duration.
- For GPS-Argos systems configured to predict Argos satellite overpasses, use Telonics Product Programmer to update satellite ephemeris stored inside the unit. See 10.8, Updating Argos Ephemeris Data.

2 Gen4 GPS Systems Components

This section of the manual describes the role and functionality of each component of the Gen4 GPS system. Each component description also includes a list of options that allow the component to be customized to fit your study.

2.1 Gen4 GPS Receiver Technology

Gen4 systems incorporate a GPS receiver for obtaining positional data. As an integral part of the µGPSI electronics assembly, the GPS receiver is carefully controlled and power managed to minimize current consumption and maximize the number of GPS positions that can be obtained. The GPS positioning schedule can be customized to meet study requirements. Standard GPS fix times for most applications range between 30-90 seconds assuming a clear view of the sky. Typical GPS position accuracy is 2-10 meters. The GPS receiver is capable of providing the following information about a position:

- Time
- Latitude
- Longitude
- Altitude
- Speed
- Heading
- Horizontal error estimate
- DOP
- Satellites used to obtain the position

All Gen4 GPS systems store the above information in log memory. Gen4 GPS systems also use the received GPS time to update the internal clock. If your Gen4 GPS system has a satellite-based data-transfer component, you may choose to include some of this information in your data transfer. Note that DOP and Satellites used to obtain the position cannot be included in the data transfer.

2.1.1 Quick Fix Pseudoranging (QFP) Technology

Quick Fix Pseudoranging (QFP) is a technology that Telonics initially developed to obtain GPS positions of marine mammals that often surface for only short periods of time. Standard GPS positioning can require that satellites be in view for 30-90 seconds. However, with as little as 3 seconds of surface time on µGPSI-23 and newer models (5+ seconds on older models), Gen4 GPS systems can obtain all raw data from the GPS satellites required for QFP post-processing. The use of QFP technology has been extended to terrestrial and avian applications as a means of reducing power consumption and thus conserving battery life. In many cases obtaining only QFP locations instead of standard GPS fixes can either extend the operational life of the system or increase the number of positions by 3-6 times.

Gen4 GPS systems are adaptive, unlike many other products that use “rapid-fixing technologies”, and can obtain both standard GPS positions and QFP positions. The advantage of this dual approach is that standard GPS fixes can be packed more densely for data transfer (e.g., up to 10 GPS positions per Argos message as compared to 1 QFP per Argos message). Further, when standard GPS positions are obtained the position can be used to determine Argos satellite overpasses and make data transfer more efficient. When clear view of the sky is limiting, QFP fixes can be obtained when standard fixes cannot. Telonics Data Converter (TDC) automatically combines the raw QFP data from the unit and GPS ephemeris from the Internet to calculate QFP positions. Telonics can equip any Gen4 model (including non-marine models) to take advantage of QFP technology. QFP technology has the following features:

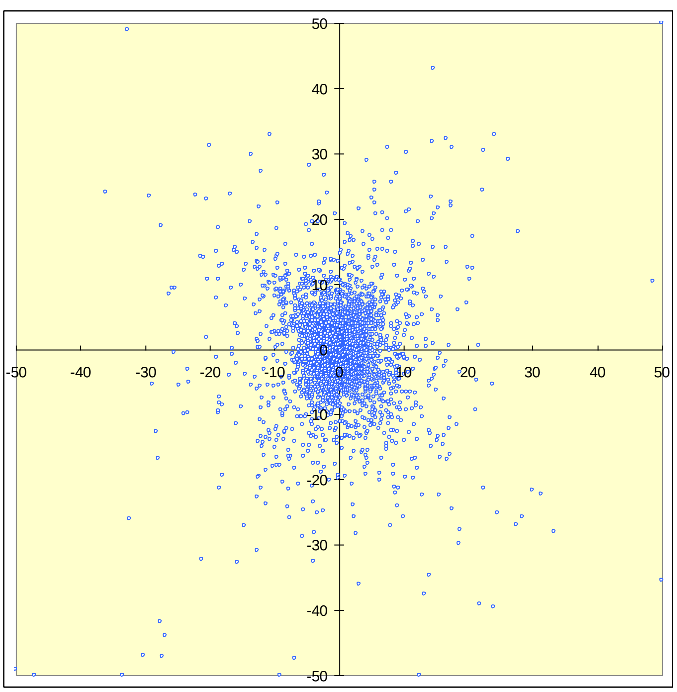
- QFP positions often fill in where the GPS receiver fails to obtain a fix (means fewer location gaps)
- QFP technology works globally (does not rely on “aiding”)
- Accuracy of QFP positioning is typically better than 25 meters
- QFP positions can be obtained in as little as 3 seconds
- QFP position data are stored in log memory (along with standard GPS fixes)
- GPS-Argos systems may optionally transmit one QFP location per message
- QFP schedule allows unit to collect QFP positions as an alternative or supplement to GPS fixes

2.1.2 Hierarchy of GPS and QFP locations

GPS and QFP positions obtained by Gen4 systems have varying quality according to GPS satellite visibility at the time the position is obtained. Typically QFP positions are about as accurate as GPS positions. The following list shows the relative quality of the different kinds of GPS and QFP locations. Higher quality positions are listed first.

- **3D GPS fix** - A location calculated from 4 or more GPS satellites. The 3D GPS fix allows the unit to correct its clock and provides a location estimate for GPS-Argos systems that predict Argos satellite overpasses.
- **Resolved QFP** - A location that is about as accurate as a traditional 3D GPS fix. However, QFP locations do not help the unit correct its clock and do not help GPS-Argos systems predict Argos satellite overpasses. QFP positions are calculated from a minimum of 4 GPS satellite signals, and position quality improves with additional satellites.
- **2D GPS fix** - A location calculated from only 3 GPS satellites. Statistically, a group of 2D fixes is less accurate than a group of Resolved QFP and 3D fixes. Like the 3D GPS fix, the 2D GPS fix allows the unit to correct its clock and provides a location estimate for GPS-Argos systems that predict satellite overpasses.
- **Resolved QFP (Uncertain) -** A location that is about as accurate as a 2D GPS fix. However, QFP locations do not help the unit correct its clock and do not help GPS-Argos systems predict Argos satellite overpasses.
- **Unresolved QFP** - A location that has undetermined accuracy. These locations are the least accurate. Most of these positions are accurate to within a few hundred meters; however, some positions may be very inaccurate (several km from the actual location).
- **Failed fix** - No location available. The unit was unable to obtain a regular GPS fix and the unit didn't see enough satellites to obtain a QFP location (or QFP was not purchased).

The following scatter plot shows Resolved QFP positions on a horizontal plane with the true location at the center and 50 meters shown in all directions. The test location had a clear view of the sky, and a single test unit generated all positions over the course of several days.



Resolved QFP Positions

< 10m	79.3%
10m – 20m	15.4%
20m – 30m	3.7%
30m – 40m	0.9%
40m – 50m	0.4%
> 50m	0.3%
Sample Size	5000+

2.1.3 Estimating the accuracy of GPS and QFP locations

Horizontal dilution of precision (HDOP) is a factor that describes the arrangement of the satellites that the receiver used to obtain the GPS or QFP location. Lower HDOP values correspond to better satellite geometry, which often results in more-accurate locations. Higher HDOP values indicate that the satellites used to calculate the location were clustered close together in the sky. HDOP multiplies the uncertainty associated with User Equivalent Range Errors (UERE). UERE accounts for inaccuracies in the prediction of the satellites' orbits, clock stability, navigation-message errors, ionospheric/tropospheric modeling errors, and correlation errors.

Gen4 systems provide HDOP for all QFP locations, including those transmitted through a satellite network. Since "Resolved QFP" locations are about as accurate as a traditional 3D GPS location, their HDOP values can be used to characterize location accuracy just like 3D GPS fixes. "Resolved QFP (Uncertain)" and "Unresolved QFP" locations have reduced accuracy, so their HDOP values are not comparable to GPS fixes. Gen4 systems provide HDOP for all GPS locations stored in log memory; however, they do not provide HDOP for GPS locations transmitted through a satellite network. µGPSI-20 based systems (including SST) provide positional dilution of precision (PDOP) instead of HDOP.

Gen4 systems also provide a horizontal error estimate for GPS locations. The horizontal error estimate is always included in log memory and may optionally be included in locations transmitted through a satellite network. The horizontal error estimate is provided by the GPS receiver module as the best estimate of the accuracy of a reported GPS position fix in the horizontal plane. The value itself represents the radius of a circle expressed in meters. The reported GPS position fix is at the center of the circle, and the GPS receiver asserts that the true position is somewhere inside the circle. The size of the circle changes with many dynamic factors including signal strength and multipath, HDOP, UERE, and receiver-specific residual errors in the positioning mathematics. The exact algorithms used by a manufacturer to calculate this parameter are usually considered to be proprietary and are generally not provided to the user community or OEMs in explicit detail. The horizontal error estimate is not available for QFP locations.

2.2 Gen4 System Sensor Technology

Gen4 GPS systems are equipped with several on-board sensors designed to provide data that can be correlated to GPS positional data. These sensors include a three-axis accelerometer, saltwater conductivity sensor, pressure sensor, and a temperature sensor. Not all sensors are available or are appropriate to all models. Using TPP, the sampling rates, sampling periods, and configuration of the sensor can be programmed to meet the needs of the study design. The sensor programming determines the amount of data collected, stored in log memory, and transmitted via the data-transfer component.

Gen4 GPS systems with a satellite-based data-transfer component can optionally reduce the resolution of transmitted data to increase data throughput; however, these systems always store data with full resolution in log memory. These systems can also transmit low-voltage and mortality indications, which are not stored in log memory on some configurations. Other data can be designated for storage in memory but not selected for transmission.

For most models, the size of the log memory does not limit the amount of data that can be collected and stored. Battery capacity tends to limit the operational life of the system and prevent the system from filling up the log memory. For systems with a satellite-based data-transfer component, the length of satellite transmission and other network-specific restrictions limit the amount of data that can be transmitted.

2.2.1 Activity Sensor Technology

The actual sensor used to recover activity data is a three-axis accelerometer designed to detect changes in acceleration in any one or combination of the three planes of motion. This sensor technology has replaced the tip-switch sensors used in previous generations of GPS systems. The sensor detects acceleration and tilt relative to gravity. The following example helps illustrate the operation of the activity sensor.

During various activities such as walking and running, there are changes in acceleration ongoing throughout the activity. In running, the amplitude of those changes may be greater as compared to walking. Further, there may be a difference in the frequency of the occurrence of those changes in a walking activity versus a running activity. A practical sensor system must rely on sampling to detect these changes because monitoring the sensor continuously draws large amounts of current and shortens the life of the system. As with any sampling strategy, the sensor may miss some changes because of the frequency of occurrence. Gen4 systems compare the level of acceleration detected from one second to the next. If the system detects an adequate change in acceleration, the system classifies and counts this second as an “active second” to indicate that some activity has occurred in that second. The sensor also detects changes in the position of the animal relative to gravity (in a sense one can think of this as a change in the animal’s tilt relative to the earth). This change in angle would occur if an animal were to be in a sternal recumbency (on its sternum) and then slowly roll over to a lateral recumbency (lying over on its side). At the present time activity is detected when the angular change is greater than the preset amount and the system classifies and then counts this as an “active second”.

In the example above, the recovered data represents the number of seconds over the data collection period, during which activity occurred. The user can select other time intervals through programming options provided by TPP. The system could provide data based on the number of two-second time intervals (or some other classification period) over the course of data collection period where activity was detected.

Gen4 systems can store activity data in log memory or transmit the data via the data-transfer component. All terrestrial models support the activity sensor. Marine models may also support the activity sensor; however, the wave action may make the sensor data difficult to interpret.

2.2.2 Mortality Sensor

The mortality sensor uses the same accelerometer as the activity sensor to evaluate the animal status as alive or dead. Unlike the activity sensor, the mortality sensor always uses “active seconds” as the classification period. See section 2.2.1 for a detailed description of how Gen4 systems determine whether or not a classification period is active. The “active seconds” are usually accumulated over an extended time period such as several hours to avoid false reporting of a mortality event. When the number of active seconds drops below a preset threshold level, the animal is classified as “dead” or in the “mortality mode”. Mortality events are stored in log memory in Gen4 systems containing μGPSI-21 electronics or newer. Gen4 GPS systems with a data-transfer component may optionally transmit the mortality flag (0 to indicate that the animal is alive or 1 to indicate that the animal is dead). The VHF beacon of any system (GPS-SOB, GPS-Argos, GPS-Globalstar, GPS-Iridium, or GPS-SST) can be configured to report mortality events by using a special pulse rate when mortality is detected. If the mortality sensor detects additional activity and the total number of active seconds now exceeds the mortality threshold, the system comes out of mortality mode and classifies the animal as “alive”.

Please note that the mortality sensor does not operate during the predeployment season. When predeployment ends, the mortality sensor is reset and begins normal operation. See section 3.2.5 for information about the predeployment season.

2.2.3 Temperature Sensing Option

Gen4 systems can measure temperature with the range of -40 to +70C and report temperatures to the nearest degree. The temperature sensor has an accuracy of +/- 2.5 degrees C. Gen4 systems store temperature measurements in log memory and can optionally send temperature measurements via the data-transfer component.

2.2.4 Saltwater (Conductivity) Sensor and Diving Data

Gen4 GPS can sample the Saltwater Sensor (SWS) and acquire data about the diving behavior of the animal. Telonics typically configures the SWS to trigger at a threshold of 12% of the conductivity of seawater. Some models also support a lower threshold that can detect saltwater, brackish water, and most freshwater (up to 0.3% of the conductivity of seawater). Using an adjustable qualification period, the system can detect an actual dive versus a splash of water over the SWS terminal. Gen4 systems store dive times and durations in log memory and can optionally transmit information about individual dives, including:

- Time of the dive
- Dive duration

Gen4 systems can also accumulate data over a configurable sample period. Gen4 GPS systems with a data-transfer component (e.g., Argos transmitter) can then transmit the following information about a sampling period:

- Percentage of time underwater (in qualified dives)
- Dive count
- Average dive duration
- Standard deviation of dive duration
- Maximum dive duration

The SWS can also detect a “haul-out” event, in which an animal does not dive for an extended time. After a configurable amount of time being hauled out, the Gen4 GPS system optionally disables the GPS receiver and/or the Argos transmitter (if equipped) to conserve energy. Gen4 systems record these haul-out events into log memory.

Gen 4 systems provide programmable SWS Failsafe operation in case foreign material attaches to the SWS terminals and provides conductivity. Typically this condition would cause the Gen 4 system to determine that it is under water continuously and suppress GPS fixes and transmissions indefinitely. However, SWS Failsafe operation allows the Gen 4 system to recognize that the sensor is compromised and take GPS fixes and make transmissions anyway. These transmissions optionally include an indication that SWS Failsafe operation is active. When this SWS Failsafe “flag” is set, you should consider underwater data collected near that time to be invalid.

SWS Failsafe operation begins after a programmable time period during which the SWS sensor continually detects saltwater. For example, SWS Failsafe operation could begin after 24 hours of continuous saltwater detection. You may select the time period best suited for your application, or you may choose to disable SWS Failsafe operation entirely.

Should the foreign material be removed, the switch will return to normal operation.

2.2.5 Pressure Sensor and Depth Data

Gen4 systems can measure underwater depth using an integrated pressure sensor. The sensor is accurate to within ±2 meters or ±1% of recorded depth, whichever is greater. When submerged, the unit measures depth at a user-selected interval. Gen4 systems store all depth readings in log memory and can optionally transmit depth information about individual dives, including:

- Dive depth profile
- Dive depth

The system can also tally depth readings into user-defined underwater “layers”. By using this approach and keeping statistics, Gen4 systems can also transmit depth information summarizing an entire sampling period:

- Layer percentages
- Dive counters by depth layer
- Maximum dive depth

The system does not collect depth readings while SWS Failsafe operation is active.

2.2.6 Low Voltage Sensor

The Low Voltage Sensor is designed to detect that the main battery is having difficulty delivering power for satellite transmissions or other critical functions. GPS-Argos, GPS-Globalstar, and GPS-Iridium systems can optionally include this one-bit field (0 for normal operation or 1 for low voltage) in the transmitted message. The sensor detects low voltage when the main battery is depleted or when the system is transmitting in cold conditions. If the unit is at the end of life and the low-voltage flag is set, consider recovering the unit if possible.

2.2.7 Proximity Detector

Gen4 systems can optionally include a Proximity Detector. This detector listens for VHF pulses being transmitted from nearby animals. The range of detection varies according to the model of the unit performing the detection, the specifications of the VHF transmitters being tracked, and the surrounding environment, from about 2 meters to as far as 30 meters. Specific units are identified by their unique pulse period. The list of units to track is preprogrammed into the unit using Telonics Product Programmer. Up to 40 unique pulse periods can be tracked. Information about which remote animals are found to be present or absent will be stored in the datalog and optionally transmitted via the data-transfer component. Note that typically no more than 10 animals can be present at any given time in order to accurately recognize the pulse periods.

Typical applications include detection of separation of mother and offspring, interactions within a herd, disease-transmission studies, monitoring watering sites, monitoring nests or burrows, and detecting birthing events.

In Iridium systems, two types of Proximity messages may optionally be sent – Normal data messages (transmitted on a routine schedule) containing information about which animals have been detected during each scheduled Update Period, and Priority messages that are transmitted as soon as a change in the state of which animals are ‘present’ is detected.

Parameters that can be specified for the Proximity detection:

- **Units to track** - The unit can be configured to detect up to 40 different pulse periods. The pulse periods are specified in milliseconds, and a description of the unit being tracked may be included. These 40 pulse periods could refer to 40 different beacons, or they could refer to fewer beacons that each has multiple pulse periods. The description could be the CTN of the tracked beacon, or it could describe the state of the tracked unit (“555123A mortality”).
- **Detector Sensitivity** - The proximity detector supports two different sensitivity modes: Low Gain and High Gain. Low Gain consumes much less energy but has a shorter detection range. High Gain consumes more energy but has a longer detection range. You can test the range of detection prior to deployment to get a better idea of the maximum distance.
- **Schedule** - The schedule determines when the unit will use the proximity detector. ‘On Periods’ of the schedule determine the minutes in which the detector is on and listening for the 1-40 VHF beacons. Update Periods of the schedule determine the periods over which attendance will be reported in the datalog and optionally transmitted via the data-transfer component..

2.3 Gen4 VHF Beacon Technology

A VHF tracking beacon is provided as an integral component of most terrestrial models and some marine, oceanographic, and meteorological models. Many field researchers are already familiar with using VHF telemetry in various tracking applications. The same basic techniques can be used to monitor and track Gen4 systems. This manual assumes that you are familiar with VHF telemetry and does not discuss these techniques in detail. If you need additional instruction using VHF telemetry, please call Telonics for literature or direct advice on the techniques.

The VHF beacon is typically used in the following ways:

- Initialization of the unit prior to deployment.
- Track the unit during the deployment.
- Reporting the success or failure of the last GPS fix attempt.
- Reporting a mortality following a period of inactivity.
- Reporting the exhaustion of the main battery pack.

- Recovering the unit after the GPS and data-transfer components have reached the end of their operational lifetimes.

During the deployment, the beacon can report the success or failure of the last GPS fix attempt. Monitoring this information over several fix attempts provides a means to assess the performance of the GPS component in systems (GPS-SOB) that do not have a data-transfer component. You can select a pulse period (or rate) to indicate the last fix was “successful” and another pulse period (or rate) to indicate the last fix attempt was “unsuccessful”. For systems where QFP is purchased, you can choose a “successful pulse period” for the VHF beacon to indicate a true GPS and a separate pulse period to indicate a QFP location.

Note that the operation of the VHF beacon is suspended and the beacon does not transmit during GPS fix attempts to avoid any potential interference with the GPS receiver.

The VHF beacon can also report when an extended period of inactivity has occurred, which is typically interpreted as a mortality event in animal-borne system.

The VHF beacon can be programmed to follow duty cycles to extend the operational life. The “on period” is the time when the beacon is actively transmitting in a normal operating mode. During the “off period”, the transmitter is typically shut off. However, the transmitter may be programmed to operate during off periods, typically at a very low pulse rate such as 12 BPM (5000 msec. pulse period). The very low pulse rate allows the unit to conserve power during off periods while still allowing the beacon to be tracked and recovered if necessary. Note that during the off period the beacon may not indicate dead battery, mortality, or other system status information, depending on programming.

In some models, the VHF tracking beacon is set up to operate on an independent battery separate from the main battery that is used to power all other components in the system. This design allows the VHF beacon to report the exhaustion of the main battery pack (for GPS and data-transfer components). The GPS and data-transfer components cease to function when the main-battery pack is depleted. The VHF transmitter remains operational as long as sufficient energy is available from the VHF battery pack.

When the main battery pack is exhausted, the VHF beacon transmits the dead-battery signal. The TPF Record shows the “dead battery” pulse rate (period) that was specified to Telonics at time of order or that you programmed into the unit using TPP. The pattern of pulses in dead battery mode consists of a single pulse “beep” repeated at a specified pulse period. In the dead battery mode, the VHF beacon does not transmit mortality events or last GPS fix status. Telonics recommends the use of a slow pulse rate (long pulse period) for this dead battery mode to help extend battery life and enhance the user’s flexibility in scheduling unit recovery.

The expected operational life of the unit in dead-battery mode depends on operational parameters selected by the user prior to deployment. The average pulse rate for all modes of operation and the actual operating temperature are the main factors in determining the operational life of the VHF beacon. The TPF record includes simulation results that indicate the expected end of life for the VHF battery pack (if equipped) and for the main (GPS-SOB, GPS-Argos, GPS-Globalstar, or GPS-SST) battery pack assuming various operational modes and temperature environment. Analyze the simulation results from TPP to help decide on a recovery schedule for a unit in the dead battery mode.

GPS-Argos and GPS-Globalstar systems can report that the main battery pack has low voltage (see section 2.2.6) by including a field in the transmitted message. The low-voltage condition in the transmitted message does not indicate that the VHF component of the system is in dead battery mode. The low voltage condition simply means that the voltage of the main battery pack dipped below a threshold value. This may indicate that the main battery pack is going to exhaust in the near future. Low voltage could also be a temporary condition due to excessive battery passivation or extremely cold conditions. If the low-voltage condition is temporary, the low-voltage flag in the transmitted message will be reset as soon as the voltage exceeds the threshold. When the main battery is actually exhausted, the unit stops making satellite transmissions and the VHF transmitter enters the dead-battery mode. If for some reason the main battery recovers from the dead-battery mode, the unit and its VHF beacon resume normal operation.

GPS-SST systems cannot report that the main battery pack has experienced a low voltage condition in the downloaded data using the SST link. However, when the main battery is actually exhausted, the unit stops receiving SST commands from the SST-901M and is no longer capable of transferring data to the SST-901M over the spread-spectrum link. At that time, the VHF transmitter enters the dead-battery mode. If for some reason the main battery recovers from the dead-battery condition, the unit and its VHF beacon resume normal operation.

GPS-Globalstar systems operate the VHF beacon under the control of an interlock device that keeps the VHF transmitter off whenever the Globalstar transmitter is on. Because the two transmitters never operate simultaneously, they are not considered to be co-located under FCC regulations.

GPS-Iridium systems operates the VHF beacon under the control of an interlock device that keeps the VHF transmitter off whenever the Iridium transceiver is on. Because the VHF beacon transmitter and Iridium transceiver never operate simultaneously, they are not considered to be co-located under FCC regulations.

2.4 Summary of Data Transfer Components

The following table summarizes the available data-transfer components for Gen4 GPS systems. Note that all systems, regardless of the included data-transfer component, store collected data in onboard storage for retrieval after recovering the system. Optional QFP technology[4] is available on all systems and provides varying benefits depending on the data-transfer component selected.

	Gen4 GPS System Type	Data Transfer Component	Description
Store On Board	**GPS-SOB**	None	With no data transfer component, these units must be physically recovered and connected to a PC to download study data. GPS-SOB systems are available in smaller configurations and with longer battery life than other Gen4 GPS systems. Optional QFP technology[3] can triple the expected battery life or number of positions compared to standard GPS technology.
Satellite	**GPS-Argos**	One-Way to Satellite	The Argos Data Collection and Location System (DCLS) provides a satellite-based data relay from GPS-Argos systems directly back to the researcher. Argos satellites provide truly global coverage and are overhead periodically. Users must obtain permission and purchase service from Argos CLS. Optional QFP technology[4] can fill in failed GPS fixes and provide additional positions after physical recovery of the system.
	GPS-Globalstar	One-Way to Satellite	The Globalstar satellite network provides a data relay from GPS-Globalstar systems directly back to the researcher. Globalstar satellites cover most of the globe, and covered locations always have a satellite overhead. Users must purchase service from a AssetLink Global. Optional QFP technology[4] can fill in failed GPS fixes and provide additional positions after physical recovery of the system.
	GPS-Iridium	Two-Way to/from Satellite	The Iridium satellite network provides a data relay from GPS-Iridium systems directly back to the researcher. The Iridium satellite network also allows the researcher to send control and configuration information to the deployed system. Iridium satellites provide coverage of the entire globe. Users must purchase service frommetOcean telematics. Optional QFP technology[4] can fill in failed GPS fixes and provide additional positions during the deployment or after physical recovery of the system.
Direct Download	**GPS-SST**	Two-Way with Mobile Radio	Before a data transfer can be performed, users must first approach the deployed GPS-SST system to within its operable communication range. This process is aided by monitoring the VHF beacon. The data transfer is then accomplished using a laptop computer equipped with a Telonics SST-901M Spread-Spectrum modem and Telonics Data Converter (TDC) software. Optional QFP technology[4] can double the expected battery life or number of positions compared to standard GPS technology.

[3] Optional QFP technology is available for purchase separately, but is included at no extra charge in GPS-Argos systems purchased for marine wildlife study applications.

3 User Changeable Parameters Control the Function of the Systems

Each Gen4 unit contains user-changeable parameters that control the function of the system during deployment. These parameters are either installed into units at the factory by our staff or installed by the users after they receive their order. Telonics offers numerous models of Gen4 systems, and each model has specific user-changeable parameters to control scheduling, duty cycles, transmitter frequencies, ID codes, and many other options.

Careful selection of these and other parameters allows the user to customize the Gen4 GPS system to meet specific research needs and operational lifetime.

3.1 The TPF File

The user-changeable parameters are contained in a TPF file that is used to program the Gen4 units. A single TPF file can program multiple units to share the same behavior. Using a single TPF file in this way helps to avoid mistakes often associated with manual duplication of settings across a group of similar units. Here are a few examples of the many shared parameters in a TPF file:

- Schedules for GPS position attempts
- Schedules for other data sampling
- VHF schedules
- Argos data uplink schedules
- Argos power level
- Format of Argos messages (for GPS-Argos systems)
- Content of Globalstar messages (for GPS-Globalstar systems)
- Content of Iridium messages (for GPS-Iridium systems)

Note that the TPF file maintains some information that is specific to each individual unit, such as:

- CTN (serial number)
- Argos ID and repetition rate (for GPS-Argos systems)
- Globalstar ESN (for GPS-Globalstar systems)
- Iridium IMEI (for GPS-Iridium systems)
- VHF beacon frequency

Therefore, all units in a TPF file will follow the same transmission schedule and handle data collection in the same manner, even though they use different unit-specific settings.

The contents of a TPF File appear in a human-readable format in a TPF Record. A TPF Record is divided into sections that group related programming options together. The sections that appear in a TPF Record differ from model to model. For example, GPS-SOB systems do not include an Argos or SST section. Some models may also have different available options for sensor data.

On the following pages there is an example TPF Record for a GPS-Argos system and an example TPF Record for a GPS-SST system. The examples provide an overview of the format of a TPF Record and a summary of the information included in the various sections of the record. A GPS-SOB system does not have the sections pertaining to the Argos data-transfer component or SST data link; however, the TPF Record would otherwise look quite similar. The example TPF for a GPS-Argos system is similar to a TPF for a GPS-Globalstar system, and key differences are discussed in the descriptions on the left-hand side.

Document Header: Identifies the name of the file and the version number of TPP.

Product Model: Identifies the model name.

Customer: Identifies the name and/or contact information of the customer.

Units: Specifies unit-specific settings such as the CTN, Argos ID or Globalstar ESN, Argos repetition rate, and VHF frequency. This section also lists the firmware version and time of programming for each unit. This section allows multiple units to be programmed with the same TPF file.

Predeployment: Specifies the duration and update period used during the predeployment/initialization test period. Argos transmitters use the repetition rate listed in the **Units** section during this test period. The VHF beacon is on during this test period. All other components (e.g., GPS, activity, and temperature) use the update period listed in this section.

GPS: Specifies the GPS-QFP strategy chosen (equipped units only). Specifies the times allocated to obtain a GPS position or a QFP position before aborting the attempt.

GPS Schedule: Specifies when and how often to take GPS fixes.

QFP Schedule: Specifies when and how often to take QFP positions.

Activity/Mortality: Specifies the planes of motion that will be monitored for activity and classification interval for monitoring activity. For example, when a second is used, the data returned will be a measure of how many seconds contain activity.
This section also specifies the directions and threshold for determining mortality.

Activity Schedule: Specifies the periods over which to accumulate activities.

Temperature Schedule: Specifies how often to measure temperatures.

TELONICS

TPF Printout
C:\My Documents\Argos Sample.tpf
TPP 2.39.1141

Product model TGW-4583-2

Customer...Joe Biologist

Units:
Unit 1:
CTN (Serial Number) 000000A
Decimal Argos ID 99998
Hex Argos ID ....FB19313 (root ID = 16070, extension & protection = 19)
Actual repetition period ....200 seconds
Argos frequency ....401.630 MHz
VHF frequency ....150.00000 MHz
Firmware version...........................SECO1124 uGPSI-20 2008.05.20
Parameter timestamp....................2008.10.15 16:00:00 UTC
Unit 2:
CTN (Serial Number) 000001A
Decimal Argos ID 99999
Hex Argos ID ....FB19326 (root ID = 16070, extension & protection = 38)
Actual repetition period ....201 seconds
Argos frequency ....401.680 MHz
VHF frequency ....151.00000 MHz
Firmware version...........................SECO1124 uGPSI-20 2008.05.20
Parameter timestamp....................2008.10.15 16:01:00 UTC

Predeployment:
Season duration.................................4 hours
Update period ....1 hour

GPS:
GPS-QFP ....Purchased
GPS Strategy ....Collect mostly QFP locations; occasionally attempt GPS fix
Fix timeout ....180 Seconds
QFP timeout.......................................20 seconds

GPS schedule:
Season 1:
Start date.......................................2000.01.01 (Saturday)
End date ....2100.01.01 (Friday)
Update period................................4 Hours

QFP schedule:
Season 1:
Start date.......................................2000.01.01 (Saturday)
End date ....2100.01.01 (Friday)
Update period................................30 Minutes

Activity/Mortality:
Activity:
Directions ....1, 2, & 3
Classification interval ....1 second
Mortality:
Directions ....1, 2, & 3
Time interval..................................10 Hours
Threshold ....5 active seconds

Activity schedule:
Season 1:
Start date.......................................2000.01.01 (Saturday)
End date ....2100.01.01 (Friday)
Update period................................1 Hour

Temperature schedule:
Season 1:
Start date.......................................2000.01.01 (Saturday)
End date ....2100.01.01 (Friday)
Update period................................30 Minutes

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Argos, Globalstar, or Iridium: Specifies the transmit power level [GPS-Argos only], minimum temperature at which the unit will transmit, and the contents of the transmitted message. The message contents can include fields that appear in every message, like the mortality flag and error-detection byte. The message contents can also include compressed data such as GPS, activity, and temperature pages that the transmitter will alternate sending.

Argos, Globalstar, or Iridium Schedule: Specifies when a transmitter should uplink messages. Argos Transmitters that use satellite overpass predictions will follow this schedule and transmit only when a satellite should be overhead.

Argos Satellites [GPS-Argos only]: Specifies the ephemeris of Argos satellites and the prediction settings on the transmitter. Transmitters can optionally use this ephemeris to predict satellite overpasses and increases operational life. And the efficiency of data transfer. The **Simulator** section uses the ephemeris from this section to estimate the reception success rate. Units that use satellite prediction should have up-to-date ephemeris prior to deployment.

VHF: Specifies the transmit power, pulse width, and pulse period of the VHF beacon. This section may specify different pulse periods for operational modes such as:

- Last GPS fix successful
- Last GPS fix QFP location
- Last GPS fix failed
- Mortality
- Dead battery

VHF Schedule: Specifies when the beacon should be on. During off periods, please be aware that the beacon typically transmits with a 5-second (12 BPM) during scheduled off periods. For most configurations, the beacon is never completely off.

Argos:

Transmit power ....500 mW
Minimum transmit temperature~.........40 degrees C
Most-recent GPS location...................Transmitted after a delay to maximize overall data transfer
Argos message fields:
Mortality flag ....Bit 1; 0 = animal is alive, 1 = animal is dead
GPS page:
GPS update time ....Up to 2100.01.01 with 1-second steps
Compressed successful fix flags.0 = fix failed, 1 = fix successful
Compressed fix delays ....0 through 255 seconds with 1-second steps
Compressed latitudes................The whole world with 9.5m resolution
Compressed longitudes.............The whole world with 9.5m resolution
Activity page:
Activity update time ....Up to 2100.01.01 with 1-second steps
Compressed activity counters ...0 through 65535 counts with 1-count steps
Temperature page:
Temperature update time ....Up to 2100.01.01 with 1-second steps
Compressed temperatures........-40 to 70 degrees C with 1-degree steps
Error detection byte........................(8 bits)

Argos schedule:

Season 1:
Start date...2000.01.01 (Saturday)
End date ....2100.01.01 (Friday)
Loop length.......................................1 Day
On period 1:
Start offset................................12 Hours
Duration....................................8 Hours

Argos satellites:

Two-line elements for Argos satellites:
Satellite 1 (2008.10.27) ....METOP-A
1 29499U 06044A 08301.82888300
2 29499 98.7227 359.2408 0001189
Satellite 2 (2008.10.27) ....NOAA 15
1 25338U 98030A 08301.17755365
2 25338 98.5671 289.7598 0011074
Satellite 3 (2008.10.27) ....NOAA 16
1 26536U 00055A 08301.17439690
2 26536 99.1688 293.3217 0010033
Satellite 4 (2008.10.27) ....NOAA 17
1 27453U 02032A 08301.36105928
2 27453 98.5197 2.0587 0012718
Satellite 5 (2008.10.27) ....NOAA 18
1 28654U 05018A 08301.35550541
2 28654 98.8797 240.7236 0013759
Argos satellite prediction on the unit...Use scheduled GPS fixes to predict Argos satellite passes
Disable satellite prediction ....After 5 days since last successful GPS Fix

VHF transmitter:

Transmit power ....Medium
Pulse width..15 ms
Pulse periods:
After a successful GPS fix ....1000 ms (60 BPM)
After a QFP location ....1000 ms (60 BPM)
After an unsuccessful GPS fix ....2000 ms (30 BPM)
Mortality..600 ms (100 BPM)
Dead battery....................................3000 ms (20 BPM)

VHF schedule:

Season 1:
Start date...2000.01.01 (Saturday)
End date ....2100.01.01 (Friday)
Duty cycle ....Always on

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Simulator: This section does not affect unit behavior. This section provides estimates of battery life, transmission-hit rate, and satellite-uplink status. Before providing these calculations, this section must specify operational assumptions such as the deployment date, environment temperature, and expected location.

The results portion of the **Simulator** provides the following estimates:

- Primary (Argos/GPS) battery life
- Energy consumption by each component
- Conservative estimate of battery life
- Battery life without satellite prediction
- VHF battery life for each operational mode
- Operating temperature range
- Transmission-hit rate
- % of collected data uplinked to Argos

Notes: Provides a brief summary text field of information in the file. It also specifies other information about the deployment. This section could be used to identify hardware options such as adjustment range of the collar. This section does not affect unit behavior.

Number of errors: Identifies the number of errors in the current TPF. The details of each error appear in the corresponding section of the parameter file. For example, an error with the mortality settings would appear in the **Activity/Mortality** section of the TPF file. TPP will not program a unit if there are any errors in the TPF file.

Number of warnings: Identifies the number of warnings in the current TPF file. The details of each warning appear in the corresponding section of the parameter file. Telonics Product Programmer can program a unit if there are warnings in the TPF file. Warnings identify possible problems, mistakes, or omissions in a TPF file. Be aware that warnings and errors cannot possibly catch unintended but legitimate system behavior and therefore users should carefully review the TPF file.

```
Simulator:
  Battery date........................................2008.10.01
  Deployment date.....................................2008.11.01
  CR-2A release date .................................2010.02.01
  Average environment temperature.....................20 degrees C
  Expected average time to fix .......................90 seconds
  Expected average time to QFP .......................20 seconds
  Transmission success
  during overpasses ..................................20%
  Expected VHF mode...................................All GPS fixes successful
  Satellite pass simulation information:
    Simulate passes...................................For expected battery life.
    Expected locations:
    Location 1........................................From 2000.01.01 to 2100.01.01,
                                                      at 33.384 N, 111.811 W
    Minimum pass elevation ...........................0 degrees
    Maximum pass elevation ...........................90 degrees
  Simulation results:
    Argos/GPS Battery
      Battery end of life.............................2010.01.19 (1 Year + 78 Days,
                                                                  CR-2A – 0.4 Months)
        Consumption by Argos .........................69.5%
        Consumption by GPS ...........................27.9%
        Consumption by Other..........................2.6%
      Conservative end of life........................2009.11.09 (1 Year + 7 Days,
                                                                  CR-2A – 2.7 Months)
      Without satellite prediction:
        Battery end of life...........................2009.09.03 (306 Days,
                                                                  CR-2A – 4.9 Months)
        Conservative end of life .....................2009.07.01 (242 Days,
                                                                  CR-2A – 7.0 Months)
      VHF Battery
        Expected mode (GPS fixes successful)
          Battery end of life ........................2010.05.19 (1 Year + 198 Days,
                                                                  CR-2A + 3.6 Months)
        Other VHF modes
          QFP location ...............................2011.09.18 (2 Years + 320 Days,
                                                                  CR-2A + 20 Months)
          GPS fixes unsuccessful .....................2011.09.18 (2 Years + 320 Days,
                                                                  CR-2A + 20 Months)
          Mortality...................................2009.10.16 (349 Days,
                                                                  CR-2A – 3.5 Months)
          Dead battery................................2012.11.15 (4 Years + 14 Days,
                                                                  CR-2A + 34 Months)
    Datalog usage at end of life .....................20%
    Minimum operating temperature.....................40 degrees C
    Maximum operating temperature.....................70 degrees C
    Satellite pass simulation (for 2 years starting at deployment):
      Location 1:
        METOP-A.......................................4376 passes predicted, 4464 hits
        NOAA 15.......................................4355 passes predicted, 3022 hits
        NOAA 16.......................................4445 passes predicted, 4181 hits
        NOAA 17.......................................4364 passes predicted, 4417 hits
        NOAA 18.......................................4442 passes predicted, 1431 hits
      Transmissions that could
      hit a satellite.................................13622 of 38954 (34%)
    Estimated # of data pages
    successfully uplinked to Argos....................1003 of 1003 pages (100%)

Notes:
  (none)

Number of errors .....................................0
Number of warnings ...................................0


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```

Document Header: Identifies the name of the file and the version number of TPP.

Product Model: Identifies the model name.

Customer: Identifies the name and/or contact information of the customer. Optionally identifies a UTC offset that allows the TPF file to show SST on periods in another time zone.

Units: Specifies unit-specific settings such as the CTN, SST frequency set, and VHF frequency. This section also lists the firmware version and time of programming for each unit. This section allows multiple units to be programmed with the same TPF file.

Predeployment: Specifies the duration and update period used during the predeployment/initialization test period. SST systems will listen for communication during this test period. The VHF beacon is on during this test period. All other components (e.g., GPS, activity, and temperature) use the update period listed in this section.

GPS: Specifies the GPS-QFP strategy chosen (equipped units only). Specifies the times allocated to obtain a GPS position or a QFP position before aborting the attempt.

GPS Schedule: Specifies when and how often to take GPS fixes or QFP locations.

Activity/Mortality: Specifies the planes of motion that will be monitored for activity and classification interval for monitoring activity. For example, when a second is used, the data returned will be a measure of how many seconds contain activity.
This section also specifies the directions and threshold for determining mortality.

Activity Schedule: Specifies the periods over which to accumulate activities.

Temperature Schedule: Specifies how often to measure temperatures.

SST: Optionally specifies a password that will be required to download data from the units. This section also specifies the duration of the blackout period. When users finish downloading data over the SST link, they can (optionally) save battery-life by initiating a blackout period so the unit will stop listening for SST communications even though the SST schedule is in an on period. After receiving a blackout command, the unit waits the grace period before it actually stops listening for SST communication.

SST Schedule: Specifies the time periods during which the SST system will listen for RF communication. If the Customer section defined a UTC offset, this schedule displays the start time of the on period in both UTC time and the specified time zone/offset. This is the time period during which the researcher will need to be in the field to download the data over the spread-spectrum link.

TELONICS

TPF Printout
C:\My Documents\SST Sample.tpf
TPP 2.39.1141

Product model TGW-4590

Customer:
Customer ....Joe Biologist
UTC offset...-7:00

Units:
Unit 1:
CTN (Serial Number) 000000A
SST frequency set..........................Set 1 (902-907MHz)
VHF frequency ....150.00000 MHz
Firmware version............................SECO1215 uGPSI-20-SST 2010.05.12
Parameter timestamp.....................2010.10.15 16:00:00 UTC
Unit 2:
CTN (Serial Number) 000001A
SST frequency set..........................Set 2 (908-913MHz)
VHF frequency ....151.00000 MHz
Firmware version............................SECO1215 uGPSI-20-SST 2010.05.12
Parameter timestamp.....................2010.10.15 16:01:00 UTC

Predeployment:
Season duration..................................4 hours
Update period ....1 hour

GPS:
GPS-QFP..Purchased
GPS Strategy......................................Collect QFP locations exclusively
QFP timeout..60 seconds

GPS schedule:
Season 1:
Start date..2000.01.01 (Saturday)
End date...2100.01.01 (Friday)
Update period.................................30 Minutes

Activity/Mortality:
Activity:
Directions ....1, 2, & 3
Classification interval ....1 second
Mortality:
Directions ....1, 2, & 3
Time interval...................................10 Hours
Threshold ....5 active seconds

Activity schedule:
Season 1:
Start date..2000.01.01 (Saturday)
End date...2100.01.01 (Friday)
Update period.................................1 Hour

Temperature schedule:
Season 1:
Start date..2000.01.01 (Saturday)
End date...2100.01.01 (Friday)
Update period.................................30 Minutes

SST:
Password ....(none)
Coding type...Default
Grace period ....2 hours
Blackout duration ....6 Days

SST schedule:
Season 1:
Start date..2010.01.06 (Wednesday)
End date...2100.01.01 (Friday)
Loop length.....................................7 Days
On period 1:
Start offset................................0
Start time..................................Wednesday 00:00 UTC
(Tuesday 17:00 UTC-7)
Duration....................................7 Hours

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VHF: Specifies the transmit power, pulse width, and pulse period of the VHF beacon. This section may specify different pulse periods for operational modes such as:

- Last GPS fix successful
- Last fix resulted in a QFP location
- Last GPS fix failed
- Mortality
- Dead battery

VHF Schedule: Specifies when the beacon should be on. During off periods, please be aware that the beacon transmits with a 5-second (12 BPM) during scheduled off periods. The beacon is never completely off.

Simulator: This section does not affect unit behavior. This section provides estimates of battery life. Before providing these calculations, this section must specify operational assumptions such as the deployment date, environment temperature, and average navigation time for GPS fixes and QFP locations.

The results portion of the Simulator provides the following estimates:

- Primary (GPS-SST) battery life
- Energy consumption by each component
- Conservative estimate of battery life
- VHF battery life for each operational mode
- Operating temperature range

Notes: Provides a brief summary text field of information in the file. It also specifies other information about the deployment. This section could be used to identify hardware options such as adjustment range of the collar. This section does not affect unit behavior.

Number of errors: Identifies the number of errors in the current TPF. The details of each error appear in the corresponding section of the parameter file. For example, an error with the mortality settings would appear in the **Activity/Mortality** section of the TPF file. TPP will not program a unit if there are any errors in the TPF file.

Number of warnings: Identifies the number of warnings in the current TPF file. The details of each warning appear in the corresponding section of the parameter file. Telonics Product Programmer can program a unit if there are warnings in the TPF file. Warnings identify possible problems, mistakes, or omissions in a TPF file. Be aware that warnings and errors cannot possibly catch unintended but legitimate system behavior and therefore users should carefully review the TPF file.

VHF transmitter:
Transmit power ....Medium
Pulse width...15 ms
Pulse periods:
After a successful GPS fix ....1000 ms (60 BPM)
After a QFP location ....1000 ms (60 BPM)
After an unsuccessful GPS fix ....2000 ms (30 BPM)
Mortality...600 ms (100 BPM)
Dead battery..................................3000 ms (20 BPM)

VHF schedule:
Season 1:
Start date..2000.01.01
End date 2100.01.01
Duty cycle.......................................Always on

Simulator:
Battery date..2010.10.01
Deployment date................................2010.11.01
CR-2A release date 2011.11.01
Average environment temperature .....20 degrees C
Expected average time to QFP ....35 seconds
Expected VHF mode..........................All GPS fixes successful
Simulation results:
GPS-SST Battery
Battery end of life......................2012.01.19 (1 Year + 78 Days, CR-2A + 2.6 Months)
Consumption by SST On Periods 2.5%
Consumption by SST Communication 1.0%
Consumption by GPS 94.5%
Consumption by Other..........2.0%
Conservative end of life............2011.11.09 (1 Year + 7 Days, CR-2A + 0.3 Months)
VHF Battery
Expected mode (GPS fixes successful)
Battery end of life ....2012.05.19 (1 Year + 198 Days, CR-2A + 6.6 Months)
Other VHF modes
QFP location ....2012.05.19 (1 Year + 198 Days, CR-2A + 6.6 Months)
GPS fixes unsuccessful ...2013.09.18 (2 Years + 320 Days, CR-2A + 22 Months)
Mortality...........................2011.10.16 (349 Days, CR-2A – 0.5 Months)
Dead battery....................2014.11.15 (4 Years + 14 Days, CR-2A + 24 Months)
Datalog usage at end of life 20%
Minimum operating temperature ....40 degrees C
Maximum operating temperature ...70 degrees C

Notes:
(none)

Number of errors 0
Number of warnings 0

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3.2 User Changeable Sensor and Transmitter Schedules

Some of the most important user-changeable parameters control the unit's schedules of operation. Gen4 systems have an advanced scheduler that gives the user control over the operation of each component over time. A *component* is a sensor (such as the temperature sensor or the GPS receiver) or a transmitter (such as the VHF transmitter or the Argos transmitter). Each component has its own schedule. The schedule can be a simple duty cycle or a complicated sequence of on/off periods. This section of the manual provides an overview of Gen4 schedules, introduces schedule terminology, and provides a few example schedules.

3.2.1 Schedule Overview

```
GPS schedule:
    Season 1:
        Start date ...................... 2009.01.01
        End date ........................ 2010.12.01
        Loop length ..................... 4 Days
        On period 1:
            Start offset ................ 11 Hours
            Duration .................... 12 Hours
            Update period ............... 1 Hour
    Season 2:
        Start date ...................... 2010.12.01
        End date ........................ 2100.01.01
        Loop length ..................... 1 Day
        On period 1:
```

This figure (right) shows a typical schedule as it appears in a TPF Record and in the display window of Telonics Product Programmer (TPP). In this example, the GPS receiver (which is considered a sensor) will acquire 12 position fixes between the hours of 11:00:00 UTC and 23:00:00 UTC every four days beginning January 1, 2009, and continuing until December 1, 2010. Understanding the scheduler terminology shown in the figure is critical to understanding the component's behavior during deployment. The following sections describe the terminology and the associated meaning in detail.

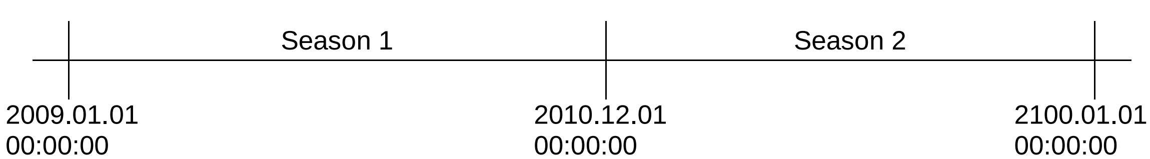
The TPF Record shows schedules using a hierarchy inherent to Gen4 scheduling. Observing this hierarchy can help users remember the meaning of the terms involved.

3.2.2 Seasons

Start and End Dates

```
GPS schedule:
    Season 1:
        Start date ...................... 2009.01.01
        End date......................... 2010.12.01
        Loop length ..................... 4 Days
        On period 1:
            Start offset ................ 11 Hours
            Duration .................... 12 Hours
            Update period ............... 1 Hour
    Season 2:
        Start date ...................... 2010.12.01
        End date......................... 2100.01.01
        Loop length ..................... 1 Day
        On period 1:
```

A schedule consists of one or more **seasons**. A season defines a period of time throughout which the component repeats the same pattern of operation. A season has a **start date** and an **end date**. A schedule with more than one season allows a component to change behavior over time. The diagram below shows a timeline of the two seasons from the sample schedule introduced above. Notice that seasons always begin and end at 00:00:00 UTC on specified date, which is the very beginning of that day. In our example, the transition from Season 1 to Season 2 occurs at exactly 00:00:00 UTC, December 12, 2010, the beginning of that day.



The Season Loop

The repeating pattern of operation inside a season is called the **loop**. Each season has its own distinct loop, and the scheduler repeats the loop continuously throughout the season. During Season 1 in the sample GPS schedule, the GPS receiver is going to collect 12 position fixes from 11:00 UTC to 23:00 UTC every four days. In this case, the **loop length** is four days because the GPS behavior repeats every four days. The diagram below shows Season 1 from this continuing example with a four-day loop length. For illustration purposes, Season 2 is not shown in the diagram.

GPS schedule:
- Season 1:
  - Start date 2009.01.01
  - End date........................ 2010.12.01
  - Loop length .... 4 Days
  - On period 1:
    - Start offset .... 11 Hours
    - Duration .... 12 Hours
    - Update period......... 1 Hour
- Season 2:
  - Start date 2010.12.01
  - End date........................ 2100.01.01
  - Loop length .... 1 Day

(Season 1)

Jan 1 - 4, 2009	Jan 5 – 8, 2009	Jan 9 - 12, 2009	…	Nov 28 - 30, 2010

Because each four-day period shown is really an iteration of the loop, the behavior of the GPS receiver component in any of the four-day periods is the same. Note that the final loop iteration ends early (after only three days, not four) because in the example Season 2 starts at 00:00:00 UTC on December 1, 2010. Remember, Season 2 has its own, separately defined loop that begins its first iteration at 00:00:00 UTC on December 1, 2010.

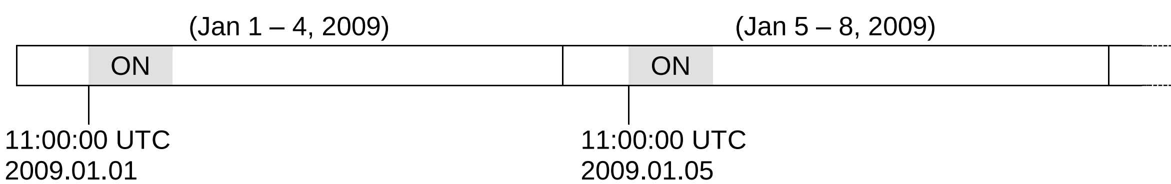
Usually, a unit begins its deployment sometime after the start date of Season 1. In our example, Season 1 starts on January 1, 2009, which is already in the past. If the deployment occurred on February 1, 2009, the GPS receiver would fall into the loop iteration already in progress according to the schedule. The unit would *not* adjust the schedule to start a new loop iteration on the deployment date. Schedules are based on the calendar and the time of day, not based on deployment date and time.

Note that if a unit is deployed *before* the start date of Season 1 for a given component, the unit can still be initialized as usual and will still proceed through the predeployment season while operating the component as usual. However, when predeployment ends in this case, the component will be off until Season 1 begins. Please refer to section 3.2.5 for more information about the predeployment season.

3.2.3 On Periods

A newly defined season and its associated loop length provide a framework in which the user can define the behavior to repeat. The first step in defining that behavior is to specify when the component should be "on" in the loop. To define an **on period**, specify a **start offset** and **duration**. The start offset specifies when the on period begins relative to the start of the loop. In the continuing example, a start offset of 11 hours in a loop of 4 days means that the on period starts at 11:00 UTC on the first day of every 4-day loop. The duration merely specifies the length of the on period. To cause the component to be active for 12 hours, the on period would have a duration of 12 hours. The following diagram continues the example from above to look closely at only the first two iterations of the loop.

```
GPS schedule:
    Season 1:
        Start date....................2009.01.01
        End date......................2010.12.01
        Loop length...................4 Days
        On period 1:
            Start offset..............11 Hours
            Duration..................12 Hours
            Update period.............1 Hour
    Season 2:
        Start date....................2010.12.01
        End date......................2100.01.01
        Loop length...................1 Day
```

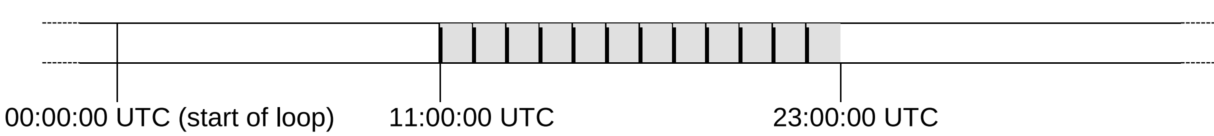


3.2.4 Update Period

The second and final step in defining the repeating behavior for a season applies only to sensor components, such as a temperature or pressure sensor or in this case a GPS receiver. Each on period in a sensor schedule must specify an **update period**, which determines how often the sensor updates its readings during the on period.

In the example from above, the update period directs the GPS receiver operation within the 12-hour on period. In the example, the GPS receiver takes 12 fixes during the on period, so the update period is one hour. The diagram below is a close-up of the beginning of the loop to show the individual update periods from the example. The timeline markers don't include dates since the loop repeats throughout Season 1.

```
GPS schedule:
    Season 1:
        Start date....................2009.01.01
        End date......................2010.12.01
        Loop length...................4 Days
        On period 1:
            Start offset..............11 Hours
            Duration..................12 Hours
            Update period.............1 Hour
    Season 2:
        Start date....................2010.12.01
        End date......................2100.01.01
        Loop length...................1 Day
```



The shaded region represents the on period we defined inside the 4-day loop, and the twelve thick vertical lines represent times that the GPS receiver would actually be attempting to acquire a position fix. Note that when the end of the on period aligns exactly with what would otherwise have been the beginning of a new update period, a sensor turns off instead of taking an additional measurement. The diagram shows this condition at 23:00:00 UTC.

Even though the TPF Record shows the update periods for all sensor schedules in the same format, each sensor observes its update period a little differently. Here are some examples:

- The temperature sensor takes a single reading at the beginning of each update period.
- The activity sensor accumulates data throughout the update period then updates its readings at the end of the update period. The activity sensor clears the accumulation at the beginning of each update period.
- At the beginning of a GPS update period, the GPS receiver turns on only long enough to obtain a single position fix (or to time out) and then turns off to conserve energy for the rest of the update period.
- The saltwater sensor and the pressure sensor both accumulate data throughout the update period and update most of their readings at the end of the update period. These sensors clear the accumulations at the beginning of each update period. Readings that pertain to a single dive are updated after each dive, not at the end of the update period.

Be sure to consider a sensor's unique characteristics when scheduling its operation.

Unlike sensor schedules, transmitter schedules do not have an entry for update periods. A transmitter schedule simply specifies when the transmitter is on or off. When the VHF beacon is in a scheduled on period, the programmed pulse period determines when the beacon transmits. When the Argos transmitter is in an on period, the Argos repetition rate determines when the unit transmits. However, other factors can influence when transmissions actually occur:

- The unit can optionally make Argos transmissions only during predicted satellite overpasses.
- Using the saltwater sensor, the unit typically synchronizes Argos transmissions to surfacing in marine applications.
- The unit does not make *any* transmissions (Argos, SST, VHF) while the onboard GPS receiver is actively obtaining a position fix.

3.2.5 Predeployment Season

As noted earlier, each component (sensor or transmitter) has its own separate schedule. However, the user can specify one universal "predeployment" season that applies to all components within the unit whenever this special season is active. When activated, the predeployment season overrides all individual component schedules for a programmable duration, usually about 4 hours. During this time, all components observe a common update period inside a continuous on period. The length of the predeployment season is generally established to allow adequate time for testing the GPS receiver and the data-transfer link.

The unit activates the predeployment season when the magnet is removed. The season then lasts for a programmable duration and uses a programmable update period. One characteristic that is completely unique to the predeployment season compared to seasons inside component schedules is that the predeployment season is not scheduled on the calendar or by the time of day. Instead, the season has a programmed duration, and it begins when the magnet is removed.

As a testing aid, the mortality sensor is disabled during predeployment. The VHF beacon will indicate the results of the initialization procedure and of GPS fix attempts during predeployment, not mortality status.

When predeployment ends, or when the unit skips predeployment because it has been programmed off, the unit begins operating all components according to their individual schedules.

3.2.6 Other Terms

Gaps between seasons are known as **offseasons**. TPP doesn't allow the user to create an offseason directly. Instead, TPP automatically inserts offseasons between seasons defined by the user.

Inside a season, gaps between on periods are known as **off periods**. However, TPP does not show off periods in a schedule, and off periods similarly do not appear in the TPF Record. TPP also does not allow the user to create off periods directly. The term "off period" is generally helpful to identify time outside on periods within the loop. However, TPP doesn't consider off periods as part of a schedule definition because it considers on periods instead.

3.2.7 Using Coordinated Universal Time (UTC)

No matter where a unit is deployed, the onboard clock keeps time in Coordinated Universal Time (UTC). Similarly, no matter where a user or PC is located, TPP treats all times as being in UTC. To create a schedule that directs behavior at specific times of day, be sure to specify the hour of the day in UTC. The first loop of a season begins at 00:00:00 UTC on the season start date.

Time in any timezone is defined by specific offset(s) from UTC. To convert a local time to UTC, subtract the timezone offset applicable to the target location and date. Because UTC does not observe Daylight Saving Time, the timezone offset in the target location may change with Daylight Saving Time. If a timezone is defined as being "UTC-7" (sometimes identified as "GMT-7"), then subtract negative 7 from the local hour to get the UTC hour. In a UTC+2 (or GMT+2) timezone, subtract positive 2 from the local hour to get the UTC hour.

It can be difficult to think about times of the day in UTC, but these times are unambiguous. Telonics has learned from experience that the inconvenience of dealing exclusively with UTC is far better than the ambiguity involved in dealing with local time.

3.2.8 Linking Schedules

The user can optionally program two or more components to share a single schedule. TPP provides this capability in a selectable schedule type called "Link To". When sensors share the same schedule, the sensors operate as if each sensor sharing the schedule had its own individual schedule defined identically to the others.

Because transmitter schedules do not have update periods, linking a sensor schedule to a transmitter schedule results in a special update period for the sensor. In this case, every transmission marks the end of the current update period for the sensor and the beginning of a new update period. Because transmissions occur at unscheduled times, often at inconsistent intervals, this kind of schedule linking is not normally used.

3.2.9 Unscheduled Sensor Operation

While most sensors follow a user-defined schedule, the low-voltage sensor and the mortality sensor operate continuously by design to provide the desired functionality. Additionally, the unit may operate other sensors outside of their schedules as necessary, without affecting the user-scheduled data collection. For example, the unit may check the saltwater sensor before making an Argos transmission even if the underwater schedule is off at the time.

3.2.10 Sample Schedules

Sample Argos Schedule

Suppose the user wants a GPS-Argos system to transmit for 6 hours every 3 days, starting at 12:00 UTC. The TPF Record would list the following schedule:

Argos schedule:
    Season 1:
        Start date.......................2000.01.01
        End date........................2100.01.01

Loop length ....3 Days
On period 1:
Start offset ....12 Hours
Duration ....6 Hours

Sample GPS Schedule

Suppose a user wants the GPS receiver to obtain position fixes at the following times:

- Deployment through 2010.12.01 – Fix every hour from 8am to 8pm UTC every day
- 2010.12.01 through end of life – Fix at 9am and 2pm UTC every other day

The TPF Record would list the following schedule:

GPS schedule:
Season 1:
Start date.......................2000.01.01
End date........................2010.12.01
Loop length ....1 Day
On period 1:
Start offset ....8 Hours
Duration ....12 Hours
Update period ....1 Hour
Season 2:
Start date.......................2010.12.01
End date........................2100.01.01
Loop length ....2 Days
On period 1:
Start offset ....9 Hours
Duration ....10 Hours
Update period ....5 Hours

Sample Activity Schedule

Suppose the user wants to accumulate activities for the following time periods each day:

- 00:00 through 8:00
- 16:00 through 18:00
- 18:00 through 20:00
- 20:00 through 22:00
- 22:00 through 00:00

The TPF Record would list the following schedule:

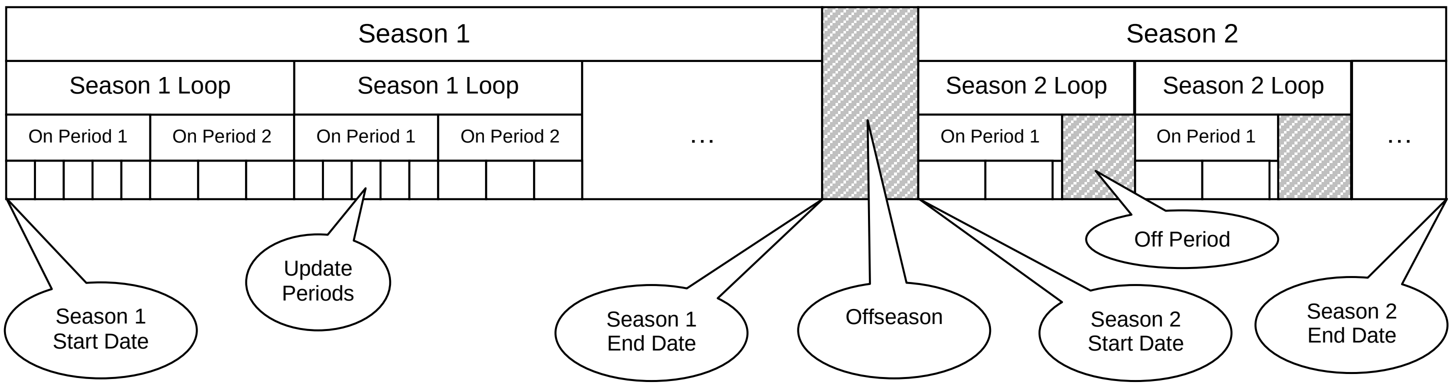
Activity schedule:
Season 1:
Start date.......................2000.01.01
End date........................2100.01.01
Loop length ....1 Day
On period 1:
Start offset ....0 Hours
Duration ....8 Hours
Update period ....8 Hours
On period 2:
Start offset ....16 Hours
Duration ....8 Hours
Update period ....2 Hour

3.2.11 TPP Timeline Window

TPP provides the Timeline Window to help users check the schedules visually on a timeline. This window can provide extra insight into complicated schedules, and the user can zoom in and out as needed. The timeline window is especially useful for visualizing sensor behavior during transition times between seasons, from one loop iteration to the next, or from an on period to an off period.

3.2.12 Generalized Schedule Diagram

The following figure helps illustrate how the various parts of a schedule fit together:



4 Factory Programming of User Changeable Parameters

All units shipped from the factory have some amount of factory programming already done on the user-changeable parameters. In fact, for many customers, the factory performs *all* programming of user-changeable parameters. For other customers, the factory merely installs default settings and allows the user to install settings appropriate for the eventual deployment. This section describes factory programming of user-changeable parameters for these different scenarios.

4.1 Specifying User Changeable Parameters during the Ordering Process

Some users prefer to receive units that have been fully programmed by Telonics. These users work directly with Telonics staff during the ordering process to establish the parameters and the desired operation of the unit. Our staff uses a programming utility called Telonics Product Programmer (TPP) to create a TPF file that contains all the programming information for the units. Since only the TPP program can display TPF files, Telonics emails a TPF Record to the customer so that the customer can confirm that the parameter programming is correct. The TPF Record is simply a .pdf file that can be viewed without having to install TPP. The user is asked to confirm that parameters contained in the TPF Record are correct. Once the user confirms that the TPF Record is correct, Telonics will use the TPF file to program the units. The user receives both a hardcopy of the TPF Record and the actual TPF file used to program the units with the shipment of the unit. All users should retain the actual TPF file in an archive to be able to recreate changes to the programming of units over time. In addition, users with GPS-Argos systems provide the TPF file to Telonics Data Converter (TDC) to process and time stamp data recovered from an Argos DS file.

The user should again review the hardcopy of the TPF Record after receiving the shipment since the TPF Record now includes additional information such as the serial numbers of the units in the order.

4.2 Reviewing Units Preprogrammed at the Factory

The TPF Record summarizes the specific programming parameters requested by the user. These parameters may include schedules for acquiring GPS positions, collecting sensor data, transferring data, or operating the VHF beacon. The research team should thoroughly review the TPF record to assure that the programming reflects the instructions you provided to the factory. The research team should also confirm that the simulations (e.g., battery life) included in the TPF record are acceptable. If you have any questions or do not understand aspects of the record, please resolve the question(s) prior to deployment by calling our factory.

The annotated TPF Record presented in section 3.1, The TPF File, can help users who are new to the review process. During the review, it is important to remember that schedule times and any other times in the TPF Record are in UTC (not local time).

If you do not understand the TPF record associated with the order and therefore cannot verify the programming, you should call or email Telonics directly and discuss any programming issues with our staff. If anything in this record seems to be incorrect, you should bring this to the attention of the factory prior to deployment. Here is the contact information for the Telonics factory:

Telephone: **In the USA call 480 892-4444**
Email: **info@telonics.com**

4.3 Ordering Systems without Specifying User Changeable Parameters

Users who prefer to program the operation of their GPS systems themselves receive the units from Telonics with default parameters. The unit will not function until the defaults are replaced by the user. Users can either build a new TPF file, or modify the default parameters in the unit into operational parameters.

5 User Programming of User Changeable Parameters

This section of the manual is intended to help a user begin the process of programming Gen4 units using a PC and a special programming cable. Users who have received units that were preprogrammed at the factory may skip this section of the manual.

5.1 Overview of Telonics Product Programmer (TPP)

TPP is a programming utility that allows you to manage the function and performance of Telonics Gen4 GPS systems. This is accomplished by creating a TPF file containing user-changeable parameters to control the functionality of the system and then installing the TPF file into your units.

TPP has an extensive user interface and a detailed help system designed to guide you in the programming process. This manual does not attempt to answer all questions about the operation and usage of TPP, list all user-changeable parameters available on each model, or replace the experience of simply using TPP. This section of the manual is designed to address general topics that may require a background understanding of the Gen4 system and TPP. The best way to become proficient in using TPP is to use the program to develop TPF files. After developing a TPF file, look at the timelines and simulations that TPP provides to assure that the programming reflects what you intended.

5.2 Basic Requirements for Installing and Using TPP

To proceed, your personal computer or laptop must have the following capabilities:

- 30 MB available hard disk space
- CD-ROM drive or access to the internet for some functions
- Microsoft Windows 2000/XP/Vista/7
- Video card capable of 800x600 resolution or better.
- Available USB port

In addition, the following software and hardware must be obtained from Telonics:

- Current version of TPP (available on the Telonics website)
- Authorization code purchased from Telonics
- Telonics Active Smart Cable, model TSC-7[4]
- CN008351-001, CN007494-001 or CN006313-001 adapter (as needed)

5.3 Getting Started with TPP

The following steps should help you to get started using TPP.

1. Download the latest version of TPP from the Telonics website (www.telonics.com). Note that TPP operates as a demo version until you input the authorization code purchased separately from Telonics. The code transforms TPP into a fully functional version of the program. After installing the authorization code, you can begin creating a new TPF file or modifying a TPF file already installed in the unit. By following the guidance provided below and using the extensive TPP help system to answer questions about user-changeable parameters, you can create a TPF files and program Gen4 GPS systems. Check the Telonics website periodically for updated versions of TPP.
2. Open TPP and select the model that you have purchased. After you select the model number, TPP displays a TPF file containing all the user-changeable parameters that can be manipulated to customize the unit to your application. Using this approach, you can customize a TPF file before you even receive your order from Telonics.

[4] A model TSC-4 smart cable is also acceptable, as is the older model TSC-3 (serial port instead of USB).

3. Each unit has an assigned CTN (serial number) that you cannot alter. The CTN is displayed on the label of the unit. In order to install a new TPF file into a unit, the unit CTN must be included in the CTN list in the unit section of the TPF file. If the CTN is not listed in the units section, TPP displays an error message when you attempt to program the unit.
4. Construct a TPF file by changing the settings and schedules of each component. This includes specifying schedules for GPS positioning, data transfer, VHF transmitter, and sensor data collection. TPP provides timelines that graphically show the schedules for data sampling, GPS position acquisition, data transfer, and VHF beacon transmission operation. Review these timelines as you construct the TPF file to assure that duty cycles and events occur at the times you intended.. In addition, TPP provides a simulator to estimate the operational life of the GPS data transfer and VHF portions of the system under various temperature and operational scenarios***.*** Review the simulator results to see the effect of your selections on the operational life of the unit.
5. ***Caution: The simulator provides estimates of operational life. Since any estimate has a margin of error, be conservative and allow additional time to recover the units using the VHF beacon.***
6. TPP provides specific error messages that helps detect programming errors. TPP Error messages must be addressed prior to programming since TPP will not program units with a TPF file that contains error messages. Modify the TPF file to eliminate errors and assure that the operational performance and life of the unit is what you intended. In addition to error messages, TPP provides warning messages to indicate that certain parameter selections should be reviewed before the unit is actually programmed. Unlike error messages, warning messages do not necessarily indicate a programming mistake. Warning messages simply draw the user's attention to a selection that could be a mistake. After you have carefully reviewed all warning messages, TPP will program units with a TPF file that contains warning messages.
7. After establishing user-changeable parameters, reviewing timelines, and checking life estimates, you can optionally send the TPF file to Telonics for an additional review. As a service to the user community, Telonics will review your TPF file and discuss the resulting operation of the unit with you. Simply email the TPF file to the coordinator with whom you placed your order, allow a day or two for the review process, and call to discuss the programming. This service allows you to be more confident that the programming parameters will produce the intended operational behavior from the unit.
8. After you (and optionally Telonics) have thoroughly reviewed the TPF file, you are now ready to send the TPF file to the unit. The help system of TPP describes the specific steps for sending parameters to the unit and provides pictures that show how to connect the PC to various configurations. This manual provides only a brief description of how to connect models and program units in the steps below.
   a. Connecting the PC to the unit:

      Configurations that are sold with battery packs (e.g., animal configurations) generally require two connections: a programming pin and a ground connection. The location of these two connections varies for different configurations. The ground connection on most configurations is a small metal loop coming out of the housing. The programming pin on GPS-Argos systems is usually on the tip of the Argos antenna. The programming pin on GPS-SOB, GPS-Globalstar, GPS-Iridium, and GPS-SST systems is usually on the tip of the VHF antenna. Some Marine configurations have the programming pin on the saltwater-sensor terminals.

      For electronics-only configurations (e.g., oceanographic and meteorological models TGE-400/401), simply use a BNC/SMA adaptor to connect the TSC-7 cable to the Argos antenna. Be sure that the battery system is applying power to the unit before sending parameters or checking the connection.

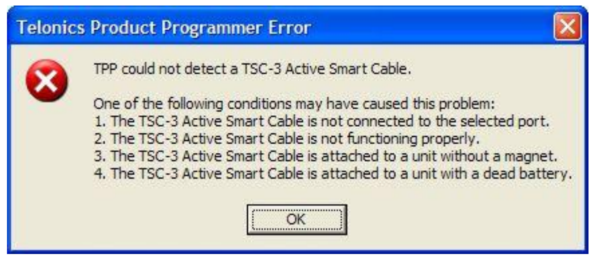
      Misconnecting the TSC-7 cable to the unit will not cause any damage to the unit.

For all configurations, be sure that the magnet is applied before attempting to communicate with the unit.

b. Testing the connection:

Press the button on toolbar or select "Check Connection to Unit" from the "Unit" menu. If you have connected to the unit correctly, TPP displays the following message:

If you have not connected the unit correctly, TPP displays one of the following error messages:



c. Installing the TPF file:

Choose “Send Parameters to Unit” from the “Unit” menu or press the button on the toolbar. While sending parameters, the cursor changes to the (hourglass) and the status bar displays “Sending parameters …”. Upon completion, the cursor returns to the default cursor, the status bar displays the results, and TPP displays a message box stating whether or not the parameter update was successful. Be sure to save a copy of the TPF file for future reference.

d. The programming process is now complete.

Telonics recommends that you archive your TPF file(s) so as to retain a copy for review and a history of modifications that are made to the programming of your units. Further, TPF files are required in some TDC data processing operations. TPF files are used by TDC to extract, process, and time stamp data recovered from Argos DS files. TDC does not use TPF files to process datalog memory because datalog files contain the same information that is stored in the TPF file.

PLEASE BE ADVISED THAT WHEN USERS PROGRAM THEIR OWN UNITS THEY TAKE FULL RESPONSIBILITY FOR ANY PROGRAMMING ERRORS.

After successfully programming the unit(s), proceed to section 6 of this manual (next) for detailed instructions on initialization.

6 Initializing Gen4 GPS Systems

All Gen4 GPS systems require that the user follow an initialization procedure before deployment. This section of the manual details two types of initialization procedures. Telonics strongly recommends the standard initialization procedure, which relies on the use of the VHF beacon, due to its simplicity. The alternate initialization procedure is intended for users who have GPS-Argos, GPS-Globalstar, or GPS-Iridium units without an integrated VHF beacon or users who cannot monitor the integrated VHF beacon.

Be sure to observe handling guidelines described in section 1.6, Handling Considerations, during all stages of deployment and recovery.

Unlike some earlier GPS systems, the initialization procedure can be completed and the magnet can be replaced on the unit to suspend unit operation until the actual deployment. Don't forget to remove the magnet prior to the actual deployment.

The unit should be reinitialized if any of the following occurs after initialization:

- The unit is transported more than 500 miles from the initialization site
- The unit is connected to a PC
- The user disconnects the batteries inside the unit (equipped models only)
- More than 3 months elapse prior to deployment

To reinitialize the unit, follow the same step-by-step procedure described below for normal initialization.

For GPS-Argos systems, ephemeris data used by the unit for making calculations of Argos satellite overpasses should not be older than 30 days (measured from the ephemeris date to the date of deployment). If necessary, refresh the ephemeris using Telonics Product Programmer (TPP) to obtain the update and to install it into the GPS-Argos unit (see 10.8, Updating Argos Ephemeris Data).

Before performing initialization on your system, please familiarize yourself with section 6.1, which describes the Predeployment Season and behaviors that are specific to the type of system being initialized.

As indicated above, users are strongly encouraged to initialize Gen4 GPS systems using the Standard Initialization Procedure:

- For GPS-SOB system initialization, refer to section 9.1.
- For GPS-Argos system initialization, refer to section 10.9.
- For GPS-Globalstar system initialization, refer to section 11.4.
- For GPS-Iridium system initialization, refer to section 12.8.
- For GPS-SST system initialization, refer to section 13.2.

If you are initializing a GPS-Argos, GPS-Globalstar, or GPS-Iridium unit and are unable to use the Standard Initialization Procedure, then please refer to the Alternate Initialization Procedure found immediately after the Standard Initialization procedure referenced above.

6.1 The Predeployment Season

To initialize correctly, the unit should be programmed with a predeployment season (see Table 1 for recommended parameters). This season is usually programmed at the factory and may also be programmed by the user with TPP. This special season begins when the magnet is removed and ends after a programmed duration. Predeployment provides an opportunity for the user to verify the proper operation of the unit before deployment. The unit's initialization occurs during the first update period of the predeployment season. During the first initialization attempt, the user can listen to the VHF beacon to determine the success or failure of the initialization attempt. Between the end of this first update period and the end of the predeployment season, units equipped with a satellite transmitter (e.g., Argos, Globalstar, Iridium, etc.) communicate initialization status via their respective link.

During predeployment, GPS-Argos systems ignore scheduled duty cycles and instead transmit continuously. Message repetition periods longer than 105 seconds are also temporarily shortened to facilitate testing during the predeployment season. When predeployment ends, the unit reverts to scheduled duty cycles and the programmed repetition period.

During predeployment, GPS-Globalstar systems ignore scheduled duty cycles and instead transmit every half hour. When predeployment ends, the unit reverts to scheduled operation of the Globalstar transmitter.

During predeployment, GPS-Iridium systems ignore scheduled duty cycles and transmit one time only at the end of the first update period. When predeployment ends, the unit reverts to scheduled operation of the Iridium transceiver.

During predeployment, GPS-SST systems ignore the duty cycles associated with wireless data transfer using the SST link. The unit is continuously listening for commands from the SST-901M and will respond with a wireless data transfer during the entire predeployment session thus allowing a test of the data-transfer link. When predeployment ends, the operational mode begins and the unit reverts to the scheduled "listening periods" assigned by TPP during programming. The unit will transfer data only during these "listening periods" when deployed in the field.

Before beginning either procedure, make note of the Predeployment "Season duration" and "Update period" programmed into the unit (listed in the TPF record). The following are recommended values:

System	Predeployment Season Duration	Predeployment Update Period
GPS-Store-On-Board	30 minutes	5 minutes
GPS-Argos	4 hours	1 hour
GPS-Globalstar	1 hour	30 minutes
GPS-Iridium	10 minutes	5 minutes
GPS-SST	30 minutes	5 minutes

Table 1: Recommended Predeployment Season Parameters

6.2 Special Considerations for Redeployment without Factory Refurbishment

The Initialization procedures outlined above are appropriate for all deployment cases, even those where a unit is being redeployed after some time already in the field. However, to redeploy a unit without first returning the unit for factory refurbishment, the user must take some extra precautions before initializing the unit for redeployment:

- Download and erase the Log Data from the unit using Telonics Data Converter (TDC)
- Update calendar dates in operational schedules and make other changes to user-changeable parameters as necessary using Telonics Product Programmer (TPP)
- Update ephemeris data in GPS-Argos units if configured to predict satellite overpasses (TPP)
- Reduce TPP battery-life estimates as necessary to account for battery energy already spent in previous deployments since the last refurbishment or battery replacement.
- Inspect unit condition for any wear or damage that might impact performance. Be particularly wary of damaged collar material and questionable canister integrity. Carefully examine the condition of exposed antennas. Do not redeploy the unit when there is damage or excessive wear.
- Wireless data transfer links should be tested to ensure they are performing correctly and successfully transferring data. GPS-Argos, GPS-Globalstar, and GPS-Iridium systems should be tested through the satellites and GPS-SST systems should be tested on the air.

This list of considerations is not necessarily exhaustive since some redeployment issues are dependent on details specific to the previous deployment. If you have any concerns about the readiness of the system for redeployment, please contact Telonics for assistance.

7 Special Considerations for Specific Applications

Telonics works extensively with researchers to provide appropriate attachment mechanisms. When placing an order, the customer selects from several options appropriate to the species under study. The customer must also be careful to handle all attachment equipment properly and avoid inappropriate modifications. This section of the manual addresses these considerations.

7.1 Collars for Terrestrial Mammal Applications

General Suitability: Most GPS systems deployed on terrestrial mammals are in collar-mounted configurations. When you receive your order, you should examine the final configuration prior to deployment on the animal to assure the suitability of the configuration. Our engineers and biologists work in conjunction with users to try to produce configurations that are suitable to the animal and do not impact normal behavior or fitness; however, in the final analysis it is the end user who determines whether or not the unit is suitable for deployment.

Antenna Issues: Collar configurations use multiple antennas. GPS-SOB systems have a GPS antenna and a VHF antenna. GPS-Argos, GPS-Globalstar, and GPS-Iridium systems have separate GPS, VHF, and satellite-uplink antennas. (Some GPS-Argos configurations share a single antenna for both Argos and VHF transmissions). GPS-SST systems have a GPS antenna, a VHF antenna, and an internalized SST antenna (often not visible) integrated on the end of the instrument package. Antennas are optimized for performance on the animal and modifying antennas may have an impact on system performance. Telonics suggests that you consult with the factory before modifying any antenna structure.

In these configurations, the GPS antenna is usually a patch antenna encased in a water–resistant, high-impact plastic housing. The user provides an approximate neck circumference at the time of order and agrees to a midpoint and adjustment range for the collar. Telonics then designs the collar so that the GPS antenna will be on the dorsal surface of the animal's neck at the midpoint of the adjustment range. A limited adjustment range of +/- 2.5 inches allows the collar to be adjusted to the neck and still have the antenna generally pointed toward the sky for good signal reception. Modifying the adjustment range by punching more holes to make the collar smaller or adding spacers that make the collar larger can result in a reduction or elimination of the GPS antenna's ability to receive signals from the GPS satellite constellation and obtain GPS fixes. These modifications can also stress the cable connection to the GPS antenna and cause a failure to the cable connection for the GPS antenna.

The VHF antenna is typically a multi-stranded stainless-steel cable. Some portion of this antenna (1-6 inches) is typically exposed to enhance VHF signal radiation. If the antenna interferes with normal animal behavior, this antenna may be cut shorter recognizing there will be a reduction in the VHF range. Telonics also recognizes that the external portion of the antenna may fatigue and break over time during the deployment. In the case of a VHF antenna this will reduce the range of the VHF component of the system. In some GPS-Argos systems the VHF antenna is combined with the Argos antenna and those configurations the length of the antenna should not be modified or the uplink to the satellite maybe lost.

Because there are many antennas integrated into the collar, do not place metallic tags or apply paints containing metallic particles to these collar configurations. Depending on the material selected, color-coded sheathes may also disrupt transmissions. If you have any questions, please consult the factory before adding any of these materials to the collar configuration.

GPS Signal Reception and Interference: Since GPS receivers are subject to signal interference, Gen4 systems suspend VHF and satellite transmissions while the unit attempts to obtain a position fix. Do not deploy any other independent VHF transmitter or electronic device not controlled by the Gen4 system on the subject animal without consulting the factory. Other electronics deployed on the subject animal may disrupt the performance of the GPS receiver.

7.2 Marine Animal Applications

Several different attachment configurations are available for marine applications. These configurations include:

- Backpack and head-mounted configurations for pinnipeds
- Backpacks and towed buoys for sea turtles
- Towed buoys for Manatees and Dugongs (Sirinians)
- Towed buoys for some large cetaceans
- Dorsal-fin mounted units for some smaller cetaceans that can be captured and handled

Due to the difficulty in recovering tags from many marine animals, most marine applications use GPS-Argos systems and rely heavily on data transmitted via Argos DCLS.

Marine configurations are designed to present a streamlined form to minimize hydrodynamic drag.

Marine units typically use an external whip antenna for the Argos transmitter. The whip antenna is designed to be above the water surface when the SWS detects surfacing.

The GPS antenna is typically internal to the housing. When gluing the unit to fur or mounting the unit on the animal, use only nonconductive materials. Do not cover or reduce the surface area of the SWS or the GPS antenna as these actions may compromise performance. If questions arise about the suitability of any adhesive material or the placement of the material, please contact Telonics before applying the material.

The VHF transmitter is not always used in Marine applications. When the VHF transmitter is used, the antenna is shared with the Argos transmitter. The VHF transmitter is not suspended when the SWS detects that the unit is underwater.

GPS Signal Reception and Interference: Since GPS receivers are subject to signal interference, Gen4 systems suspend VHF and Argos transmissions while the unit attempts to obtain a position fix. Do not deploy any other independent VHF transmitter or electronic device not controlled by the Gen4 system on the subject animal without consulting the factory. Other electronics deployed on the subject animal may disrupt the performance of the GPS receiver.

7.3 Oceanographic Buoys, Meteorological Balloons, and other Payload Recovery Applications

Gen4 GPS systems used in these applications are typically supplied to the user as electronics-only models (e.g., TGE-400 and TGE-401). The models are designed as components to be integrated into the user's application or experiment. Because of the diversity of user applications and the specificity of the requirements for peripherals, many users supply their own battery packs, appropriate cabling/connectors, and antennas designed for their specific application. However, Telonics can supply some of these peripherals as items purchased separately from the GPS system. Please consult with the factory if you require peripherals. Mechanical outline drawings for these models and a connection diagram showing the TGE-401 and peripherals are provided in Appendix 5.

The TGE-400 and TGE-401 are sealed in a hermetic housing that protects the electronics from moisture. Note that the peripherals may require their own waterproof packaging or incorporation into an external waterproof housing and this packaging is a user's responsibility. Also note that the TGE-4xx series are not suitable for high-pressure applications (systems that are subjected to depths of greater than 100 ft). For high-pressure applications the units must be contained pressure-proof housing provided by the user.

The user is also responsible for supplying the appropriate battery pack(s). The specifications provided in Appendix 1 for the TGE-4xx series provides details of the current and voltage requirements. The user should consider the temperature environment where the unit is deployed when designing the battery pack(s) for the GPS system. When the user has selected the battery pack(s) and established their capacities, TPP's simulator can help you estimate the operational life of the system. Remember the estimates provided by TPP will only be as good as the data characterizing the battery pack(s).

When integrating the antennas used with the TGE-4xx series, an understanding of basic antenna theory and practical experience concerning antenna deployment are assumed. In general, users should not deploy antennas next to other conductive materials like metal surfaces or other antennas which could cause detuning and alter the radio frequency (RF) radiation pattern of the antenna. Coaxial cabling (50 Ω impedance) should not be crimped or distorted in the deployment.

8 Recovering and Converting Data using Telonics Data Converter (TDC)

8.1 Overview Telonics Data Converter (TDC)

Telonics Data Converter (TDC) converts raw data from Telonics Gen4 GPS Systems into data reports formatted as comma-separated values (.csv). TDC generates report data using standard engineering units and associates it with the time of its acquisition. TDC reports open in any spreadsheet program, such as Microsoft Excel, and can be processed by custom software.

TDC provides different functionality depending upon which GPS system technology is being used.

GPS-SOB Systems

- Download, convert and create reports from the datalog memory. Note that TDC does not use TPF files to process datalog memory because datalog files contain the same programming information that is stored in the TPF file.
- Create files compatible with Google Earth so that you can map transmitter locations interactively.
- Erase the datalog from a unit

GPS-Argos Systems

- Download, convert and create reports from the datalog memory. Note that TDC does not use TPF files to process datalog memory because datalog files contain the same programming information that is stored in the TPF file.
- Erase the datalog from a unit
- Download the parameters (TPF) from a GPS-Argos unit
- Maintain a list of your Argos transmitters
- Convert and create reports from Argos files in Full DS format. TPF files are used by TDC to extract, process, and time stamp data recovered from Argos DS files.
- Use TDC in batch mode to convert Argos data without user intervention.
- Log files or take existing log files from a TSUR-400 and then convert and create reports.
- Create files compatible with Google Earth so that you can map transmitter locations interactively.
- Convert and create reports in real time from TSUR-400 Uplink Receiver directly connected to the PC

GPS-Globalstar Systems

- Download, convert and create reports from the datalog memory. Note that TDC does not use TPF files to process datalog memory because datalog files contain the same programming information that is stored in the TPF file.
- Erase the datalog from a unit.
- Download the parameters (TPF) from a GPS-Globalstar unit.
- Maintain a list of your Globalstar transmitters.
- Retrieve emails from Globalstar containing transmissions from GPS-Globalstar systems or downloads data directly from the Telonics Server.
- Convert and create reports from data recovered via Globalstar. TPF files are used by TDC to extract, process, and time stamp the data transmitted by the GPS-Globalstar system.
- Use TDC in batch mode to convert Globalstar data without user intervention.
- Create files compatible with Google Earth so that you can map transmitter locations interactively.

GPS-Iridium Systems

- Download, convert and create reports from the datalog memory. Note that TDC does not use TPF files to process datalog memory because datalog files contain the same programming information that is stored in the TPF file.
- Erase the datalog memory in a GPS-Iridium system.
- Download the parameters (TPF) from a GPS-Iridium system.
- Maintain a list of GPS-Iridium systems.
- Downloads emails containing transmissions from GPS-Iridium systems or downloads data from the metOcean telematics LiNC server.
- Convert and create reports from Iridium data. TPF files are used by TDC to extract, process, and time stamp data recovered via Iridium.
- Use TDC in batch mode to convert Iridium data without user intervention.
- Create files compatible with Google Earth so that you can map locations interactively.

GPS-SST Systems

- Download, convert and create reports from the datalog memory. Note that TDC does not use TPF files to process datalog memory because datalog files contain the same programming information that is stored in the TPF file.
- Maintain a list of SST units, including the connection settings and download preferences for each unit.
- Download data over the spread-spectrum link and display statistics about the link.
- Convert the data downloaded over the spread-spectrum link and create reports.
- Create files compatible with Google Earth so that you can map locations interactively.
- Erase the datalog from a unit.

8.2 Basic Requirements for Installing and Using TDC

The user's personal computer or laptop must have the following capabilities:

- Microsoft Windows 2000/XP/Vista/7 with Internet Explorer version 5.5 or newer.
- Display: 800 x 600 or greater, 256 colors or more
- RAM: 32 MB available; large data conversions require more memory
- Active Internet connection to convert QFP data
- Available USB port

In addition, the following software and hardware must be obtained from Telonics:

- Current version of TDC (available on the Telonics website)
- Authorization code purchased from Telonics
- Telonics Active Smart Cable, model TSC-7[5]
- CN008351-001,CN007494-001, or CN006313-001 adapter (as needed)
- Telonics SST-901M RF Modem for downloading from GPS-SST systems over the wireless link

[5] A model TSC-4 smart cable is also acceptable, as is the older model TSC-3 (serial port instead of USB).

8.3 Obtaining an Authorized Version of TDC

The first step in handling data from a GPS System is to download the current version of TDC from the Telonics website (www.telonics.com). Install the authorization code (purchased separately from Telonics) into TDC to transform the “Demo Version” into an “authorized version” that provides full capabilities. Install the authorization code from the “About Telonics Data Converter” window (listed under the “Help” menu). Check the Telonics website periodically to find updated versions of TDC.

8.4 Recovering Data from Log Memory

The unit must have battery power for TDC to download its log memory. The pulsing of the VHF beacon is a good indication that there is sufficient power to download memory. To recover data files from the log memory of any Gen4 GPS product, connect the TSC-7 Active Smart Cable to the computer.

Connect the other end of the TSC-7 cable to the GPS unit. Sometimes the connection to the unit requires a special adapter to interface to the unit. Consult the help section of TDC for pictures of the physical connections to various models and to determine which adapter is appropriate for your configuration. To download log memory, TDC uses the same connections, cables and adapters that TPP uses to program the unit.

Configurations that are sold with battery packs (e.g., animal configurations) generally require two connections: a programming pin and a ground connection. The location of these two connections varies for different configurations. The ground connection on most configurations is a small metal loop coming out of the housing. The programming pin on GPS-Argos systems is usually on the tip of the Argos antenna. The programming pin on GPS-SOB and GPS-SST systems is usually on the tip of the VHF antenna. Some Marine configurations have the programming pin on the saltwater-sensor terminals.

For electronic-only configurations (e.g., oceanographic and meteorological models TGE-400/401), simply use a BNC/SMA connector to connect the TSC-7 cable to the Argos antenna. Be sure that the battery system is applying power to the unit before retrieving log memory.

For all configurations, be sure that the magnet is applied before attempting to communicate with the unit

To download log memory using TDC:

1. Make sure that the Smart Cable is connected to the transmitter and to the PC. Also, be sure that the magnet is attached to the transmitter.
2. From the Main Menu in TDC, select "Download Datalog..." under the Unit menu.
3. Select the Port where the Smart Cable is connected.
4. Press the Browse Button and then choose a name for your datalog file.
5. Press the Start Button to begin downloading your datalog. After a few minutes, the Results field will indicate the approximate time remaining to complete the datalog download.
6. After downloading the datalog, TDC will display the option to convert the datalog (if it is not busy converting other data).
7. Once TDC has finished downloading the datalog, press the Close button to close the Download Window.

Additional information on the download process is available in the help section of TDC

8.5 TDC Reports

TDC reports are customized to the GPS system, model, programming parameters, and data source. Each TDC report presents the appropriate data and omits columns that do not apply. For example, TDC reports do not include columns for sensors that have not been selected. Data contained in the TDC reports are time stamped and generally proceed through time from the start of the deployment (rows of oldest data) to the end of the deployment (rows of most recent data). The report is organized based on the collection time of the data rather than the transmission time of the data through the data-transfer system.

When using **GPS-SOB systems**, users get data from only one source: the log memory. Since most users download the log memory only one time (after recovering the system), TDC typically generates a single report that contains the complete dataset.

When using **GPS-SST systems,** users can retrieve data from the SST data-transfer link or from directly downloading the log memory after recovering the system. Data downloaded over the SST link is identical to the data downloaded directly from log memory. When using the SST link, users can elect to download all data, only new data, or data collected within a certain date range.

When using **GPS-Argos systems**, users may receive data from multiple sources. Users can receive data from Argos DCLS, log memory from recovered units, TSUR-400 uplink receivers, and Local User Terminals (LUT).

During deployment, users receive Argos DS files from Argosweb or email attachments. TDC can process multiple DS files at once; however, most users choose to convert DS files as soon as they receive them. TDC can be configured to generate a new report for each DS file or append data to an existing TDC report. In addition to including transmitted GPS positions and sensor data, TDC reports also show Argos Doppler positions.

If the user recovers the GPS-Argos system, the user can download log memory to provide another source of data. The log memory provides all GPS positions and sensor data with full resolution, even if the data has limited resolution when transmitted to Argos. Since the log memory provides a complete set of GPS positions and sensor data, the datalog report can serve as a backup and help fill in the data gaps that can occur when the unit is unable to transmit all data through the limited bandwidth of Argos. Since Argos and datalog reports each contain some information that does not appear in the other report, users must review both reports to obtain the complete data set. TDC does not merge the data from multiple data sources. The user must review reports manually or provide custom software to analyze the reports from different data sources.

When using **GPS-Globalstar systems,** users receive data in email from Globalstar or by having Globalstar route data automatically to the Telonics server. When using email, Telonics Data Converter typically retrieves and processes Globalstar email directly, bypassing any e-mail client program (like Outlook). However, Telonics suggest configuring the service from Globalstar to automatically route incoming data to the Telonics server, where TDC can more easily pick it up. TDC can be configured to generate a new report or to append new data to an existing report when new data arrives from the Globalstar satellite network.

If the user recovers the GPS-Globalstar system, the user can download log memory to provide another source of data. The log memory provides all GPS positions and sensor data with full resolution, even if the data has limited resolution when transmitted to Globalstar. Since the log memory provides a complete set of GPS positions and sensor data, the datalog report can serve as a backup and help fill in the data gaps that can occur when the unit is unable to transmit all data through the limited bandwidth of Globalstar.

8.6 Interpreting a Sample TDC Report for Log Memory

This section provides a sample TDC report from converted log memory. Note that the report organizes data by the time of its acquisition. The report covers the time period from 00:00:00-02:03:00 and includes GPS positions, activities, and temperatures.

The Acquisition Time and Acquisition Start Time columns show when measurements or positions were taken. For accumulated data types such as activity counts, these columns show the time period over which the unit accumulated the data.

The GPS Fix Attempt column indicates whether a successful GPS fix is a 2D or 3D fix.

The Predeployment Data column shows whether or not the row contains data from predeployment.

The other columns specify the actual data measurements or positions. Note that the report also specifies the following information for each data column: units of measurement, data resolution (when the unit needs to compress data for Argos transmissions), and the minimum and maximum values that may appear in the column.

This sample report omits columns for UTM Coordinates, GPS Speed, GPS Heading, Satellite Bitmap, and Errors so that the report fits on a single page. The sample report also displays several columns with reduced widths, which truncates the titles of some columns. The help system of TDC provides a complete list of all columns and a description of each column. The Telonics Data Converter webpage has links to download sample reports (CSV files) that do not omit columns or truncate titles. Go to www.telonics.com and click software to access the webpage for TDC.

Telonics Data Report										
CTN	000001A									
Comment	Sample Report									
Measurement Units			degrees	degrees	meters	meters			degrees C	
Resolution										
Range Minimum			-90	-180	-535	0		0	-40	
Range Maximum			90	180	65000	655.35		65535	70	
Acquisition Time	Acquisition Start Time	Fix Attempt	GPS Latitude	GPS Longitude	Altitude	Horizontal Error	Positional Dilution	Activity	Temperature	Predeployment
2008.12.02 00:00:00	2008.12.02 00:00:00								15	No
2008.12.02 00:00:32	2008.12.02 00:00:00	Succeeded (3D)	33.384148	-111.811013	342	4.63	1.8			No
2008.12.02 00:30:00	2008.12.02 00:30:00								15	No
2008.12.02 01:00:00	2008.12.02 00:00:00							2045		No
2008.12.02 01:00:00	2008.12.02 01:00:00								14	No
2008.12.02 01:00:25	2008.12.02 01:00:00	Succeeded (2D)	33.384352	-111.811201	380	56.15	17.2			No
2008.12.02 01:30:00	2008.12.02 01:30:00								14	No
2008.12.02 02:00:00	2008.12.02 01:00:00							958		No
2008.12.02 02:00:00	2008.12.02 02:00:00								14	No
2008.12.02 02:03:00	2008.12.02 02:00:00	Failed								No

8.7 Interpreting a Sample TDC Report for Argos, Globalstar, or Iridium Data

This section provides a sample report from TDC for a GPS-Argos system. Note that the report organizes data by the time of its acquisition. The report covers the time period from 00:00:00-01:08:21 and includes an Argos location, GPS position, activity, and temperature. Note that for GPS-Globalstar systems, the columns containing Argos location data do not appear, and "Argos ID" is replaced by "Globalstar ESN". Note also for GPS-Iridium systems, columns containing Argos location data are replaced by columns containing Iridium location data, and "Argos ID" is replaced by "Iridium IMEI".

The Acquisition Time and Acquisition Start Time columns show when measurements or positions were taken. For accumulated data types such as activity counts, these columns show the time period over which the unit accumulated the data.

The GPS Fix Attempt column indicates whether a GPS fix attempt succeeded or failed. Note that when processing Argos data, TDC cannot determine whether a successful GPS fix is a 2D or 3D fix.

The Satellite Uplink column lists "Hit" if the row represents the time that a satellite transmission is received. The actual data extracted from this transmission is listed in separate rows throughout the report (ordered by acquisition time).

The Predeployment Data column shows whether or not the row contains data from predeployment. Some predeployment data may appear at the end of the report with blank acquisition times since TDC is unable to determine acquisition times during predeployment.

The Error column identifies CRC errors and other data errors.

The other columns specify the actual data measurements or positions. Note that the report also specifies the following information for each data column: units of measurement, data resolution (when the unit needs to compress data for satellite transmissions), and the minimum and maximum values that may appear in the column.

This sample report omits columns for Argos Altitude, Fix Time, UTM Coordinates, Receive Time, Satellite Name, and Repetition Count so that the report fits on a single page. The sample report also displays several columns with reduced widths, which truncates the titles of some columns. The help system of TDC provides a complete list of all columns and a description of each column. The Telonics Data Converter webpage has links to download sample reports (CSV files) that do not omit columns or truncate titles. Go to www.telonics.com and click software to access the webpage for TDC.

Telonics Data Report												
CTN	000001A											
Comment	Sample Report											
Argos ID	99998											
Measurement Units			degrees	degrees		degrees	degrees		degrees C			
Resolution						0.000043	0.000043					
Range Minimum						-90	-180	0	-40			
Range Maximum						90	180	65535	70			
Acquisition Time	Acquisition Start Time	Argos Loc	Argos Lat	Argos Lon	Fix Attempt	GPS Latitude	GPS Longitude	Activity	Temperature	Satellite	Predeployment	Error
2008.11.08 00:00:00	2008.11.08 00:00:00								24		No	
2008.11.08 00:00:32	2008.11.08 00:00:00				Succeeded	33.384005	-111.811002				No	
2008.11.08 00:30:00	2008.11.08 00:30:00								23		No	
2008.11.08 01:00:00	2008.11.08 00:00:00							2045			No	
2008.11.08 01:00:00	2008.11.08 01:00:00								23		No	
2008.11.08 01:05:01	2008.11.08 01:05:01	A	33.381	-111.808						Hit	No	
2008.11.08 01:08:21	2008.11.08 01:08:21									Hit	No	CRC

8.8 Interpreting a Sample TDC Report including Quick Fix Pseudoranging (QFP) Data

Telonics Gen4 GPS Systems use a rapid-fix technology called Quick Fix Pseudoranging (QFP) in all applications on marine mammals and sea turtles. QFP is also an option that can be requested on other Gen4 GPS systems.

This sample report (from the Telonics Data Converter software) is for a marine GPS-Argos system. Data is organized by the time of its acquisition. The report covers the time period from 18:00:00-22:03:50 and includes the following types of data:

- Argos positions and location classes. [GPS-Argos systems only.]
- GPS positions taken every hour. The Fix Attempt column identifies whether these positions are standard GPS or GPS-QFP.
- Dive data accumulated over each hour.

The Acquisition Time and Acquisition Start Time columns show when measurements or positions were taken. For accumulated data types such as dive counts, these columns show the time period over which data was accumulated.

The remaining columns specify the actual data measurements or positions. Note that the report also specifies the following information for each data column: units of measurement, data resolution (when the unit needs to compress data for Argos transmissions), and the minimum and maximum values that may appear in the column.

This sample report omits columns for Argos Altitude, GPS Altitude, Fix Time, UTM Coordinates, DOP, Satellite Bitmap, Receive Time, Satellite Name, and Repetition Count so that the report fits on a single page. The sample report also displays several columns with reduced widths, which truncates the titles of some columns. The help system of TDC provides a complete list of all columns and a description of each column. The Telonics Data Converter webpage has links to download sample reports (CSV files) that do not omit columns or truncate titles. Go to www.telonics.com and click software to access the webpage for TDC.

Telonics Data Report												
CTN	000003A											
Comment	Sample Report											
Argos ID	99997											
Measurement Units			degrees	degrees		degrees	degrees		dives	Hit	Yes/No	
Resolution						0.000043	0.000043	0.782%				
Range Minimum						-90	-180	0.000%	0			
Range Maximum						90	180	100.000%	127			
Acquisition Time	Acquisition Start Time	Argos Loca	Argos Latit	Argos Long	Fix Attempt	GPS Latitude	GPS Longitude	Underwater	Dive Count	Satellite	Predeployment	Error
2008.10.01 18:03:05	2008.10.01 18:00:00				Succeeded	10.000001	-31.150425				No	
2008.10.01 19:00:00	2008.10.01 18:00:00							39.100%	20		No	
2008.10.01 19:02:31	2008.10.01 19:00:00				Resolved QFP	10.001255	-31.150432				No	
2008.10.01 20:00:00	2008.10.01 19:00:00							31.280%	23		No	
2008.10.01 20:01:38	2008.10.01 20:00:00				Resolved QFP	10.002005	-31.151002				No	
2008.10.01 20:03:50	2008.10.01 20:03:50	A	10.003	-31.151						Hit	No	CRC

9 GPS-SOB Systems

GPS-SOB (Store-On-Board) systems combine a GPS receiver with a nonvolatile data log memory. Different models are equipped with various sensors for collecting data that can be associated with the GPS positions. A programmable VHF beacon transmitter is onboard for tracking and recovering the system. These units must be recovered in order to make a physical connection to download data as there is no other data-transfer component. Downloading data is achieved by connecting the unit to a PC or laptop and using Telonics Data Converter (TDC) software.

9.1 Initialization Procedure for GPS-Store-on-Board Systems

1. Before starting the initialization process, ensure that the unit has a clear view of the sky and is physically separated from other units by at least 10 meters.
2. Tune your VHF receiver to the VHF beacon frequency for the unit being initialized.
3. If the magnet is not already applied, apply the magnet until the VHF beacon stops transmitting (usually about 15 - 30 seconds).
4. Remove the magnet and start a stopwatch so that the time required for events below can be recorded.
5. After 5 – 10 seconds, the VHF beacon generates a double pulse (beep) and then stops transmitting. A GPS position fix attempt is now underway.
6. Wait for the VHF beacon to start transmitting again. VHF beacon transmissions will resume in 15 seconds to 2 minutes.
7. Evaluate the results of the initialization attempt by listening to the pulse (beep) pattern of the VHF beacon. The beacon will be transmitting the pattern until the end of the first update period. The initialization status patterns are:

   Successful Initialization

   A 2-beep pattern (beep beep – pause – beep beep – pause – etc.) indicates a successful initialization. This unit is now ready for deployment in its current geographic area.

   Unsuccessful Initialization

   a. A 3-beep pattern (beep beep beep – pause – beep beep beep – pause – etc.) typically indicates that the unit could not obtain a GPS position even though a full attempt was made to do so. Be sure the unit has a clear view of the sky and then retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.
   b. A 4-beep pattern may indicate a serious problem with the unit. **Do not deploy the unit.** Reapply the magnet to the unit, and contact Telonics for assistance.
   c. A single-beep pattern (beep – pause – beep – pause – etc.) means the battery that powers the GPS and data-transfer components of the system is dead or possibly recovering from a period of extended storage. The pulse period in this condition will correspond to programmed period for "dead battery" provided in the TPF record. Retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.

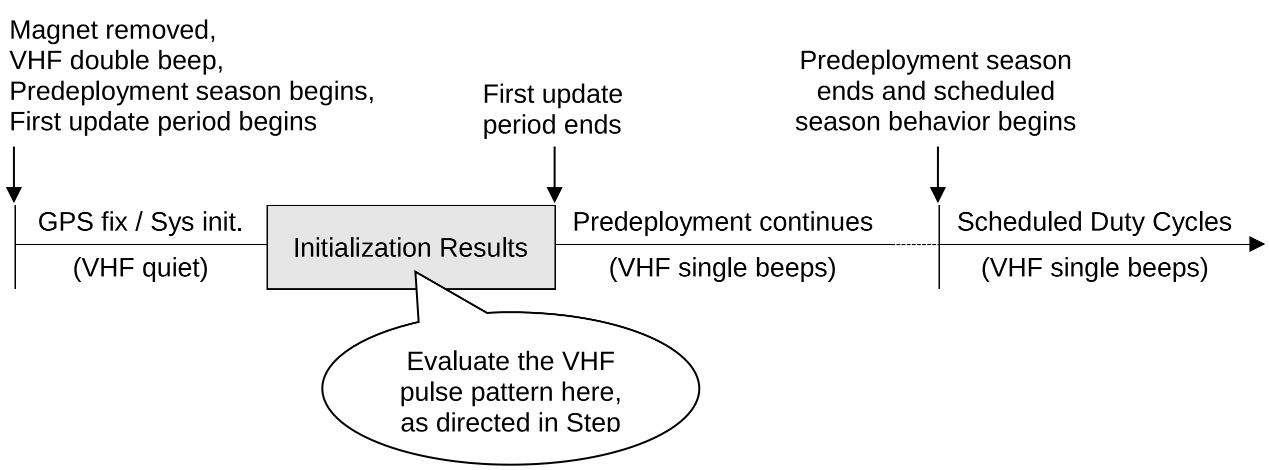


Figure 1: Standard Initialization Timeline for GPS-SOB Systems

9.2 System Tests

VHF Range

The units should be tested to evaluate the performance of the VHF beacon with the receiving equipment that will be used to monitor the beacon during the study. When evaluating the test results, be aware that VHF range performance can vary dramatically. The VHF beacon on the unit, the receiving equipment, and the surrounding environment all affect the actual VHF range. The typical range performance from a collar mounted unit is 1-3 km when monitored from the ground and 10 + km when monitored from the air. A range performance of only a few hundred meters would tend to indicate a problem, so be sure to consult Telonics before deploying any units with severely limited VHF range.

10 GPS-Argos Systems

The Gen4 Argos Transmitter relays data collected by the unit to satellites in orbit. The transmitter follows a user-defined schedule and relays sensor data specifically selected by the user. The transmitter can optionally compress data in the uplink messages to increase the amount of study data conveyed. The transmitter can also optionally transmit only during satellite overpasses.

10.1 Brief Overview of the Argos and SCD Systems

Argos

Argos is a data collection and location system (DCLS) carried on-board near-polar orbiting satellites with global coverage. The Argos system is operated by Collection and Location Services (CLS) and is chartered to provide services for environmental research. Use of the system requires program approval by CLS. CLS is responsible for issuing ID codes for transmitters used on the system. Four to six satellites Low Earth Orbiting Satellites (LEOs) carry the Argos receiver-processor package. Typical satellite overpass times are 2-15 minutes in length. Maximum Argos messages are 31 or 32 bytes in length and can only be repeated at repetition rates of 40 - 200 seconds. The result is that there is limited bandwidth for data transfer. CLS recovers, processes, and delivers data to users. In addition to recovering the GPS and sensor data uplinked by the GPS-Argos units, Argos also provides Doppler-derived positions. CLS charges a fee for using their system. Please refer to the CLS and Argos websites for more-extensive technical information:

http://www.argos-system.org/
http://www.clsamerica.com/
http://www.cls.fr/welcome_en.html

SCD

The SCD (Satelite de Coleta de Dados - Data Collection Satellite) is a Brazilian satellite operated by Instituo Nacional de Pesquisas Espaciais (INPE) is often viewed as a complimentary system to Argos. The system has historically been used for collecting meteorological data throughout the country of Brazil. The SCD system has limited data-dissemination services, forcing users to process data that is in a very raw format. As a result, the SCD system has not historically been used as extensively as the Argos system. Please direct any applications for using the SCD system to INPE.

Users must obtain a thorough understanding of the Argos DCLS system or SCD system capabilities and limitations to successfully program and operate the Gen4 GPS-Argos transmitter.

10.2 Gen4 GPS-Argos System Overview

The Telonics Gen4 GPS-Argos system uses a new generation of Argos-transmitter technology. These systems are highly configurable and the following settings are under software (TPP) control:

- Transmitter frequency. The Argos transmitter is frequency agile and can be programmed in 1 kHz.steps over the full Argos frequency range from 401.630-401.680 MHz. The transmitter also supports the full SCD frequency range from 401.618-401.622 MHz in 500 Hz steps. Argos requires that the transmitter frequencies be distributed over the frequency band to minimize interference between transmitters. As a general rule, the Argos center frequency (401.650 MHz) should be avoided to minimize competition with a large number of Argos transmitters already deployed and operating at that frequency. Be aware that noise sources in Mongolia, China, and the Mediterranean have sometimes disrupted Argos transmissions in those regions. Argos currently does not provide any specific frequency recommendations to avoid this disruptive noise. After learning more about the noise sources responsible for the interference, Argos may be able to recommend certain frequencies that minimize transmission problems.

- Transmitter power level. Argos or SCD transmitter power levels. Gen4 systems can be programmed to preset power levels allowing the low level to be used in regions with minimal interference and the high level to be used in areas where interference may be a problem. Standard-power systems have two power levels, 400 mw and 500 mw, that can be selected using TPP. High-power systems designated with an H following the part number (e.g.TGW-4580H) have a single fixed power level of 800 mw.

- ID numbers
- Repetition rates
- Message contents, resolution, and structure.
- Duty cycles and seasonal schedules.
- Transmitting Argos data only during predicting satellite overpasses.

Marine GPS-Argos systems also support the following features:

- Suppression of uplink transmissions during submergence
- Synchronization of transmissions with surfacing
- Optional disabling of GPS and/or Argos functionality when hauled out.

10.2.1 Establishing the Argos Message Content

Each GPS-Argos model contains various sensor options (the sensor, signal processing circuitry, and the firmware) appropriate to that model. Telonics Product Programmer (TPP) can be used to selectively enable sensor data collection and establish a data collection schedule. All or some specifically selected data types can be included for uplink transmission and recovery through the Argos DCLS. All sensor data is also automatically stored in log memory and if the unit is recovered these data can be downloaded and processed using TDC.

Gen4 GPS systems have two options for the format of transmitted data. The systems can transmit "Last N" data and/or "Compressed" data to Argos. “Last N” data represent the classical approach to transmission of Argos data where data are accumulated into the message in specific fields occupying certain bit positions in the message. As the name implies, “Compressed” data is a highly compressed form of the data designed to maximize data density in the Argos uplink message. Contemporary GPS systems often require transfer large volumes of data and are limited by the Argos bandwidth. The information provided below should aid in determining the most-appropriate method and strategy of data transmission for your application. TPP allows you to configure the transmitter's operational parameters (specifically the Argos message contents) to match the research needs. TPP also has a feature that assesses the probability of getting data through the Argos system based on the selections of the user-changeable parameters in the TPF file. If you are programming the system, this tool should be consulted as various scenarios are considered. If Telonics is programming the system for you, these options should have been discussed at time of order.

10.2.2 “Last N” Data

The user may require that certain data are transmitted with each message. Data transmitted in every message are called “Last N” data. Every Argos message from a Gen4 system contains all of the "Last N" data specified in the operational parameters (in TPP). For example, if you configure the Argos message to contain the last-three GPS positions and the last five activity counts obtained, then every message the transmitter sends will include the transmitter's most-recent three GPS positions and most-recent five activity counts. The position data and activity data are laid out in the Argos message as described by the TPF file or record. To extract data from received messages, you can use your own software to split recovered message data into individual fields and scale the data to engineering units (degrees of latitude or longitude, meters of altitude, etc). It will also be necessary to reconstruct the time base to establish the time at which the data were collected. This process can be very complicated particularly when there are complex duty cycles and/or extended “off” times. Alternatively, Telonics Data Converter (TDC) can be used to recover the data and the time base. TDC simplifies the process and is recommended for extracting Last N data.

Unfortunately “Last N” data take up a lot of message space and getting more data through Argos’ limited bandwidth requires alternative techniques to compress the data. To maximize data throughput, keep the amount of “Last N” data to a minimum so the remaining message space is available for compressed data.

Telonics has established a “Simple GPS Format”, described in section 10.12, for users who require only a small amount of data to be transferred.

10.2.3 Compressed Data

When the Argos message is configured to include any data described as "compressed", every Argos message from your Gen4 system contains exactly one "page" of compressed data. Using pages, more data can be contained in an Argos message than by using “Last N” data. Using compressed data also increases the chances of getting any given data set through the Argos system.

To extract data from these compressed pages, the user must import the data into Telonics Data Converter (TDC) to decompress the data and reestablish the time base. Processing compressed data with user software instead of TDC is not practical and is not supported by Telonics.

Using compressed data, there may be several pages of data with each page containing different types of data. For example, there would be a separate page for GPS positions, temperature, activity, and dive data. Using this approach, one message may hold a page with the most-recent six GPS locations and the next message may hold a page containing the last nine activity counts. Another message may hold a page carrying six GPS locations from yesterday. A single page holds only data pertaining to its page type, and the amount of data in the page depends on its size and compressibility.

The unit keeps a group of the most-recent pages ready for transmission and chooses which page to transmit using a strategy that maximizes the chances of every page getting through. Please be aware that while this strategy maximizes the chances of data being successfully uplinked, it can also cause delays in data recovery and even temporary “gaps” in the recovered data. Users must be patient and allow the system plenty of time to uplink the data and to fill any recent data gaps. In some configurations the group of recent pages ready for transmission contains study data covering the previous two or three weeks or more.

While the unit is collecting data for a new page, the data are held in a "partial page". Partial pages hold the most-recently collected data, but the amount of data in partial pages varies. As an example, a partial GPS page may have only one location in it, or it may have six locations.

Gen4 systems based on μGPSI-20 electronics can optionally transmit partial pages. When the user selects transmission of partial-page data, the system alternates between transmitting a partial page and a "full" page from the group of most-recent pages. Transmission of partial pages provides a higher probability of acquiring the very recent data at the penalty of reducing data throughput. To maximize the chances of recovering all the data from the Argos link, partial pages should be turned off. To improve the chances of recovering the most-recent GPS position quickly, partial pages should be turned on. When a user actually recovers the data is still dependent on the Argos transmission duty cycle, but sending the partial page will help the user obtain more recent GPS positioning which in turn can help the user find the Gen4 system.

Gen4 systems based on μGPSI-22 electronics (and newer) do not transmit partial pages of non-GPS data. Additionally, these newer systems provide greater flexibility for transmitting the partial page of GPS positions. The options include transmitting the partial GPS page:

- on a periodic basis
- in every other message if the unit is in the mortality mode
- on a user specified basis

Note that TPP presents these options as different ways to transmit the most-recent GPS position instead of using the term “partial page”. The options in TPP provide greater flexibility for choosing when the unit should transmit the most-recent GPS positions. Additional information on these programming options can be found in the help system for TPP.

10.3 Establishing Argos Transmission Schedules

Gen4 GPS-Argos systems can use three transmission strategies to reduce energy consumption, extend operational life of the system, and provide the most efficient data transfer. First, Gen4 systems can be programmed prior to deployment to transmit during specific periods of time ("on" periods of the duty cycle) when there is a high frequency of satellite overpasses for the expected deployment location. Second, Gen4 GPS-Argos systems are able to use on-board satellite overpass predictions and the most-recent GPS location to determine when a satellite overpass is occurring. This option can further reduce energy consumption by transmitting only during a limited transmission window when there is a satellite in view at the most recently obtained GPS position of the unit. The unit can be configured to use one or both approaches at the direction of the user. The third approach is a special case and has been developed for systems deployed a fixed sites or on units where there is little chance of substantial movement (more than 100 miles). For these studies, the unit may optionally predict overpasses over a fixed location instead of using the most-recent GPS location. Using this option, the unit assumes that the specified position is correct for the entire deployment.

10.3.1 Transmitting Argos Data on Fixed Schedules

When using a simple duty cycling without on-board satellite overpass predictions, the user specifies an expected location of the unit for either the entire study duration or for specific time segments of the study. TPP can be used to obtain the ephemeris data and then calculate satellite-overpasses for the specified location(s). TPP can then be used to manually schedule transmission "on" periods during intervals that have a high frequency of overpasses and program the unit with the selected duty cycles. The unit follows this established schedule of "on" periods and "off" throughout the deployment or for selected time periods. This typically results in "on" and "off "periods of several hours (e.g., 6 hours "on" and 42 hours "off"). The scheduled duty cycle is used in the simulator section of TPP to calculate the operational life of the unit. Note, that the cumulative view of all the satellites during the "on" period(s) may be 10% - 20% of the "on" period. While this approach is much more efficient than transmitting continuously, the unit still makes many Argos transmissions when there are no satellites in view.

10.3.2 Transmitting Argos Data only during Satellite Overpasses

Gen4 GPS-Argos Systems are able to predict Argos satellite overpasses for the last GPS location obtained by the system. Using this technique, uplink transmissions can be limited to times when there are satellites in view thereby reducing the energy consumption of the system. Since Gen4 systems do not receive confirmation when satellites successfully receive a message, units must transmit the same message several times to have a high probability of successful data transfer. Transmitting data only during times when a satellite is overhead results in a more-efficient transfer of data through the Argos DCLS system.

Gen4 GPS-Argos systems can use "Argos" satellite ephemeris data and the position of the unit provided by the last GPS position fix to determine the orbital path of the satellites carrying the Argos DCLS package. This approach can further restrict the transmissions to times when the satellite in view at the location of the unit and within an "on" period. This approach saves power, but there are currently some limitations. Some satellites carrying the Argos DCLS packages do not have stabilized orbits, so the unit must actually transmit for a short time before and after each predicted satellite overpass to account for this uncertainty. As the satellite ephemeris ages, the uncertainty increases and the unit's transmission windows are automatically expanded by the firmware in the unit. Units deployed with older ephemeris will transmit for a longer time before and after each satellite overpass as compared to a unit with current ephemeris, reducing battery life. A unit that has been deployed for 7-9 months must open the transmission windows substantially (this is done by the unit automatically based on the age of the ephemeris) to make sure the transmissions occur during the overpass. Note that the "on" period is not expanded simply the transmission windows for the predicted overpass. At some point after this time, the transmission windows are expanded to the point where the unit is transmitting throughout most of the programmed "on" period and satellite prediction no longer significantly reduces energy consumption (as compared to simply using a fixed duty cycle). Therefore, to achieve maximum operational life from the unit using on-board satellite prediction, ephemeris data must be updated by the user (with TPP) or returned to Telonics for updating for all selected satellites if the deployment is delayed and the ephemeris data in the unit is older than 30 days. For detailed instructions on how to use TPP to update the ephemeris data, see section 10.8.

When using the on-board satellite overpass predictions, the simulator in TPP uses the age of the ephemeris and the deployment date to calculate the operational life of the unit. The simulator takes into account the automatic expansion of the transmission windows that occurs over time.

Another limitation occurs if the unit loses the ability to obtain new GPS positions. After a preprogrammed period of time without an updated GPS position, the unit reverts to the selected “on” times prescribed by the programming. If GPS positioning is reestablished, the unit will again follow the on-board derived prediction schedule.

Alternatively, Gen4 systems can predict overpasses over a single fixed position (perhaps in the center of a study area) instead of using the last position provided by the GPS receiver.

Note: The Argos system is by charter expected to support a minimum of two satellites in the constellation. The actual number of commissioned satellites carrying the DCLS package has been increasing over recent years to 5-6 satellites operational platforms. Most users welcome the additional satellite coverage that aids in the transfer of more data through the system and provides a more-even distribution of satellite coverage over a 24 hour period. However, some users may choose to limit the number of satellites used in conjunction with on-board overpass prediction to maximize the operational life of the unit. This choice is supported in TPP and allows further refinement of the data transfer. For details of how specific satellites are selected using TPP and the effect on operational life, refer to the help section of TPP.

10.4 Metering Argos Transmissions to Extend Battery Life

Telonics Argos Transmitters can optionally reduce the amount of energy spent on Argos transmissions by carefully metering them. Using this feature extends battery life and allows more accurate prediction of the end of life.

The metering features, which are described below, work in concert with the Argos Transmission Schedules described above, including the option to transmit only during satellite overpasses. The metering features are not an alternative to the schedules; instead, the metering features serve to limit the number of transmissions during scheduled transmission times.

10.4.1 Transmissions per Metering Period

The user may specify the number of transmissions to be sent during a metering period, and the user also specifies the duration of the metering period. For example, a transmitter could be configured to transmit only 25 transmissions every two hours. In that case, during a scheduled 4-hour “on” period, the transmitter would send only 50 transmissions.

This feature is especially useful in marine applications where the number of transmissions during an “on” period depends on animal behavior -- specifically surfacing behavior. An animal spending an unusual amount of time on the surface or hauled out during an “on” period could easily transmit so many times that the same data are received repeatedly and many of the transmissions are essentially wasted. Under these circumstances, the transmission limit in each metering period provides needed control resulting in power savings that extend operation in the field.

Accumulating Unused Transmissions

If the animal doesn’t spend enough time at the surface, a metering period may end before the allowed number of transmissions has occurred. In this case, the transmitter may optionally accumulate or “bank” the unused transmissions, to be used later. The subsequent metering period would then be allowed to exceed its allotment by the number of accumulated transmissions. The user enables or disables this accumulation feature in TPP. The user may also specify a limit on the total number of accumulated transmissions and on the number of those accumulated transmissions that can be used in any one metering period.

10.4.2 Interleaving "Location-Only" Transmissions

If the transmitter is configured with an Argos message longer than the minimum transmission length allowed by Argos, energy consumption can be reduced by configuring the transmitter to replace some of the longer, data-bearing transmissions with short, "location-only" transmissions. Using TPP, the number of interleaved location-only transmissions can be specified. These location-only transmissions contain no biologically significant data, so this feature is best suited for applications not requiring large amounts of biological data to be recovered via Argos.

For reference, the longest message allowed by Argos requires 920 milliseconds of transmission time, but a location-only transmission is on the air for only 360 milliseconds. Interleaving long and short messages results in a significant savings in transmission power.

10.5 Setting up Argos Processing to obtain correct data files for use with TDC

Telonics has standardized on a specific data file/format as the input file for TDC. Argos has many file structures, and the correct file must be requested from Argos when the user sets up the program. The data file is the input file used for converting Argos raw data to TDC reports. Selecting the wrong file from Argos will defeat the conversion process.

TDC requires the following settings for your ***Argos Technical File***. You may send this information to Argos in place of filling out an Argos Technical file.

- **32 8-bit sensors for Argos IDs less than 32768; 31 8-bit sensors for all other IDs (including new IDs)**
- **Message length is variable (length should not be checked on format)**
- **A1 decimal processing (recommended) or A2 hexadecimal processing**

Data files can be obtained via Argos Direct email, which is recommended, or by downloading data via the ArgosWeb. We recommend obtaining files via email because ArgosWeb stores data for only 10 days.

When requesting Argos Direct email service (recommended), please specify the following options:

- **Select the "DS" data format, which includes all validated locations and all messages collected by all satellites**
- **Select the "Attached text file (.txt)" output format**
- **You may optionally choose to have your data "compressed" to reduce Argos fees**
- **Do not request data encryption**
- **Select email as your delivery option and specify an email address**

When using the ArgosWeb service, select PRV DS for download.

It is extremely important that you make arrangements with Argos as soon as you receive approval for your program and prior to our final “through the satellite testing phase” to receive the correct file/format. Failure to specify the correct files and processing may result in loss of data and delays in shipment of your order from Telonics.

Also be sure to include the following information:

Name of Program Leader, Organization and address with Country, Telephone Number, E-Mail address and the names and phone numbers of any colleagues who are authorized to modify your processing requirements.

10.6 Recovering Data from Argos Data Processing and Dissemination Centers

Satellites receive the transmitted messages from GPS-Argos systems and relay the messages back to ground stations. These ground stations then pass the messages along to Argos Processing Centers around the world. Argos allows the user to recover transmitted messages via direct access on Argosweb or by receiving email attachments. Argos offers numerous data formats, so it is important to get data that is in a format that is compatible with TDC. Users must make arrangements with Argos to receive data in the correct format prior to beginning their studies or data may be lost. See section 10.5 for details.

In addition to delivering the transmitted messages from Gen4 systems, Argos can provide calculated using a Doppler positioning technique that is independent of the GPS system. To obtain the Argos position, several uplink messages must be received by the satellite during the course of an overpass. Doppler positions tend to be less accurate as compared to GPS positions. TDC also presents these Argos positions as part of the output report.

To set up TDC to convert Argos DS files use the procedure below.

1. Organize TPF files.
   Create a folder to hold the TPF file(s). Place the TPF file(s) for your units in this folder.
2. Set Options.
   From the Options Menu, select "File Locations..." to view the Options Window. Set the preferred directory for TPF files and the report destination folder by typing the full path in the provided field. Select a directory by pressing the "Browse" button next to the field. From the Options Window, view different groups of options by clicking the tabs near the top of the window. Once the program options have been determined, press the "OK" button to save the changes.
3. Search for new transmitters.
   From the Argos/Uplink Files tab in the Main Window, press the "Add or Edit Transmitters" button to launch the Transmitters Window. From this window, press the "Add..." button, which causes Telonics Data Converter to search for new transmitters. TDC searches for new transmitters by looking inside each TPF in your preferred TPF directory. Once TDC has finished searching the folder, press the "OK" button to add the new transmitters. If TDC finds multiple TPF files for the same transmitter, activate the desired TPF file by selecting the transmitter and double-clicking the TPF file from the list of available parameters. Press the "OK" button when finished so that TDC will remember these new transmitters.
4. Obtain Data from Argos.
   Obtain Argos data files in the proper format. Please see section 10.5 for detailed instructions on how to obtain properly formatted data from Argos. Create a folder to hold the DS files that you would like to process.
5. Select your Data Source.
   Select the Argos/Uplink Files tab in the Main Window. Press the "Change..." button on the Main window to launch the Select Data Source window. Select the "Argos data in specific folder" choice from the Source drop-down list. Press the "Browse" button to select the folder that holds the unprocessed Argos messages. Press the "OK" button when finished selecting the data source.
6. Convert Data.
   On the Main window, verify that the appropriate transmitters are displayed and checked. TDC can convert data only for transmitters that have active parameters. If a new transmitter has been added and it does not appear on the Main window, then go to the Transmitters window and activate the appropriate parameters. The "Convert" button is disabled if there are no transmitters displayed and checked on the Main window. When ready to convert your data, press the "Convert" button. The time required for TDC to convert source data depends on the size of your source-data files and the speed of your computer. When TDC has finished the conversion, the results section should display the name of the generated report. This file will be located in the report destination folder.

10.7 Recovering Data from a TSUR-400 Uplink Receiver

TDC also supports recovering and converting data from an Argos Uplink receiver. An Uplink receiver is designed to capture Argos uplink messages transmitted from Argos Transmitters.

To convert data from a TSUR-400 Uplink Receiver using TDC:

1. Configure the Uplink Receiver.
   TDC converts messages from uplink receivers that are in normal mode only, so the uplink receiver should not be in diagnostic mode. Do not enable the ID Filter on your uplink receiver, since this feature may inadvertently filter out messages for one of your transmitters. Please refer to the operational manual of the TSUR-400 Uplink Receiver if you need assistance configuring the uplink receiver.
2. Connect the Uplink Receiver to your Computer.

   Connect your uplink receiver to an available serial port on your computer (COM1-COM9) or directly to a USB port, depending on the type of Telonics cable you are using. See the documentation provided with the uplink receiver for more details on connecting an uplink receiver to a computer.
3. Review Transmitters with Active TPF files.
   From the Argos/Uplink tab, click the Add or Edit Transmitters button to display the Transmitters Window. Verify that all of the transmitters to be processed have an active TPF file. One easy way to determine if a transmitter has active parameters is to look at the transmitter list on the left section of the window. Transmitters that do not have active parameters appear with an "ID not selected" instead an Argos ID. See the Activate/Deactivate Parameters section in the help system of TDC for assistance activating parameters.. After reviewing the active transmitters, press the OK Button on the Transmitters Window to close the window and save the changes.
4. Select the Data Source.
   Select the Connected Uplink tab from the Main Window. Select the serial port where your uplink receiver is connected (or select “USB” when using a Telonics USB adapter). Press the Start Button to begin converting messages from the connected uplink receiver.
5. Turn on the Uplink Receiver.
   At this point, the system is ready to convert data. Turn on your uplink receiver if it is not on already.
6. Wait for Messages.
   TDC converts messages as they arrive. From the Main Window, specific messages can be viewed, the display can be paused, and reports generated.
7. Log Uplink Messages.
   TDC can also log uplink messages while it converts the data from the directly connected uplink receiver. To log uplink messages, see the help system of TDC.

10.8 Updating Argos Ephemeris Data

The “Argos Satellites” section of the TPF record and the TPF file (viewed in TPP) shows the satellite-prediction setting and the ephemeris date. If a unit uses satellite predictions and has ephemeris that is older than 30 days, the ephemeris should be updated before deployment. Follow the steps below to update the ephemeris.

1. Download and install the latest version of Telonics Product Programmer (TPP) from the Telonics website. You do not need to purchase or enter an authorization code to update Argos ephemeris data.

2. Start TPP. Close the evaluation-version message and the model-selection window so that only the main TPP window is visible.

3. Be sure the magnet is applied to the unit.

4. Connect one end of the Smart Cable to the PC and the other to the unit. If you are not sure how to connect to your model, please refer to the detailed connection instructions and diagrams in the help system of TPP.

5. Choose “Send Updated Ephemeris to Unit” from the Unit menu or press the  button on the toolbar. Be sure that your computer is connected to the Internet while updating ephemeris on the unit. While TPP updates the ephemeris, the status bar displays “Updating ephemeris …”. Upon completion, TPP updates the status bar to indicate that it has finished updating ephemeris.

6. Repeat steps 3-5 for each of your units.

7. To view a list of all the units that have updated ephemeris, choose “Ephemeris Updates” from the View menu.

10.9 Standard Initialization Procedure for GPS-Argos Systems

1. Before starting the initialization process, ensure that the unit has a clear view of the sky and is physically separated from other units by at least 10 meters.
2. Tune your VHF receiver to the VHF beacon frequency for the unit being initialized.
3. If the magnet is not already applied, apply the magnet until the VHF beacon stops transmitting (usually about 15 - 30 seconds).
4. Remove the magnet and start a stopwatch so that the time required for events below can be recorded.
5. After 5 – 10 seconds, the VHF beacon generates a double pulse (beep) and then stops transmitting. A GPS position fix attempt is now underway.
6. Wait for the VHF beacon to start transmitting again. VHF beacon transmissions will resume in 15 seconds to 2 minutes.
7. Evaluate the results of the initialization attempt by listening to the pulse (beep) pattern of the VHF beacon. The beacon will be transmitting the pattern until the end of the first update period. The initialization status patterns are:

    Successful Initialization

    A 2-beep pattern (beep beep – pause – beep beep – pause – etc.) indicates a successful initialization. This unit is now ready for deployment in its current geographic area.

    Unsuccessful Initialization

    a. A 3-beep pattern (beep beep beep – pause – beep beep beep – pause – etc.) typically indicates that the unit could not obtain a GPS position even though a full attempt was made to do so. Be sure the unit has a clear view of the sky and then retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.
    b. A 4-beep pattern may indicate a serious problem with the unit. **Do not deploy the unit.** Reapply the magnet to the unit, and contact Telonics for assistance.
    c. A single-beep pattern (beep – pause – beep – pause – etc.) means the battery that powers the GPS and data-transfer components of the system is dead or possibly recovering from a period of extended storage. The pulse period in this condition will correspond to programmed period for “dead battery” provided in the TPF record. Retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.

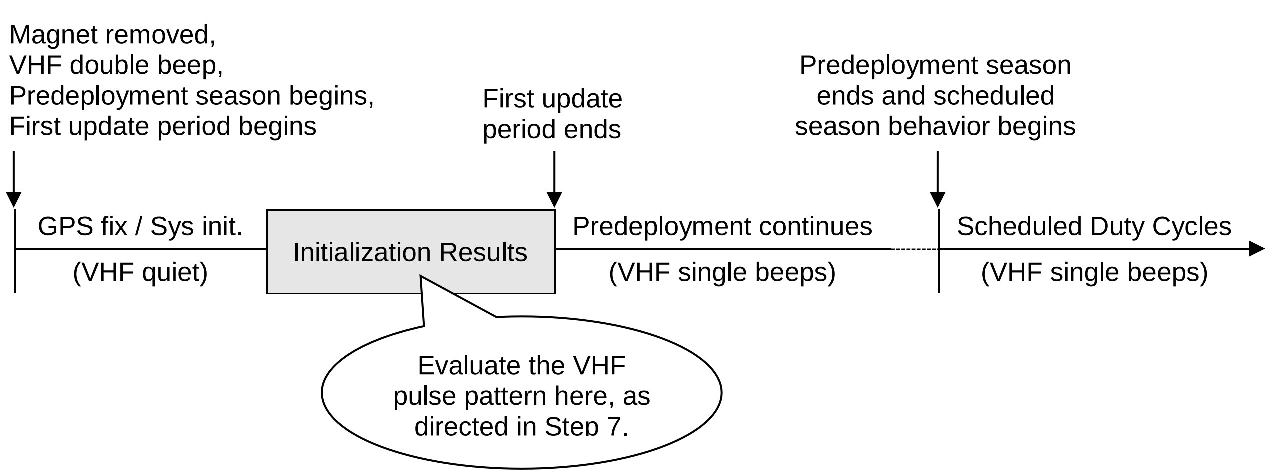


Figure 2: Standard Initialization Timeline for GPS-Argos Systems

10.10 Alternate Initialization Procedure

1. Apply the magnet for at least 35 seconds.
2. Determine when the next suitable Argos satellite overpass(es) will occur at your location. You can log in to Argos Web (http://www.argos-system.org/) to see upcoming overpasses if necessary. Choose one or more overpasses to assure the Argos transmitter is able to transfer data to the satellite.
3. Wait until about 15 minutes prior to the beginning of the overpass before proceeding.
4. During this testing process, make sure the unit has a clear view of the sky and the units are separated by a minimum of ten meters.
5. Remove the magnet to start the predeployment season.
6. Allow the unit to complete its predeployment season and continue making transmissions. Consult the TPF record to determine the duration of the predeployment season.
7. Retrieve data from the satellite service provider (e.g., Argos, Globalstar, or Iridium). Analyze the data using Telonics Data Converter or your own custom tools. You can observe the initialization status of the unit by reviewing this data. Any successful GPS fix indicates proper unit initialization.
8. If the converted data doesn't show any successful GPS fixes, repeat this procedure at least once (for GPS-Iridium systems, allow the unit to recover for 20 minutes with magnet applied between initialization attempts). If there are no data available for retrieval, or if retrieved data continue to show only failed GPS fix attempts, do not deploy the unit. Contact Telonics for assistance.

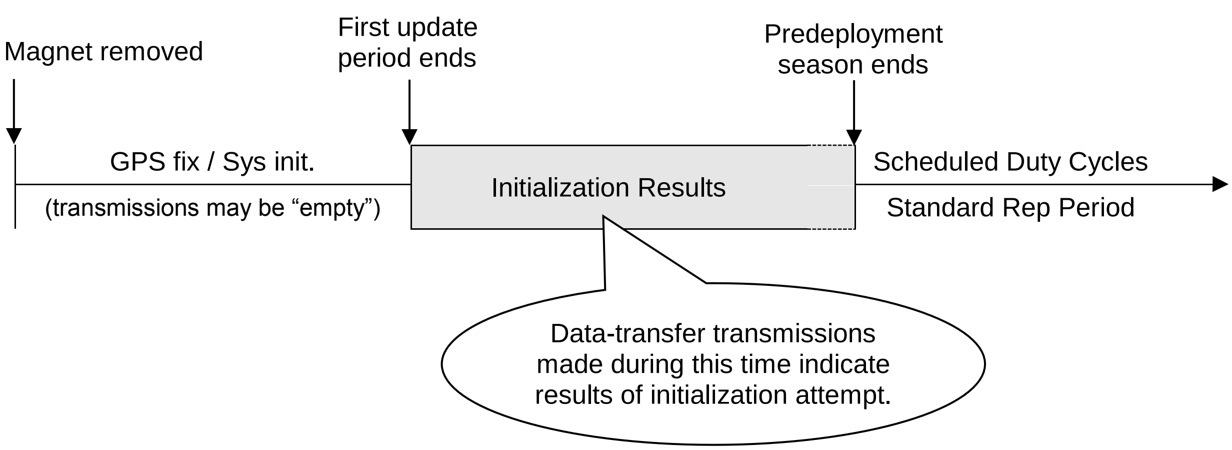


Figure 6: Alternate Initialization Timeline

10.11 System Tests

VHF Range

The units should be tested to evaluate the performance of the VHF beacon with the receiving equipment that will be used to monitor the beacon during the study. When evaluating the test results, be aware that VHF range performance can vary dramatically. The VHF beacon on the unit, the receiving equipment, and the surrounding environment all affect the actual VHF range. The typical range performance from a collar mounted unit is 1-3 km when monitored from the ground and 10 + km when monitored from the air. A range performance of only a few hundred meters would tend to indicate a problem, so be sure to consult Telonics before deploying any units with severely limited VHF range.

Argos Uplink

The units should undergo a test of the Argos data-transfer component using the procedure below.

1. Apply the magnet for at least 35 seconds.
2. Determine when the next suitable Argos satellite overpass(es) will occur at your location. You can log in to Argos Web (http://www.argos-system.org/) to see upcoming overpasses if necessary. Choose one or more overpasses to assure the Argos transmitter is able to transfer data to the satellite
3. Wait until about 15 minutes prior to the beginning of the overpass before proceeding.
4. During this testing process, make sure the unit has a clear view of the sky.
5. Remove the magnet to start the predeployment season.
6. Wait at least long enough for the Argos satellite overpass to finish. Preferably, allow the full predeployment period to expire making it possible to recover data from several overpasses.
7. Retrieve data from Argos. Depending on the number of overpasses, verify that several transmissions were received by the satellites and processed by Argos. Failure to receive any uplinked messages suggests a problem and these units should not be deployed.

10.12 A “Simple” GPS Argos Transmission Format (TDC not required)

Research groups that do not require intensive data transfer through the Argos systems may choose to use a “standard template” that can be decoded without the use of TDC.

Telonics Gen4 GPS Argos Transmitters have fully programmable Argos message contents. This section describes a simplified Argos message layout for GPS data. The table below provides instructions for converting the raw message data into standardized units. You can recover data from Argos messages formatted in this manner without Telonics Data Converter.

Message Format

Telonics Product Programmer (TPP) establishes the format of the Argos message. The following is the TPP presentation of the Argos message format covered in this document.

Argos message fields:

Last 3 fix times............. Bits 1-90 (90 bits); Up to 2036.01.01 with 1-second steps (30 bits)
Last 3 latitudes............. Bits 91-159 (69 bits); The whole world with 2.3845-meter resolution (23 bits)
Last 3 longitudes........... Bits 160-231 (72 bits); The whole world with 2.3845-meter resolution (24 bits)
Last 3 horizontal errors. Bits 232-240 (9 bits); <10m, 10-20m, 20-30m, 30-40m, 40-50m, […] (3 bits)
Error detection .... Bits 241-248 (8 bits); Legacy 8-bit CRC

Data Recovery

This message format allows the transmitter to send three GPS positions in a single Argos message. A single value in the message occupies a unique range of data bits in the message. The meaning of any value in the message can be deciphered by applying a conversion formula to convert the value into standardized units such as seconds or degrees of latitude or longitude. The following table describes the bit ranges and conversion formulas for this message format. The term ‘n’ in the conversion formulas refers to the raw value stored inside the listed bit range.

Argos Data Conversion

<table>
<tr><th>Bit Range</th><th>Name</th><th colspan="2">Conversion Formula</th><th>Results</th></tr>
<tr><td>1 – 30</td><td>Fix Time ‘A’</td><td colspan="2" rowspan="3">n + 1143849600</td><td rowspan="3">UNIX Time
(see below)</td></tr>
<tr><td>31 – 60</td><td>Fix Time ‘B’</td></tr>
<tr><td>61 – 90</td><td>Fix Time ‘C’</td></tr>
<tr><td>91 - 113</td><td>Latitude ‘A’</td><td colspan="2" rowspan="3">n * (256*90/1073741824) – 90</td><td rowspan="3">degrees in [-90, +90)</td></tr>
<tr><td>114 - 136</td><td>Latitude ‘B’</td></tr>
<tr><td>137 - 159</td><td>Latitude ‘C’</td></tr>
<tr><td>160 - 183</td><td>Longitude ‘A’</td><td colspan="2" rowspan="3">n * (256*180/2147483648) – 180</td><td rowspan="3">degrees in
[-180, +180)</td></tr>
<tr><td>184 - 207</td><td>Longitude ‘B’</td></tr>
<tr><td>208 - 231</td><td>Longitude ‘C’</td></tr>
<tr><td>232 - 234</td><td>Horizontal Error ‘A’</td><td rowspan="3">n * 10
(minimum value)</td><td rowspan="3">(n +1) * 10
(maximum value)</td><td rowspan="3">horizontal uncertainty
(meters)</td></tr>
<tr><td>235 - 237</td><td>Horizontal Error ‘B’</td></tr>
<tr><td>238 - 240</td><td>Horizontal Error ‘C’</td></tr>
</table>

Be careful to extract the raw ‘n’ values correctly from the message. Data from Argos may or may not display the ‘n’ values directly, depending on your Argos technical file. If the values are not displayed directly, they must be extracted and reassembled before applying the conversion formulas.

The error-detection byte allows errors in an Argos message to be detected through mathematical analysis. However, transmitters using this message format often repeat data from one transmission to the next, which allows detection even correct message errors without analyzing the error-detection byte. The section below, Error Detection Byte, gives a technical description of the error-detection byte and the required analysis.

UNIX Time

When the result of a conversion formula yields “UNIX Time”, the result is the number of seconds since 00:00:00 Jan 1, 1970 UTC. For example, a UNIX Time of 1206403200 represents 00:00:00 March 25, 2008 UTC. There are exactly 1206403200 seconds in the 13963-day period between Jan 1, 1970 @ 00:00:00 and March 25, 2008 @ 00:00:00.

Error Detection Byte

The error-detection byte allows Telonics customers to validate the contents of an Argos transmission. While in transit, the wireless transmission is subject to radio interference, which can damage the message and prevent the Argos satellite or handheld receiver from receiving the message properly. If the transmitter includes the error-detection byte, then we can review the contents of the Argos “message” to detect this kind of corruption.

A computer must inspect the message at the bit level and follow a specific algorithm to generate an expected value for the error-detection byte. If the expected value matches the value received by the satellite or handheld receiver, then the message is almost certainly intact. Telonics Data Converter (TDC) automatically validates each message if the transmitter includes the error-detection byte.

The error-detection byte uses a CRC (cyclic redundancy check) calculation that provides a high likelihood of detecting errors in the message.

Computer Algorithm (Legacy CRC Only)

Customers not using TDC may choose to write custom software to validate Argos messages themselves. This option is available to customers choosing the legacy CRC option in TPP. Selecting other CRC options in TPP necessitates the use of TDC to validate the Argos message.

Here is the computer algorithm: First, initialize <crc> (a one-byte variable) to 0xFF. Then do the following for each data bit in the message (not including the bits that hold the CRC itself): Shift <crc> left one bit; if the bit that shifts out of the byte doesn't equal the message bit that we're processing this iteration of the loop, exclusive-OR a 3 into <crc> after the left shift. After processing all of the bits, take the one's complement of <crc>.

The following page contains computer programming source code written in C. The code follows the algorithm described in the previous paragraph.

Once this algorithm generates the expected value for the CRC, the expected value can be compared to the received value. If the values match, the message is almost certainly intact. If the value doesn't match, the message may still be intact if the transmitter was operating inside the predeployment season at the time of transmission. In that case, the transmitter sends [CRC ^ 0x50] instead of [CRC].

This code snippet assumes that the message's data bits are arranged contiguously into an array of unsigned bytes called "dataBuffer". Note that getting the data bits arranged this way may not be a trivial task since DS data from Argos isn't necessarily showing message bytes. It is necessary to know how many bits each value in the Argos message occupies. This information is available in the TPF record. Also, if messages are received from a source other than Argos, it is necessary to determine correct starting point of data in the message. If unit uses a 28-bit ID and the receiver sees it as a 20-bit ID, the receiver will show the last ID byte as data when it really isn't data. The CRC does not protect that byte, so do not include that data in the data buffer array. Data directly from Argos doesn't have this potential ambiguity.

```
uint8 crc;
int i;

// uint8 dataBuffer[31] already contains the message data

crc = 0xFF;

// for each data bit in the data
// processing bits from left to right

for (i = 0; i < MESSAGE_DATA_BITS; i++)
{
   // if the data bit is 1...
   if (dataBuffer[i / 8] & (0x80 >> (i % 8)))
   {
      // if the bit about to be shifted out of the crc is 1...
      if (crc & 0x80)
         // shift the crc left by 1 bit
         crc = (uint8)(crc * 2);
      else // the bit about to be shifted out of the crc is 0...
         // shift the crc left then XOR with 3
         crc = (uint8)((crc * 2) ^ 3);
   }
   else // the current data bit is a zero.
   {
      // if the bit about to be shifted out of the crc is 1...
      if (crc & 0x80)
         // shift the crc left then XOR with 3
         crc = (uint8)((crc * 2) ^ 3);
      else // the bit about to be shifted out of the crc is 0...
         // shift the crc left by 1 bit
         crc = (uint8)(crc * 2);
   }
}

crc = (uint8)~crc;  // Take one's complement of CRC (invert all bits)
```

10.13 Dive Profile Algorithm for GPS-Argos Users without TDC

A dive profile in an Argos message doesn't directly specify the times during the dive that correspond to the profile's list of depth readings. Telonics Data Converter determines these times based on the dive duration. To determine the times without using TDC, the user needs both the dive duration and the following equation. The equation calculates the uniform interval between depth readings included in the dive profile.

Let:

D = dive duration in seconds, D > 0;
M = pressure measurement interval in seconds, 1 ≤ M ≤ 255;
N = number of profile points, 1 ≤ N ≤ 32;
I = interval between depth readings in this dive profile (seconds)

If D ≤ M x N, then:

$$I = M$$

Otherwise:

$$I = M \times 2^{\left\lfloor \log_2\left(\frac{D-1}{M \times \left(\left\lfloor \frac{N}{2} \right\rfloor + 1 \right)} \right) \right\rfloor}$$

After calculating the uniform interval for a particular dive profile, the user can easily determine the time of each depth reading in the profile. The first depth reading in the profile corresponds to the dive time at which the calculated interval first expired, starting at the time of submersion. The second depth reading occurred exactly one interval after the first depth reading in the profile, and so forth.

Due to the unit's method of dive profiling, a profile will often have one or more unused profile points. These points are at the end of the profile. The user can identify the unused points by noticing that the time of those measurements is after the end of the dive. The unit transmits zero depth for the unused profile points.

C-style pseudocode

```
uint32 diveDuration, measurementInterval, numProfilePoints, profilePointInterval;

profilePointInterval = measurementInterval;
if (diveDuration > measurementInterval * numProfilePoints)
{
    profilePointInterval = measurementInterval <<
        log2( (diveDuration - 1) / (measurementInterval * (numProfilePoints/2 + 1)) );
}
```

where `log2()` is a function defined as follows:

```
int8 log2(uint32 value)
{
   int8 log;
   for (log = -1; value != 0; log++)
      value >>= 1;
   return log;
}
```

Examples

Here are two examples that show depth times for dives up to 25 seconds. The example on the left shows a configuration with four profile points, and the example on the right shows five profile points. The examples show how to apply the interval ***I*** as calculated using the equation above.

M = 1 and N = 4					
D	*I*	t_1	t_2	t_3	t_4
1	1				
2	1	1			
3	1	1	2		
4	1	1	2	3	
5	1	1	2	3	4
6	1	1	2	3	4
7	2	2	4	6	
8	2	2	4	6	
9	2	2	4	6	8
10	2	2	4	6	8
11	2	2	4	6	8
12	2	2	4	6	8
13	4	4	8	12	
14	4	4	8	12	
15	4	4	8	12	
16	4	4	8	12	
17	4	4	8	12	16
18	4	4	8	12	16
19	4	4	8	12	16
20	4	4	8	12	16
21	4	4	8	12	16
22	4	4	8	12	16
23	4	4	8	12	16
24	4	4	8	12	16
25	8	8	16	24	

M = 1 and N = 5						
D	*I*	t_1	t_2	t_3	t_4	t_5
1	1					
2	1	1				
3	1	1	2			
4	1	1	2	3		
5	1	1	2	3	4	
6	1	1	2	3	4	5
7	2	2	4	6		
8	2	2	4	6		
9	2	2	4	6	8	
10	2	2	4	6	8	
11	2	2	4	6	8	10
12	2	2	4	6	8	10
13	4	4	8	12		
14	4	4	8	12		
15	4	4	8	12		
16	4	4	8	12		
17	4	4	8	12	16	
18	4	4	8	12	16	
19	4	4	8	12	16	
20	4	4	8	12	16	
21	4	4	8	12	16	20
22	4	4	8	12	16	20
23	4	4	8	12	16	20
24	4	4	8	12	16	20
25	8	8	16	24		

As the examples show, a dive doesn't always use all of the profile points requested. For example, the 7-second dive in these examples uses only 3 of the 4 or 5 profile points requested.

11 GPS-Globalstar Systems

The Gen4 GPS-Globalstar unit relays data collected by the unit to satellites in orbit. The transmitter follows a user-defined schedule and relays sensor data specifically selected by the user.

The Globalstar satellite network consists of 48 space vehicles in low-earth orbit (LEO). Overpasses provide continuous coverage over most of the globe. The GPS-Globalstar unit uses Globalstar's Simplex Data network which has a larger coverage area and historically more robust performance compared to Globalstar's Voice/Duplex network. Only the polar regions and a few areas where there are no Globalstar ground stations have no coverage in the Globalstar Simplex Data network.

Messages are up to 144 bytes in length and are on the air for up to 26 seconds. In most cases, Globalstar requires transmitters to wait approximately 30 minutes before generating the next transmission. The result is a limitation on the amount of data that can be transferred over the satellite link. Users carefully choose which study data to transfer using this link and which periods of day permit transmitting.

Data received by the satellite is relayed to a ground station in real time. Transmissions that successfully negotiate these links are delivered directly to the end user within minutes, usually via e-mail. Due to the continuous coverage provided by the large satellite network, GPS-Globalstar systems never need to wait for a satellite overpass.

The Globalstar satellite network provides a one-way link for the unit to transmit data back to the researcher. Because the unit cannot know when a transmission was successfully received, users typically configure the unit to transmit any given piece of data multiple times to increase likelihood of delivery.

Globalstar identifies individual transmitters on the satellite network by Electronic Serial Number, or ESN. The programming record generated by Telonics Product Programmer correlates a unit's Globalstar ESN (e.g., 0-12345) with its Telonics CTN (e.g., 678910A) and VHF beacon frequency, if equipped.

11.1 Establishing Globalstar Message Content

Each GPS-Globalstar model contains various sensor options (the sensor, signal processing circuitry, and the firmware) appropriate to that model. Telonics Product Programmer (TPP) can be used to selectively enable sensor data collection and establish a data collection schedule. All or some specifically selected data types can be included for uplink transmission and recovery through the Globalstar network. All sensor data is also automatically stored in log memory and if the unit is recovered these data can be downloaded and processed using TDC.

Some GPS-Globalstar models from Telonics offer one very basic choice of Globalstar message content. For example, the RECON systems merely transmit the most recent GPS fix(es), and you may choose whether to include one GPS fix or multiple GPS fixes.

However, more sophisticated GPS-Globalstar systems from Telonics transmit specific data you select by data type. For example, you might choose to transmit environmental temperatures but not data from the activity sensor. You might choose to transmit GPS latitude and longitude but not altitude. The more data you elect to transmit, the more time you will need to schedule as "on" time in the Globalstar transmitter schedule. More scheduled transmitter operation reduces battery life.

When data selected for transmission becomes too old, the unit no longer transmits that data[6]. Thus there is a window of opportunity for collected data to be successfully transferred through the Globalstar system. In some cases, you may specify the size of this window of time, typically known as the Globalstar "data window". Normally you should choose a window size that allows data to be transmitted 2 or 3 times over

[6] One exception to this rule is "Most-recent GPS location", a data item that you can select to be transmitted. In this case, the unit continues transmitting the most-recent location, no matter how old it is.

the course of a few days, which provides a high likelihood that it will be successfully received by the satellite network.

Telonics Product Programmer can simulate your deployment to help you see how many times data is likely to be transmitted, given the size you have chosen for the data window. Many factors determine the number of repetitions, such as data window size, data selected for transmission, relevant sensor schedules, transmitter schedule, and message length. When you order units and select these programming options, Telonics will help by explaining how the various choices may impact your study.

At any given time during your study, the set of data that is eligible for transmission can be quite large – much more than any single Globalstar message can carry. For example, if your data window is 10 days and you are transmitting GPS positions which are collected 24 times per day, there are 240 GPS positions eligible for transmission at any given time. Even a full-length transmission of 144 bytes cannot hold that much data. The unit divides this data set into multiple transmissions and finishes transmitting the entire data set before re-transmitting any of it. Therefore, depending on the number of Globalstar transmissions allowed by the user-configured Globalstar schedule, and depending on the amount of data in the entire data set, a given piece of data may be transmitted zero, one, or more times before finally becoming too old to transmit.

In some cases, you must also choose the length of your Globalstar message. For many deployments, a 72-byte message is a good compromise between probability of delivery, efficiency of data transfer, and cost of satellite service. Studies collecting large amounts of data may need to use longer messages, especially where terrain and canopy allow good visibility of the sky. Studies conducted in very difficult environments with limited visibility of the sky may need to use shorter messages to increase probability of delivery while sacrificing the amount of total data delivered. Keep in mind that each message received incurs a fee with the Globalstar satellite service provider, and larger messages cost more than smaller ones. Telonics can help you make these choices by explaining the potential impacts to your study.

11.2 Establishing Globalstar Transmission Schedules

Researchers must determine which times of day are best suited for the GPS-Globalstar system to make transmissions to the satellite network. This selection is typically made with animal behavior in mind. In collar configurations, the Globalstar antenna is mounted dorsally to provide optimal view of the sky. If the animal typically hides or swims during predictable times of day, then avoid transmitting during these times.

Another consideration for selecting the times of day to transmit is the researcher's own schedule. If the Globalstar message is configured to include the most-recent GPS location, then the researcher might want to know the most-recent location at a certain time of day, perhaps when a visit to the field might be possible.

Because the Globalstar satellite network provides continuous coverage, there is no need to select transmission periods based on overpass predictions as is commonly done with Argos systems.

When considering shorter or longer "on" periods in the transmitter schedule, make adjustments in increments of a half hour. The unit waits half an hour between consecutive transmissions based on Globalstar specifications, so making smaller increments might not change the number of expected transmissions.

11.2.1 Priority Events

The GPS-Globalstar system can identify specific events during the deployment as "Priority Events". Currently, there are four Priority Events; Mortality, Resurrection, Trap Triggered, and Trap Re-Set. When the GPS-Globalstar system detects a Priority Event, the system optionally transmits a number of unscheduled messages to the Globalstar network. Transmitting multiple messages helps ensure that notice of the event gets through the satellite network.

Telonics can optionally send a message to your email or mobile phone immediately upon receiving notice from the GPS-Globalstar system of the Priority Event. These messages contain the system CTN (serial number), Globalstar ESN, event description, time the event occurred, and latest known GPS fix time and location at time of transmission. A sample message is shown below:

```
CTN:  123456A
ESN:  0-2365111
Mortality
http://maps.google.com/maps?t=k&q=33.384161,-111.811273
Msg:  2017.02.09 09:23
GPS:  2017.02.09 09:00
HzEr: 25m
```

Resurrection and Trap messages are formatted in similar fashion to the Mortality message (only the event description is different).

Because Priority Events induce unscheduled transmissions, you may need to plan for shorter battery life than predicted by Telonics. Telonics cannot anticipate the number of Priority Events your deployment will encounter.

11.3 Satellite Service for GPS-Globalstar Systems

Telonics Gen4 GPS-Globalstar transmitters are compatible with the Simplex Data Service on the Globalstar Satellite Network. To receive satellite data from your Globalstar transmitters, you must purchase service through our partnered service provider AssetLink Global. Each successful Globalstar transmission from one of your Telonics Gen4 GPS-Globalstar transmitters is first received by AssetLink Global and then forwarded to Telonics Data Converter (TDC).

You must "provision" each Telonics Globalstar transmitter individually with AssetLink Global before it can transmit through the satellite network. In order to provision transmitters, you must first establish your service account with AssetLink Global and create a "message route" in your account.

This document describes:

- Establishing a Service Account with AssetLink Global
- Routing Globalstar Messages to Telonics Data Converter
- Provisioning Transmitters
- Decommissioning Transmitters

You must provision each Telonics Globalstar transmitter to activate it on the satellite network. The satellite network cannot receive messages from a transmitter that has not yet been provisioned.

11.3.1 Establishing a Service Account with AssetLink Global

If you don't already have one, you must first establish an account with AssetLink Global[7] to receive Satellite Services for Telonics equipment. You will receive login information for the AssetLink Global self-service website, https://assetview.tms-orbcomm.com/assetlinkglobal/, which allows you to specify where Globalstar should route messages from your transmitters.

Contact: AssetLink Global Service <service@assetlinkglobal.com>
Request: Globalstar Satellite Service for Telonics equipment

You may also reach AssetLink Global sales and support via postal mail or telephone if necessary:

AssetLink Global
1153 Bergen Parkway #M352
Evergreen, CO 80439

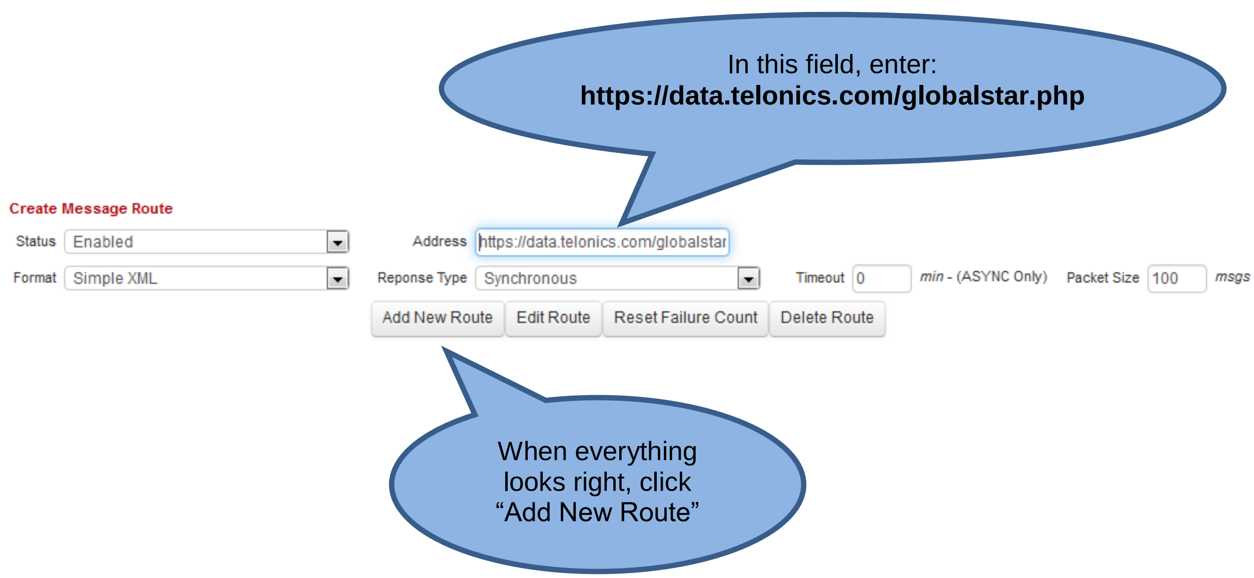
In US: 1-888-53-ASSET
Worldwide: +1 303 862-8745

11.3.2 Routing Globalstar Messages to Telonics Data Converter

Satellite service with AssetLink allows you to route messages (transmissions) from your Gen4 GPS-Globalstar transmitters to Telonics Data Converter. You must use the AssetLink self-service website https://assetview.tms-orbcomm.com/assetlinkglobal/, also known as AssetView, to specify the routing. Use AssetView to create a "message route" as described below.

Create a Message Route (https://assetview.tms-orbcomm.com/assetlinkglobal/)

From the "Route Manager" menu, choose "Routes". Then enter the information for a new route as shown below. When everything looks right, click "Add New Route".



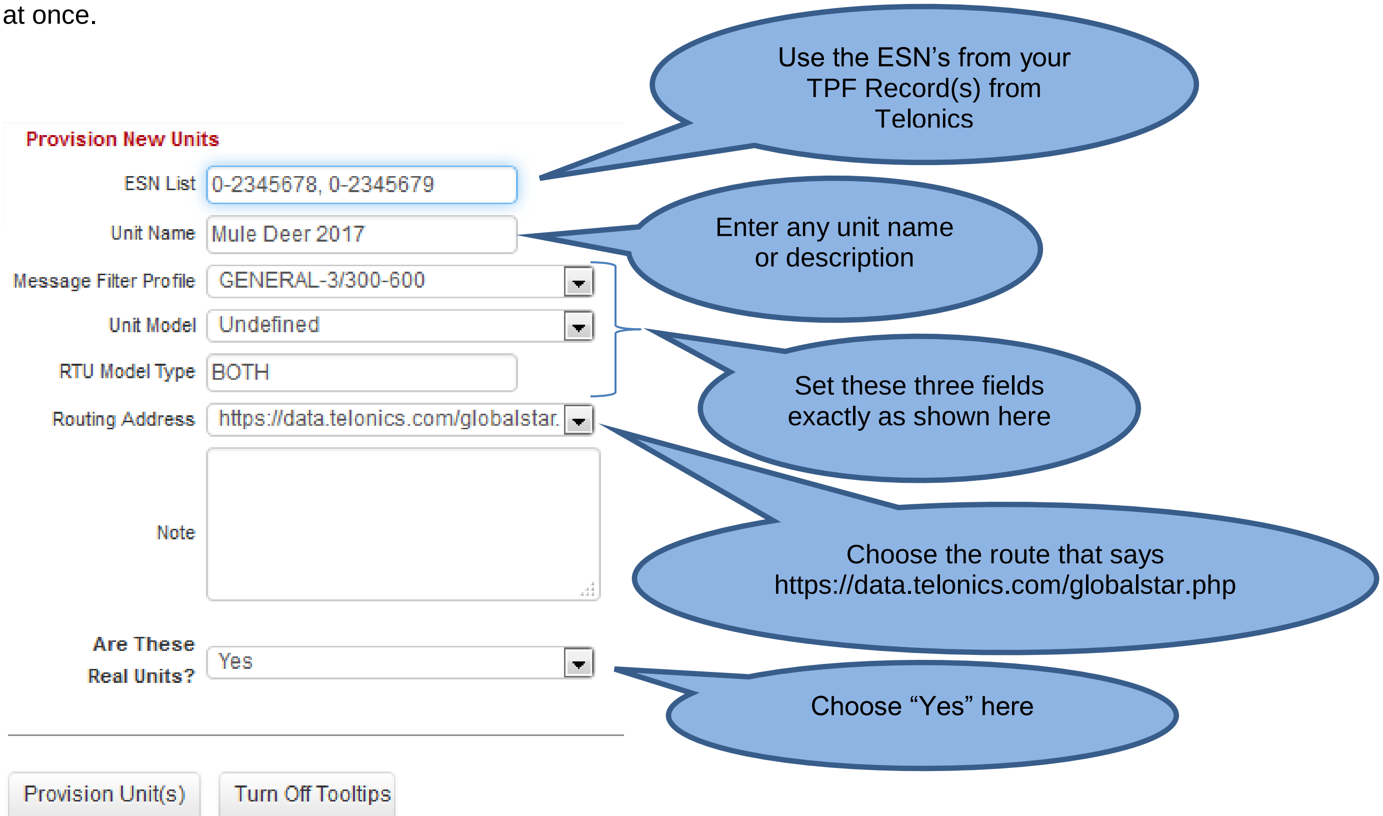
[7] Telonics customers with active Globalstar service from ORBCOMM (formerly Comtech Mobile Datacom) may continue using this service instead of creating a new account with AssetLink Global. Both service providers are suitable, pricing is identical, and both include access to https://assetview.tms-orbcomm.com/assetlinkglobal/.

11.3.3 Provisioning Transmitters

Before you can test or deploy a Gen4 GPS-Globalstar transmitter, you must use the AssetLink Global self-service website https://assetview.tms-orbcomm.com/assetlinkglobal/, also known as AssetView, to "provision" the transmitter and to establish its messaging profile. In the provisioning process, you provide basic information about the transmitter, as shown below, and AssetView configures the Globalstar network to receive and process transmissions from your transmitter.

The provisioning process requires you to supply the Electronic Serial Number (or ESN) for each unit. You can find the ESN in the "Units" section of the TPF record(s) supplied by Telonics with the delivery of your transmitters. The TPF record is typically a printed document or a pdf file. If you have Telonics Product Programmer software, you can open the TPF file, also supplied by Telonics, to find the ESN. For large orders, Telonics also sends you an email with the ESN List you can copy and paste directly.

Use the example below as a guide when provisioning units. As shown, you may provision multiple units at once.



When everything looks right, click "Provision Unit(s)". The provisioning process takes several minutes. You can check on the provisioning status of your units from the Unit Manager page.

AssetLink Global charges a one-time service fee for provisioning a transmitter, and there is an additional monthly access fee for every provisioned transmitter, even if it isn't transmitting. Per-message fees also apply to all provisioned transmitters.

11.3.4 Decommissioning Transmitters

While a transmitter is “provisioned”, AssetLink Global charges monthly service fees and per-message fees. When you are finished using a transmitter or if it becomes lost or destroyed etc, you may want to “decommission” it to stop the monthly fees. If you need to decommission one or more transmitters, use the AssetView website, https://assetview.tms-orbcomm.com/assetlinkglobal/. Decommissioned transmitters cannot use the satellite network until they are re-provisioned.

In general, you should not decommission a transmitter that you intend to deploy again. For example, when sending a unit back to Telonics for refurbishment, you should generally not decommission it. The fee to re-provision a decommissioned transmitter is many times larger than the monthly fee to keep the transmitter provisioned. Be sure to check with AssetLink Global for updated pricing when deciding to decommission a transmitter.

11.4 Standard Initialization Procedure for GPS-Globalstar Systems

1. Before starting the initialization process, ensure that the unit has a clear view of the sky and is physically separated from other units by at least 10 meters.
2. Tune your VHF receiver to the VHF beacon frequency for the unit being initialized.
3. If the magnet is not already applied, apply the magnet until the VHF beacon stops transmitting (usually about 15 - 30 seconds).
4. Remove the magnet and start a stopwatch so that the time required for events below can be recorded.
5. After 5 – 10 seconds, the VHF beacon generates a double pulse (beep) and then stops transmitting. A GPS position fix attempt is now underway.
6. Wait for the VHF beacon to start transmitting again. VHF beacon transmissions will resume in 15 seconds to 2 minutes.
7. Evaluate the results of the initialization attempt by listening to the pulse (beep) pattern of the VHF beacon. The beacon will be transmitting the pattern until the end of the first update period. The initialization status patterns are:

    Successful Initialization

    A 2-beep pattern (beep beep – pause – beep beep – pause – etc.) indicates a successful initialization. This unit is now ready for deployment in its current geographic area.

    Unsuccessful Initialization

    a. A 3-beep pattern (beep beep beep – pause – beep beep beep – pause – etc.) typically indicates that the unit could not obtain a GPS position even though a full attempt was made to do so. Be sure the unit has a clear view of the sky and then retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.
    b. A 4-beep pattern may indicate a serious problem with the unit. **Do not deploy the unit.** Reapply the magnet to the unit, and contact Telonics for assistance.
    c. A single-beep pattern (beep – pause – beep – pause – etc.) means the battery that powers the GPS and data-transfer components of the system is dead or possibly recovering from a period of extended storage. The pulse period in this condition will correspond to programmed period for “dead battery” provided in the TPF record. Retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.

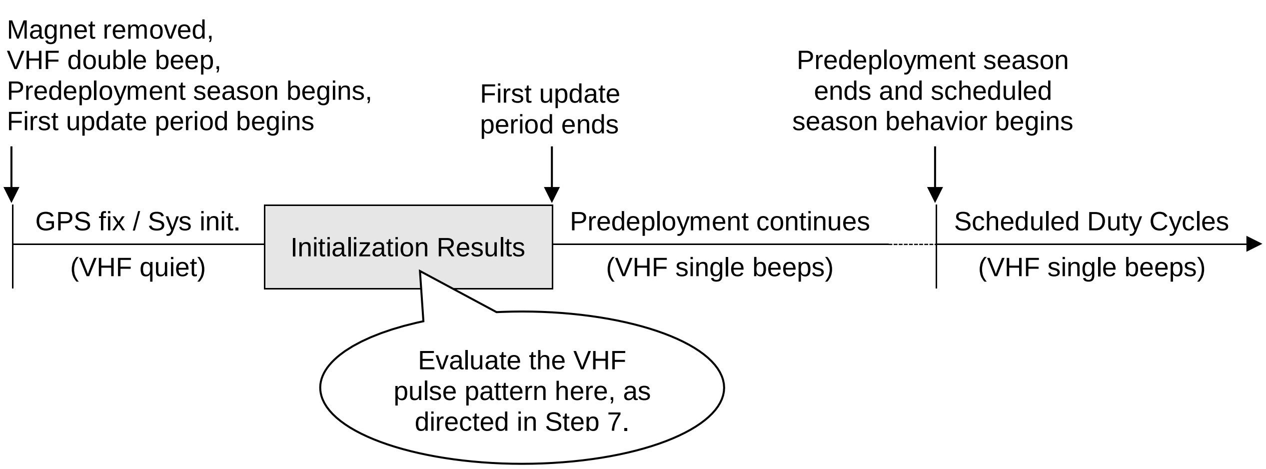


Figure 3: Standard Initialization Timeline for GPS-Globalstar Systems

11.5 Alternate Initialization Procedure

1. Apply the magnet for at least 35 seconds.
2. During this testing process, make sure the unit has a clear view of the sky and the units are separated by a minimum of ten meters.
3. Remove the magnet to start the predeployment season.
4. Allow the unit to complete its predeployment season and continue making transmissions. Consult the TPF record to determine the duration of the predeployment season.
5. Retrieve data from the satellite service provider (e.g., Argos, Globalstar, or Iridium). Analyze the data using Telonics Data Converter or your own custom tools. You can observe the initialization status of the unit by reviewing this data. Any successful GPS fix indicates proper unit initialization.
6. If the converted data doesn't show any successful GPS fixes, repeat this procedure at least once (for GPS-Iridium systems, allow the unit to recover for 20 minutes with magnet applied between initialization attempts). If there are no data available for retrieval, or if retrieved data continue to show only failed GPS fix attempts, do not deploy the unit. Contact Telonics for assistance.

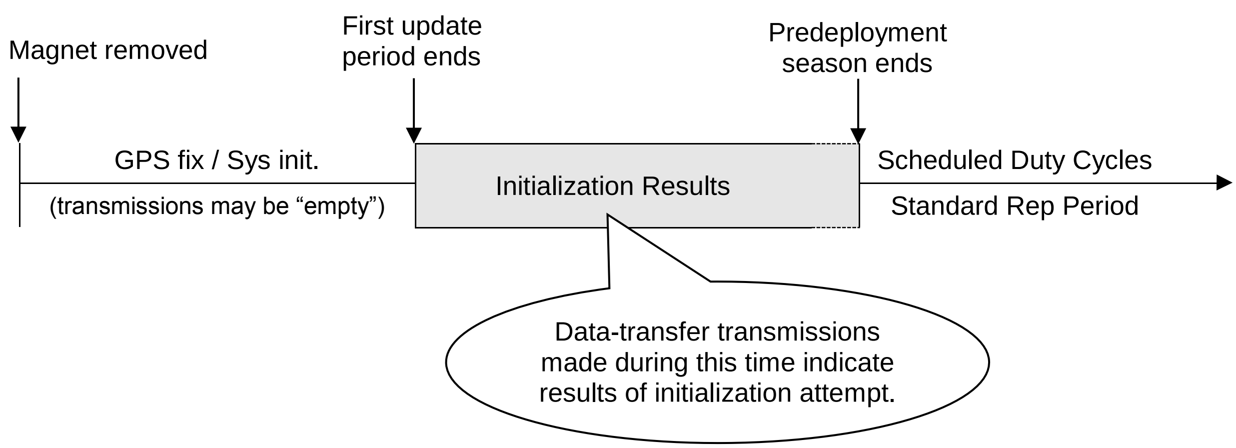


Figure 6: Alternate Initialization Timeline

11.6 Recovering Data from the Globalstar Satellite Network

Globalstar satellites receive messages transmitted by GPS-Globalstar systems and relay the messages back to ground stations. These ground stations then pass the messages along to the Globalstar Backoffice for processing and message reassembly. AssetLink Global, the service provider, receives the message automatically and delivers it to the Telonics Server. Telonics Data Converter retrieves the data from the Telonics Server and processes the satellite transmissions. Before deploying a GPS-Globalstar system, you must activate your Globalstar transmitters and make sure the data is being delivered. See section 11.3 for detailed instructions.

To set up TDC to download Globalstar data and generate reports, use the procedure below. Refer to TDC online help as needed.

1. Enter Username and Password
   From the Recon tab in the main window of TDC, click the link next to Download Account.
   Enter the username and password provided by Telonics. Click OK.
2. Synchronize TDC with the Telonics Server
   Click the Sync Now button. TDC will download a copy of all Globalstar data from the Telonics Server. The first time you synchronize data on a computer may take a while. Future syncs will be quick because TDC only has to download new data since the last sync.
   If you check the Auto Sync option, TDC will periodically check for new data automatically.
3. Review the transmitter summary
   After syncing data, TDC displays the current location and status of all transmitters.
   The summary displays the time of the most-recent Globalstar transmission and GPS fix.
   The Status column indicates which units are currently reporting mortality or low voltage.
   To view a current transmitter location in Google Maps, click coordinates in the Location column.
   To view the current locations in Google Earth, click Map Selected Units or Map All Units links.
   To assign a transmitter name, click the Name column.
4. Generate reports
   Check the Box next to each transmitter to be included in the reports.
   Choose which data to be included in the reports. Options include all data, data since the last report, recent data from a specified number of days, or data from a particular date range.
   Click the Report button to generate a report for each unit.
   The Reports column of the transmitter summary displays the name of each generated report file.

11.7 System Tests

VHF Range

The units should be tested to evaluate the performance of the VHF beacon with the receiving equipment that will be used to monitor the beacon during the study. When evaluating the test results, be aware that VHF range performance can vary dramatically. The VHF beacon on the unit, the receiving equipment, and the surrounding environment all affect the actual VHF range. The typical range performance from a collar mounted unit is 1-3 km when monitored from the ground and 10 + km when monitored from the air. A range performance of only a few hundred meters would tend to indicate a problem, so be sure to consult Telonics before deploying any units with severely limited VHF range.

Globalstar Uplink

The units should undergo a test of the Globalstar data-transfer component using the procedure below.

1. Be sure the unit has active satellite service as described in section 11.3.
2. Apply the magnet for at least 35 seconds.
3. During this testing process, make sure the unit has a clear view of the sky and is within the Globalstar simplex coverage area.
4. Remove the magnet to start the predeployment season.
5. Wait at least one hour, which gives the unit time to make two distinct uplink attempts. The unit makes one distinct uplink attempt every half hour while the predeployment season is active.
6. Reapply the magnet to the unit. (However, DO NOT deploy the unit with the magnet in place; the magnet turns off the unit.)
7. Use TDC to retrieve your Globalstar data and to generate a data report. Failure to receive any uplinked messages suggests a problem and these units should not be deployed.

12 GPS-IRIDIUM Systems

The Gen4 GPS-Iridium system follows a user-defined schedule to collect and relay specific types of sensor data to the researcher. The GPS-Iridium system delivers its collected data using the Iridium satellite system, which is operated by Iridium Communications, Inc.

The Iridium satellite system consists of 66 satellites in low Earth orbit (LEO) at an altitude of approximately 780 km. Satellites are distributed in six orbital planes, spaced 30 degrees apart, with 11 satellites in each plane. The orbital planes are inclined 86.4 degrees, providing full global coverage, including the polar regions.

The Iridium satellites form a *network* in space. Each satellite is linked to four other satellites; two to neighboring satellites fore and aft in the same orbital plane, and one satellite in each adjacent plane. Messages transmitted to an Iridium satellite are routed through the network and then downlinked to one of the Iridium *Gateways*. Iridium operates two gateways; one in Wahiawa, Hawaii (primarily for the U.S. military) and the other in Tempe, Arizona for commercial customers. The Iridium gateway is a specialized ground station that provides connectivity to the public switched telephone network (for voice services) as well as the internet (for data services).

Data received by an Iridium satellite is relayed through the network to a gateway in real time. Messages that successfully negotiate these links are delivered directly to the end user within minutes, usually via e-mail. Due to the continuous coverage provided by the satellite network, GPS-Iridium systems never need to wait for a satellite overpass.

Messages are up to 340 bytes in length and are on the air for up to 20 seconds. Best practice usage of the Iridium transceiver limits the amount of data sent to 340 bytes per hour. Users must carefully choose which study data to transfer using this link and which periods during the day permit transmitting.

The Iridium satellite network provides a two-way link for data communication between the deployed unit and the researcher. The two-way nature of the system provides for acknowledgement of transmitted data. Once data have been received successfully by the Iridium network, the acknowledged data do not need to be transmitted again. This results in a significant energy savings over the span of the deployment. The two-way nature of the Iridium system also enables the deployed system to receive user commands, allowing the researcher to change data collection and transmission behaviors while the study is in progress.

Iridium identifies individual transceivers on the satellite network by International Mobile Station Equipment Identity, or IMEI. The programming record generated by Telonics Product Programmer correlates a unit's IMEI with its Telonics computer tracking number (CTN) and VHF beacon frequency, if so equipped.

12.1 Establishing Iridium Message Content

Each GPS-Iridium model contains various sensor options (the sensor, signal processing circuitry, and the firmware) appropriate to that model. Telonics Product Programmer (TPP) can be used to selectively enable sensor data collection and establish a data collection schedule.

All or some specifically selected data can be included for uplink transmission and recovery through the Iridium network. GPS-Iridium systems transmit only data you select by *data type*. For example, you might choose to transmit environmental temperatures but not data from the activity sensor. You might choose to transmit GPS latitude and longitude, but not altitude. As you might expect, the GPS-Iridium system will be able to remain in the field for a longer period of time if small amounts of data are transmitted periodically rather than large amounts of data (over the same time period). When selecting the data to be transmitted, keep in mind that <u>all</u> sensor data are automatically stored in log memory, and if the unit is recovered, these data can be downloaded and processed using Telonics Data Converter (TDC).

12.2 Iridium Transmission Behavior

As sensor data are collected, data designated for transmission are buffered in GPS-Iridium system memory in blocks. When a transmission block becomes full, it also becomes eligible to be transmitted. Because the GPS-Iridium system has a two-way link with the satellite network, data sent to the satellite can be acknowledged, allowing data to be transmitted only as needed. When a data block is transmitted successfully, that data block is then deleted from system memory. If the data block is not transmitted successfully, it remains in system memory and becomes eligible to be re-transmitted at a later time (typically 4 hours). Note that if a new data block becomes eligible for transmission while an older data block is waiting to be re-transmitted, the new data block has priority and is transmitted first (the GPS-Iridium system has a preference for sending the newest data first and oldest data last). In cases in which data blocks remain in memory, unable to be transmitted successfully, their authorization to be transmitted expires after a programmed number of days (typically 10) at which time those blocks are deleted from memory. Note that when data designated for transmission are deleted, sensor data stored in *log memory* are unaffected and still available to be downloaded and processed if the system is physically recovered.

Typically, GPS-Iridium systems are programmed to acquire and transmit sensor data at a “comfortable” rate with a transmission occurring once per day, or once every 2 days, and so on. Occasionally, a situation arises in which the data collection regime produces data at a rate that is so low that transmissions might occur as much as weeks apart. This can happen because the GPS-Iridium system is designed to maximize the amount of user data (payload) carried in each transmission. This is done because there is significant overhead (time and battery energy) involved in connecting to the Iridium network. Generally speaking, more battery energy is available for running the system and transmitting sensor data when the system transmits large payloads less often, than when it transmits small payloads more often. In practice, hearing from fielded units on an infrequent basis can be somewhat unsettling for some researchers. For this reason, the GPS-Iridium system provides a setting that establishes an upper limit on the time between transmissions. This mechanism works by limiting the amount of time sensor data are accumulated into a transmission block. While collecting data, if the programmed amount of time passes with no occurrence of an Iridium transmission, data collection into the current transmission block is declared complete and the block is marked as being ready to transmit. While this feature may increase the researcher’s comfort level by causing the system to transmit more often, it does cause the system to transmit smaller payloads, which increases the amount of battery energy spent on Iridium network connection overhead. Note that in many deployments, the Iridium portion of the power budget is fairly small, so spending a little more on connection overhead doesn’t necessarily present a large penalty in terms of time in the field.

12.3 Establishing Iridium Transmission Schedules

Researchers must determine which times of day are best suited for the GPS-Iridium system to make transmissions to the satellite network. This selection is typically made with animal behavior in mind. In collar configurations, the Iridium antenna is mounted dorsally to provide optimal view of the sky. If the animal typically hides or swims during predictable times of day, then avoid transmitting during these times.

Another consideration for selecting the times of day to transmit is the researcher’s own schedule. If the Iridium message is configured to include the most-recent GPS location, then the researcher might want to know the most-recent location at a certain time of day, perhaps when a visit to the field might be possible.

Because the Iridium satellite network provides continuous coverage, there is no need to select transmission periods based on overpass predictions as is commonly done with Argos systems.

12.4 Controlling Data Acquisition and Transmission Using Geofencing

A geofence can be described as a virtual boundary around a physical geographical space. A geofence is defined by a set of coordinates surrounding an area. Geofences may be established and maintained by a range of GPS-enabled devices including smart phones and devices designed for commercial applications like trucking and farming. Geofencing has also proven to be a useful tool for many animal tracking studies. Although different animal telemetry manufacturers implement geofencing features in different ways, there are basic similarities in that geofencing is a mechanism that allows one or more geographical areas to be defined and provides customized data acquisition and transmission behavior based on whether the study subject is in "inside" or "outside" the geofence(s). A study subject is considered "inside" when inside "any" defined geofence, and is considered "outside" when outside "all" defined geofences. Note that the speed of detecting that an animal has crossed a boundary and is now in or out of a geofenced area will depend on how much time has elapsed between crossing the boundary and acquisition of the next GPS position. Therefore, the rate at which fix attempts are scheduled directly influences the time it will take the unit to detect boundary transitions. Also note that if Quick Fix Pseudoranging (QFP) is used for obtaining positions, QFP data do not provide a resolved position until post processing has occurred and therefore cannot contribute to the detection of boundary transitions.

- Telonics GPS-Iridium systems can support up to 50 geofenced areas. Geofenced areas may overlap.

- Telonics GPS-Iridium systems support multiple geofence types to establish area(s) of special interest:
    - Rectangle – upper left and lower right coordinates are specified.
    - Circle – center point and radius are specified.
    - Polygon – Up to 50 points may be specified. Polygons may be concave or convex, and may be "closed" (last point and first point are the same), or "open" (first point and last point are not the same).

- Separate Inside and Outside schedule sets are provided to control:
    - QFP data acquisition.
    - GPS data acquisition.
    - Underwater data acquisition.
    - Activity data acquisition.
    - Temperature data acquisition.
    - VHF Beacon transmissions.
    - Iridium transmission behavior specified by date range:
        - Transmission interval.
        - Transmission retry delay.
        - Message expiration.

- GPS-Iridium systems may be programmed to assume that they are inside a geofence or outside all geofences until actual position becomes known.

- GPS-Iridium systems may be programmed to limit inside/outside schedule changes for cases in which it is anticipated that the study subject may linger near a fenced area boundary. This feature reduces gaps in activity data collection and underwater data collection resulting from the inside/outside schedule changes.

- Transmission of geofence reports (inside/outside transitions) via Iridium can be:
    - Disabled.
    - Enabled during scheduled Iridium "on" periods and "off" periods.
    - Enabled only during scheduled Iridium "on" periods.
    - Enabled only during scheduled Iridium "off" periods.

- Geofence reports include:
    - Unit serial number.
    - Date and time of the inside/outside transition that triggered the transmission.
    - Latest known GPS data (may be newer than that which originally triggered the notification).
    - Latest known solvable QFP data, if newer than the latest GPS fix by at least 2 hours.
    - Inside/outside status for each defined geofence (per latest known GPS data).

- Original GPS data that triggered the notification, if different from the latest known GPS data.
- Inside/outside status for each defined geofence (per original GPS data), if inside *any* geofence.
- Current temperature

12.5 Controlling Data Acquisition and Transmission Using Auxiliary Schedule Sets

Telonics GPS-Iridium systems take advantage of the two-way communications to alter the behavior of the system in the field. Auxiliary schedules are created in TPP and installed in the unit prior to deployment. Then, while the study is in process, instructions that specify which schedule should be operational can be sent to the GPS-Iridium system for implementation. In addition to the default schedule set, which controls all data acquisition and transmit behaviors, GPS-Iridium systems provide three additional (Auxiliary) schedule sets. Auxiliary schedule sets are useful for increasing or decreasing the intensity of data collection and/or data transmission.

- As with the default schedule set, each Auxiliary schedule set provides the capability to control:
    - QFP data acquisition.
    - GPS data acquisition.
    - Underwater data acquisition.
    - Activity data acquisition.
    - Temperature data acquisition.
    - VHF Beacon transmissions.
    - Iridium transmission behavior specified by date range:
        - Transmission interval.
        - Transmission retry delay.
        - Message expiration.

- GPS-Iridium systems can be directed to execute an Auxiliary schedule (or return to the default schedule) by sending commands over the Iridium data link.

- Commands to GPS-Iridium systems are sent over the Internet using TPP (Telonics Product Programmer) software.

- GPS-Iridium systems check for user commands when transmitting collected data. If the user desires a lower command processing latency, the GPS-Iridium system can be programmed to check for user commands at a rate of choice, even when no data are available to be transmitted. Note that battery life will be affected and additional per-check charges will be incurred when no data are available to be retrieved.

- After receiving a schedule change command, GPS-Iridium systems will switch to the specified schedule immediately and will continue to execute that schedule until directed to do otherwise.

12.6 Priority Events

The GPS-Iridium system provides a feature called the “Priority Event”. Currently, GPS-Iridium systems provide support for four Priority Events; Mortality, Resurrection, Inside Geofence, and Outside Geofence. Priority messages are formatted in binary form so as to be compact. All priority messages contain the system CTN (serial number), Iridium IMEI (obtained from the Iridium email subject line), event description, time the event occurred, and latest known GPS fix time and location at time of transmission. If the QFP option has been purchased, and solvable QFP data are available and newer than the latest GPS fix by at least 2 hours, then the QFP data set will be included as well. If you use metOcean LiNC Data Service, you can receive priority notifications on your regular email address or cellphone. Alternatively, you can configure TDC to check an email server periodically for new messages and then forward priority messages in human-readable text form to any number of email addresses. A sample priority message is shown below:

```
CTN:  689456A
IMEI: 300************
Mortality
@2016.03.15 06:07:05
http://maps.google.com/maps?t=k&q=33.384161,-111.811273
@2016.03.15 04:00:48
```

Resurrection messages are formatted in similar fashion to the Mortality message (only the event description is different).

Geofence messages, like Mortality and Resurrection messages, contain the latest known GPS time and location. Geofence messages also contain the Geofence status consistent with the latest known GPS location. In cases in which a Geofence status change message cannot be delivered right away (and must be delivered later via retry after conditions have changed), the message will also contain the original GPS time, location and Geofence status that triggered the notification.

With the GPS-Iridium system, collected sensor data (temperature, GPS locations, etc.) can only be transmitted during Iridium transmission “on periods”. Priority event messages are unique in that they can be transmitted at *any time*, even when not in an Iridium on period. Note however, that priority events are “throttled” and therefore limited to one transmission of each priority event type per 24 hour period. This is done to limit the impact on battery life (priority events are random in nature and cannot be planned for in battery lifetime estimates).

12.7 Satellite Service for GPS-Iridium Systems

Telonics Gen4 GPS-Iridium systems are compatible with the Short Burst Data (SBD) Service on the Iridium Satellite Network. To receive data from your GPS-Iridium systems, you must purchase service through our partnered service provider metOcean telematics (formerly JouBeh Technologies). GPS-Iridium systems can deliver messages to the metOcean telematics LiNC data service or to a dedicated email account that will receive only Iridium messages.

12.7.1 Option 1: LiNC data service

LiNC is the preferred option for accessing data. With LiNC data service, there is nothing for you to set up or configure; metOcean telematics will simply provide you with a Username and Password. LiNC allows TDC to access your data from multiple locations, and is less likely to experience issues associated with restrictive network firewalls. LiNC also allows you to receive notifications of priority events such as mortalities and geofence changes on your normal email account or cell phone. metOcean telematics charges an extra $5 a month per transmitter to use the LiNC data service. If you decide to use LiNC data service, you can disregard the email instructions in the following section.

12.7.2 Option 2: Dedicated email account

The other option for receiving Iridium data is to use a dedicated email account. The unconverted data will arrive at the dedicated email account, available for download by TDC, which acts as an email client. TDC requires exclusive access to this special email account, so you must not access the account from any other email client (e.g., Microsoft Outlook, Mozilla Thunderbird, a web browser). Other email clients may make modifications (including minor changes not visible to you) to the email that is stored on the server, preventing TDC from downloading your Iridium data.

Your network administrator can use the instructions below to create a new email account on the email server at your agency or company. Iridium will optionally send a copy of your unconverted data to up to four additional email addresses. **Please set one of these additional addresses to iridium.customer@telonics.com just in case you need technical support from Telonics.**

EMAIL INSTRUCTIONS FOR NETWORK ADMINISTRATOR:
Telonics Data Converter (TDC) requires its own dedicated email account to download Iridium data. TDC works with most IMAP and POP3 services, and IMAP is the preferred email service. TDC will leave a

copy of all emails on the POP/IMAP server, so be sure the account has enough space to hold all Iridium emails (each Iridium email is about 1kB). Do not configure any clients (e.g., Microsoft Outlook) to access this email account. TDC should be the exclusive user of this email account. After setting up this account, the following information must be entered into TDC:

1. Type of email server (IMAP or POP3)
2. Name of email server
3. TCP port of email server
4. IMAP folder (if it's something other than "Inbox")
5. Email address
6. Logon User Name
7. Logon Password

Many customers have elected to use a Gmail account instead of relying on the POP/IMAP server they use for their normal email account. Keep in mind that using a Gmail account won't necessarily eliminate all issues associated with network firewalls. Many restrictive networks block access to outside POP and IMAP email servers, including Gmail. If you do decide to create a dedicated Gmail account, be sure to turn on "Access for less secure apps" after logging in with a web browser (https://www.google.com/settings/security/lesssecureapps).

Testing Iridium Message Delivery

Telonics recommends that you test the delivery of Iridium messages to your dedicated email account. Telonics provides access to a web page that allows you to test message delivery without using a real transceiver and at no cost.

Step 1: Open the Iridium email test page

Using your internet browser, navigate to http://www.telonics.com/iridiumTest.php.

Step 2: Configure the test message

- Enter the address of your dedicated Iridium email account.
- Enter the Iridium transceiver IMEI you want to include in the test message. Be sure to use an IMEI that appears in the TPF record included with your system(s).

Step 3: Send Test Message

Once you have a test message configured, the **Send Test Message** button will be enabled. When you click the button, the test message will be sent, and then the button will be disabled.

Step 4: Receive Test Message

After sending the test message, wait a few minutes for the email to arrive at your dedicated email account. Then, use Telonics Data Converter (TDC) to download the test message. When TDC reports that data from your GPS-Iridium system has been downloaded and saved to a file, message delivery is complete. For help in TDC with downloading Iridium email or with any other task, please use TDC Help.

12.7.3 Establishing a Service Account with metOcean telematics & activating transceivers

First establish an account with metOcean telematics (if you don't already have one). They will assign you an account number, which you will need to include in the email below to activate your transceivers. Here is their contact information:

metOcean Telematics
21 Thornhill Drive, Dartmouth, Nova Scotia, CANADA B3B 1R9
Tel: +1-902-468-2505 / Fax: +1-902-468-4438
sales@metocean.com | www.metocean.com

Once you have an account number, please review the TPF Record (programming file that Telonics sends you) to determine which service plan will provide the lowest cost for your study.
Send an email with the following information, replacing the IMEI List, “Plan X” (with the lowest cost plan for your study), the Data Distribution List, and the Account Number.

TO: service@metocean.com
SUBJECT: REQUESTING SBD ACTIVATION
BODY: IMEI List: *(TELONICS WILL EMAIL YOU THIS LIST)*
300000000000001
300000000000002
…
300000000000099
Plan X *(TELONICS WILL EMAIL YOU A TPF RECORD INDICATING THE PLAN WITH THE LOWEST COST)*
Data Distribution List:
Telonics LiNC (if using the Telonics LiNC service)
OR
iridium.customer@telonics.com
Dedicated.Iridium.Email@YourCompany.com *(SEE INSTRUCTIONS IN SECTION 12.7.2)*
Account number:
Your_metOcean_telematics_Account_Number_Here

12.7.4 Deactivating transceivers

If you need to deactivate one or more transceivers, send an email with the following information:
TO: service@metocean.com
SUBJECT: REQUESTING SBD DEACTIVATION
BODY: IMEI List: *(List of IMEIs to deactivate)*
300000000000045
300000000000046
…
300000000000055
Account number:
Your_metOcean_telematics_Account_Number_Here

12.8 Standard Initialization Procedure for GPS-Iridium Systems

1. Before starting the initialization process, ensure that the unit has a clear view of the sky and is physically separated from other units by at least 10 meters.
2. Tune your VHF receiver to the VHF beacon frequency for the unit being initialized.
3. If the magnet is not already applied, apply the magnet until the VHF beacon stops transmitting (usually about 15 - 30 seconds).
4. Remove the magnet and start a stopwatch so that the time required for events below can be recorded.
5. After 5 – 10 seconds, the VHF beacon generates a double pulse (beep) and then stops transmitting. A GPS position fix attempt is now underway.
6. Wait for the VHF beacon to start transmitting again. VHF beacon pulses will resume in 3 or 5+ minutes.
7. Evaluate the results of the initialization attempt by listening to the pulse (beep) pattern of the VHF beacon. The beacon will be transmitting the pattern until the end of the predeployment season. The initialization status patterns are:

Successful Initialization

A 2-beep pattern (beep beep – pause – beep beep – pause – etc.) indicates a successful initialization. This unit is now ready for deployment in its current geographic area.

Unsuccessful Initialization

a. A 3-beep pattern (beep beep beep – pause – beep beep beep – pause – etc.) typically indicates that the unit could not obtain a GPS position even though a full attempt was made to do so. This pattern at 3 minutes into initialization confirms an unsuccessful GPS fix attempt, whereas a 3-beep pattern that begins 5+ minutes into initialization indicates an unsuccessful Iridium transmission. Allow the unit to recover for 20 minutes with the magnet applied. Then, ensure that the unit has a clear view of the sky and retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.

b. A 4-beep pattern may indicate a serious problem with the unit. **Do not deploy the unit.** Reapply the magnet to the unit, and contact Telonics for assistance.

c. A single-beep pattern (beep – pause – beep – pause – etc.) means the battery that powers the GPS and data-transfer components of the system is dead or possibly recovering from a period of extended storage. The pulse period in this condition will correspond to programmed period for "dead battery" provided in the TPF record. Retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.

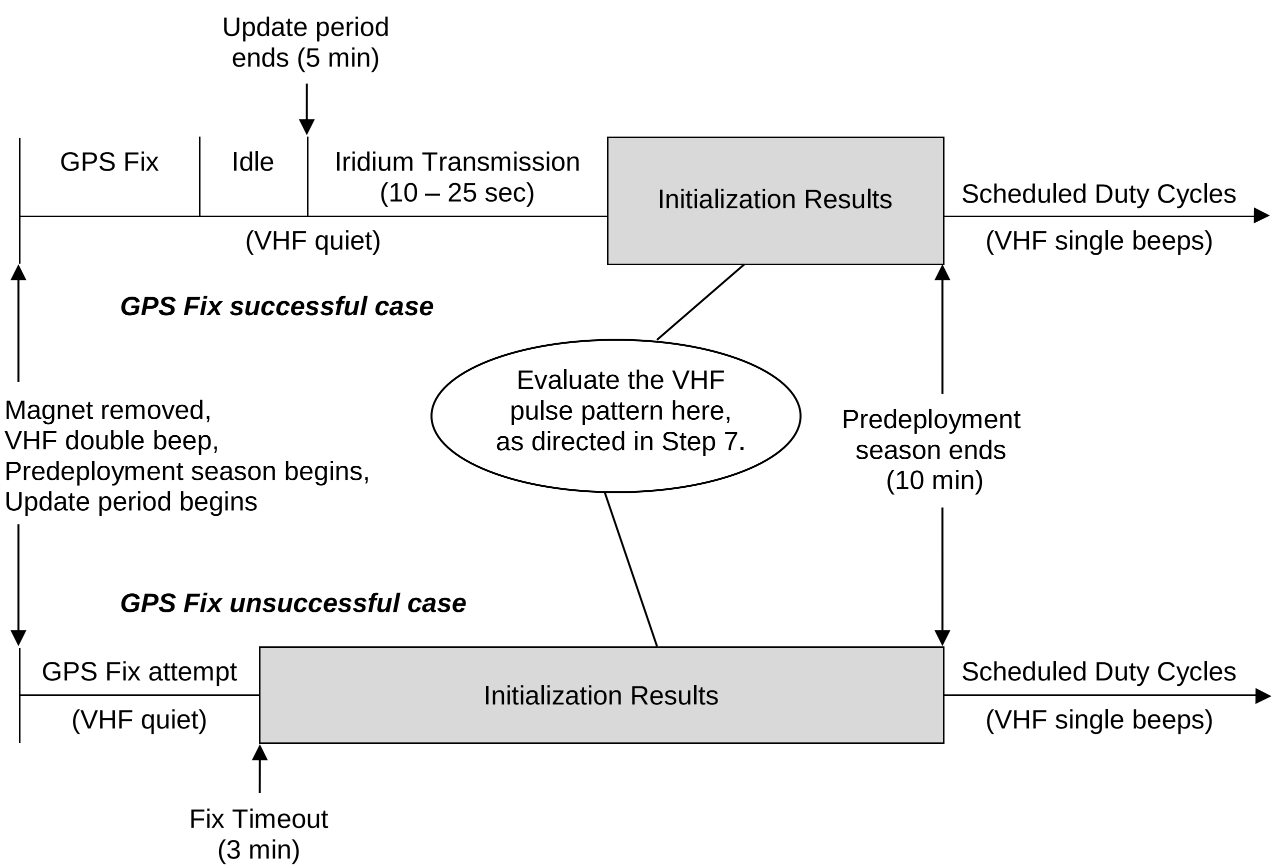


Figure 5: Standard Initialization Timeline for GPS-Iridium Systems

Note that times shown for GPS Fix Timeout, Update period length, and Predeployment season length are typical. Refer to the TPF record for your system for actual values.

12.9 Alternate Initialization Procedure

1. Apply the magnet for at least 35 seconds.
2. During this testing process, make sure the unit has a clear view of the sky and the units are separated by a minimum of ten meters.
3. Remove the magnet to start the predeployment season.
4. Allow the unit to complete its predeployment season and continue making transmissions. Consult the TPF record to determine the duration of the predeployment season.
5. Retrieve data from the metOcean LiNC service or from your dedicated email account as appropriate using TDC. Process the data and then inspect the report(s). Any successful GPS fix indicates proper unit initialization.
6. If there are no data available for retrieval, repeat this procedure at least once (allow the unit to recover for 20 minutes with magnet applied between initialization attempts). If the problem persists, do not deploy the unit. Contact Telonics for assistance.

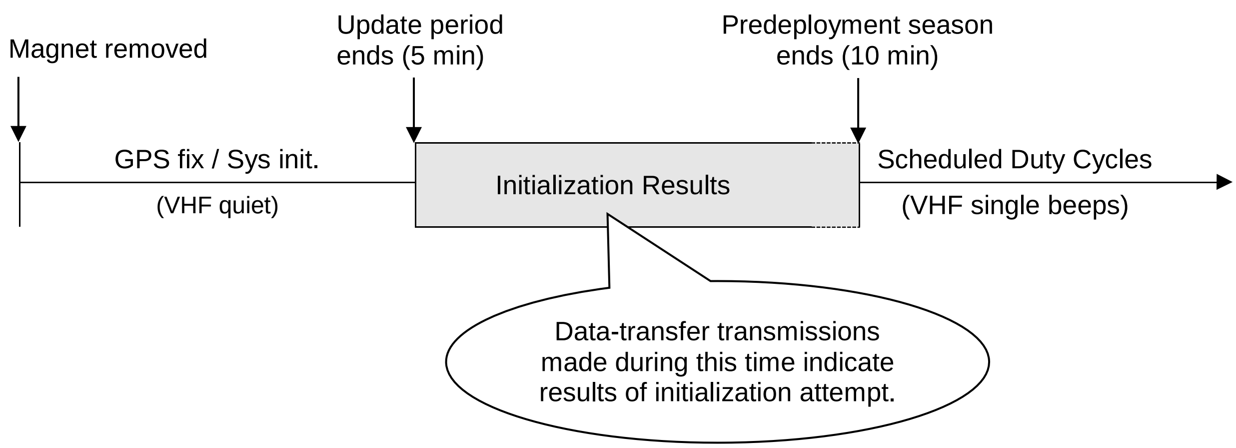


Figure 6: Alternate Initialization Timeline

12.10 Recovering Data from the Iridium Satellite Network

Iridium satellites receive messages transmitted by GPS-Iridium systems and relay the messages back to an Iridium Gateway. The Gateway then delivers the data to the metOcean telematics LiNC service or to one or more email accounts of your choice. Telonics Data Converter (TDC) retrieves these messages and processes the data they contain.

Before deploying GPS-Iridium systems, you must create an account with the Iridium service provider and then activate the Iridium transceivers onboard your GPS-Iridium systems. The activation procedure specifies how your GPS-Iridium systems will deliver their data (via the metOcean telematics LiNC service, or via conventional email). See section 12.7 for detailed instructions.

To set up TDC to process data from your GPS-Iridium systems, follow the procedure below. Refer to TDC online help as needed.

1. Organize TPF files.
   Create a folder to hold the TPF file(s). Place the TPF file(s) for your units in this folder.
2. Set Options.
   From the Options Menu, select "File Locations..." to view the Options Window. Set the preferred

directory for TPF files and the report destination folder by typing the full path in the provided field. Select a directory by pressing the "Browse" button next to the field. From the Options Window, view different groups of options by clicking the tabs near the top of the window. Once the program options have been determined, press the "OK" button to save the changes.

3. Search for new transmitters.
   From the Iridium tab in the Main Window, press the "Add or Edit Transmitters" button to launch the Transmitters Window. From this window, press the "Add..." button, which causes TDC to search for new GPS-Iridium transmitters. TDC searches for new transmitters by looking inside each TPF in your preferred TPF directory. Once TDC has finished searching the folder, press the "OK" button to add the new transmitters. If TDC finds multiple TPF files for the same transmitter, activate the desired TPF file by selecting the transmitter and double-clicking the TPF file from the list of available parameters. Press the "OK" button when finished so that TDC will remember these new transmitters.

4. Process Iridium email.
   Click the link to “Download Iridium email”. The first time you do this, you must specify the folder TDC uses to store the downloaded messages. You must also click the Configure… button to specify TDC’s server access parameters. Select the appropriate account type: Gmail (IMAP), LiNC download, IMAP server, or POP server. Then, enter access/authentication parameters (username, password, and so on) as required. After TDC downloads email, it offers to process the new messages. Optionally, you may request that TDC process all emails received to date. When TDC has finished the conversion, the results section displays the name of the generated report. This file will be located in the report destination folder.

12.11 System Tests

VHF Range

The units should be tested to evaluate the performance of the VHF beacon with the receiving equipment that will be used to monitor the beacon during the study. When evaluating the test results, be aware that VHF range performance can vary dramatically. The VHF beacon on the unit, the receiving equipment, and the surrounding environment all affect the actual VHF range. The typical range performance from a collar mounted unit is 1-3 km when monitored from the ground and 10 + km when monitored from the air. A range performance of only a few hundred meters would tend to indicate a problem, so be sure to consult Telonics before deploying any units with severely limited VHF range.

Iridium Uplink

The units should undergo a test of the Iridium data-transfer component using the procedure below.

1. Be sure the unit has active satellite service as described in section 12.7.
2. Apply the magnet for at least 35 seconds.
3. During this testing process, make sure the unit has a clear view of the sky.
4. Remove the magnet to start the predeployment season.
5. Wait for the predeployment season to end (typically 10 minutes).
6. Reapply the magnet to the unit. (However, DO NOT deploy the unit with the magnet in place; the magnet turns off the unit.)
7. Use TDC to retrieve your Iridium data and to generate a data report. Failure to receive an uplinked message suggests that there could be a problem. In this case, the unit should be allowed to recover for 20 minutes with magnet applied and then the test should be repeated. If the unit fails the test 3 times consecutively, then the unit should not be deployed and you should contact Telonics for assistance.

12.12 Full Reprogramming over the Iridium Link

Gen4 TGW-4x77-4 and TGW-4x79-4 systems (running SECO1581 firmware or newer) support full reprogramming of user parameters over the Iridium link. Any user parameter setting that can be changed with the programming cable can also be changed over the Iridium link. By trying a couple different configurations, you can optimize your study without having to run separate pilot studies. This feature also allows you to establish geofences after observing the locations of the deployed units. Keep in mind that the unit consumes energy and incurs service charges when it is fully reprogrammed over the Iridium link, so you may want to limit how many times you reprogram your units.

To update user parameters in a fielded unit, you will need access to a computer with TPP (Telonics Product Programmer) and internet connectivity. The following steps outline the update process:

- Prepare a .TPF file containing new user parameters.
- “Send TPF via Iridium” from the Telonics Product Programmer File menu
- Save the .TPF file.
- The fielded unit contacts the Iridium satellite network.
- Receive notification from the fielded unit that the update was performed.
- Update Telonics Data Converter with the new .TPF file for the fielded unit.

Prepare a .TPF file containing new user parameters:

You must start with a TPF file that has already programmed the unit(s). There is information inside this file that will be needed to support reprogramming over Iridium; you cannot start with a blank TPF file.

Send TPF via Iridium:

From the File menu in TPP, choose “Send TPF via Iridium”. Select which unit you would like to reprogram and then click the Send button.

Save the .TPF file:

Save the file after sending it over Iridium. This file contains the only record detailing how your unit is programmed and is a good choice for the .TPF to use should your unit require additional programming updates in the future.

Fielded unit contacts the Iridium satellite network:

When the fielded unit contacts the Iridium network to offload collected data or to perform a mailbox check, the update messages will be transferred to the fielded system one message at a time. You will receive additional automated emails from Iridium to your dedicated email or LiNC account each time a message is successfully transferred. Note that because reprogramming relies on the targeted system establishing contact with the Iridium satellite network, a delivery latency will occur.

Note that in some cases, not all update messages will be delivered successfully in the first contact. When the fielded system next contacts the Iridium system to offload collected data or perform a mailbox check, transfer of update messages will resume. This process will continue until all update messages have been delivered.

The queued messages required for reprogramming the unit will remain queued at the Iridium for a maximum of 5 days. If the messages have not been retrieved within 5 days, they will be discarded.

Receive notification from the fielded unit that the update was performed:

After the fielded unit receives all messages from the Iridium link, the unit will switch to that new TPF file if it is valid. The unit will then send a priority message indicating that is now running the new TPF file. If the entire TPF file is not properly received over the Iridium link, the unit will send a priority message indicating that it could not switch to the new TPF file. In this case, the unit will continue to operate with the same settings as before you attempted the reprogramming.

Update Telonics Data Converter with the new .TPF file for the fielded unit:

After you have successfully reprogrammed your unit, be sure to update the transmitter settings in Telonics Data Converter so that it can use the proper TPF file to convert your data.

12.13 Releasing the collar before the programmed release date

TGW-4x77-4 and TGW-4x79-4 GPS-Iridium systems equipped with a CR-5 or CR-7 collar release device provide a mechanism by which the collar can be released at user request. For situations in which the researcher wishes to release the collar before the planned release date, TPP (Telonics Product Programmer) can be used to send a “release command” to one or more targeted systems.

In order for this feature to work properly:

- The collar must be specially built to optimize radio communications between the GPS-Iridium system and the CR-5/CR-7.
- The GPS-Iridium system must be programmed with the CTN (serial number) of the CR-5/CR-7 installed on the collar. The .TPF file used to program the GPS-Iridium system must be saved and must remain available for TPP to use when initiating the release command.

When the need arises to perform a release on one or more CR-5/CR-7 equipped GPS-Iridium systems in the field:

1. Open TPP and load the .TPF file for the system to be released. This is required for system security reasons.
2. Click File | Trigger Collar Release.
3. Select a system to be released and click Send.

TPP will then send the command over the Internet to the Iridium gateway for dispatch to the selected system. The release message will remain queued at the Iridium gateway until such time as the targeted system sends a data collection or priority message, or performs a mailbox check (a procedure that only checks for user command messages). The release command will then be transferred to the targeted GPS-Iridium system and then executed immediately. Because the transfer of the release command relies on the targeted system establishing contact with the Iridium satellite network, a processing latency will occur.

13 GPS-SST Systems

The Gen4 GPS-SST unit uses a two-way spread spectrum radio modem providing direct data download and recovery capability for a GPS-SST system. Data transfer is similar to a two way FM modem, but uses newer Spread Spectrum technology that eliminates the requirement for individually licensing each transceiver as a mobile radio station and therefore eliminates complicated licensing requirements for the user. Telonics SST equipment communicates in the 902-928 MHz Industrial, Scientific, and Medical (ISM) band and is certified for use in the United States by the Federal Communications Commission (FCC) and in Canada by Industry Canada (IC).

The data transfer system is composed of two spread-spectrum transceivers. One spread-spectrum transceiver is integrated with the deployed Gen4 system that acquires GPS and sensor data. The other transceiver is an SST-901M that is paired with an antenna and connected to a portable computer. The researcher uses Telonics Data Converter (TDC) software to instruct the SST-901M to recover data from the deployed GPS-SST unit.. The SST data link is an extremely efficient way to recover data as only a few percent of the unit’s on-board battery capacity is used to transfer data in typical applications leaving as much as 98% of the energy for collecting GPS positions, GPS-QFP position fixes and other biologically significant data.

The GPS-SST unit deployed on the animal can be programmed using TPP to “listen” for user commands sent from the SST-901M during specific time periods. Upon receiving a download command, the unit can transfer GPS and sensor data to the SST-901M at line of sight (LOS) ranges of one to four miles (1.6-6.4 km) on the ground and up to eight miles (12.8 km) to an aircraft. The system has an effective data transfer rate of approximately 8100 bits/sec under typical download conditions as measured in field tests on animals. That rate corresponds to a transferring 720 GPS fixes (30 days X 1 GPS fix per hour) in 22 seconds. Unlike many satellite based data recovery systems that recover only selected portions of the total data collected, Gen4 SST systems recover the complete contents of the log memory over the SST radio link. Therefore the data recovered from the unit deployed in the field is the same as the log data recovered using TDC directly connected to the unit with a TSC-7 cable. The system can be operated on the ground using one of two models of handheld omnidirectional antennas (CM 008828-900 or CM007724-900) or from an aircraft using an aircraft belly-mounted omnidirectional blade antenna (CM 007724-900).

Typical usage of the system is to program the unit to be deployed in the field with a block of time (4-8 hours) from 1 to 4 times per month when the unit will listen for user-initiated commands from the SST-901M. The user goes to the field during one of these programmed “listening” periods and first detects the system using the VHF system. Using conventional VHF telemetry techniques, the user moves into range to download the data using the SST data transfer system. The user can also choose to program a series of days each month to avoid inclement weather conditions. If weather prevents the download of data one day, the next “listening” period can be used. After downloading data from the deployed unit, the user can optionally use the “black out” command to cancel the rest of the listening period.

13.1 Radio Frequency Licensing in the ISM (Industrial, Scientific, and Medical) band

Both SST units (the unit on the animal, and the SST-901M) deployed as part of the GPS-SST system comply with Part 15 of the FCC rules and are certified with the FCC and IC for legal operation when used in accordance with approved antennas, the operating setup and instructions provided in this manual. *The user does not need to apply for a license when using certified equipment.* The SST-901/SST-901M RF system employs frequency hopping spread-spectrum communication technology. While communicating, these units use a set of 50 frequencies that occupy a 5.1 MHz segment within the 902 - 928 MHz ISM (Industrial, Scientific, and Medical) band. The SST-901/SST-901M can be programmed to operate using one of the following frequency sets:

Set 1: 902.102 – 907.100 MHz
Set 2: 908.120 – 913.220 MHz
Set 3: 915.260 – 920.360 MHz

Set 4: 922.808 – 927.908 MHz

Studies conducted in the United States or Canada may use any of the four frequency sets. Studies conducted outside the United States and Canada may be restricted to certain frequency set(s). It is the user's responsibility to coordinate with the appropriate governing organization in the county of deployment to determine whether or not the SST-901/SST-901M can be imported and deployed. In cases in which one or more frequency sets are prohibited, and if required as a condition of importation/deployment, equipment models can be customized so as to allow only authorized frequency sets to be selected for use. Generally speaking, it doesn't matter which frequency set is used as long as it is authorized for use in the deployment area. The GPS-SST system employs features in its communication strategy to cope with interference and ensure reliable data transfer. However, if you are aware that other radio communications are being conducted in or near the study area, and you are fortunate enough to know the frequency range of these potentially interfering signals, you should select a frequency set that avoids overlap completely or as much as possible. Both the GPS-SST unit (the deployed unit) and SST-901M **must** be programmed to use the **same** frequency set (otherwise communications will not be possible between the two units).

13.2 Standard Initialization Procedure for GPS-SST Systems

1. Before starting the initialization process, ensure that the unit has a clear view of the sky and is physically separated from other units by at least 10 meters.
2. Tune your VHF receiver to the VHF beacon frequency for the unit being initialized.
3. If the magnet is not already applied, apply the magnet until the VHF beacon stops transmitting (usually about 15 - 30 seconds).
4. Remove the magnet and start a stopwatch so that the time required for events below can be recorded.
5. After 5 – 10 seconds, the VHF beacon generates a double pulse (beep) and then stops transmitting. A GPS position fix attempt is now underway.
6. Wait for the VHF beacon to start transmitting again. VHF beacon transmissions will resume in 15 seconds to 2 minutes.
7. Evaluate the results of the initialization attempt by listening to the pulse (beep) pattern of the VHF beacon. The beacon will be transmitting the pattern until the end of the first update period. The initialization status patterns are:

   Successful Initialization

   A 2-beep pattern (beep beep – pause – beep beep – pause – etc.) indicates a successful initialization. This unit is now ready for deployment in its current geographic area.

   Unsuccessful Initialization

   a. A 3-beep pattern (beep beep beep – pause – beep beep beep – pause – etc.) typically indicates that the unit could not obtain a GPS position even though a full attempt was made to do so. Be sure the unit has a clear view of the sky and then retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.
   b. A 4-beep pattern may indicate a serious problem with the unit. **Do not deploy the unit.** Reapply the magnet to the unit, and contact Telonics for assistance.
   c. A single-beep pattern (beep – pause – beep – pause – etc.) means the battery that powers the GPS and data-transfer components of the system is dead or possibly recovering from a period of extended storage. The pulse period in this condition will correspond to programmed period for "dead battery" provided in the TPF record. Retry the initialization. If the unit continues to fail initialization, contact Telonics for assistance.

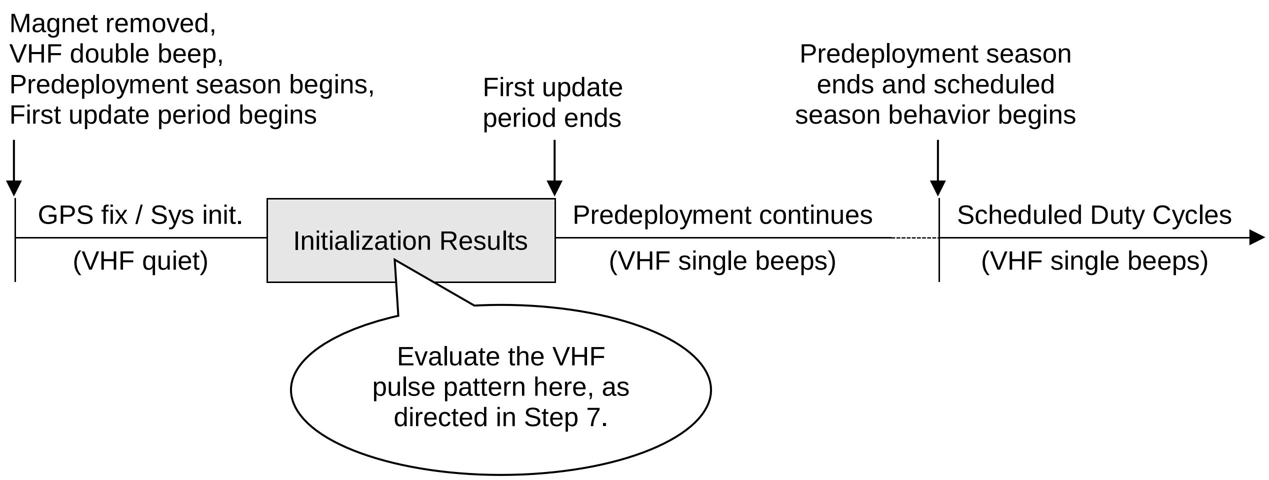


Figure 4: Standard Initialization Timeline for GPS-SST Systems

13.3 System Tests

VHF Range

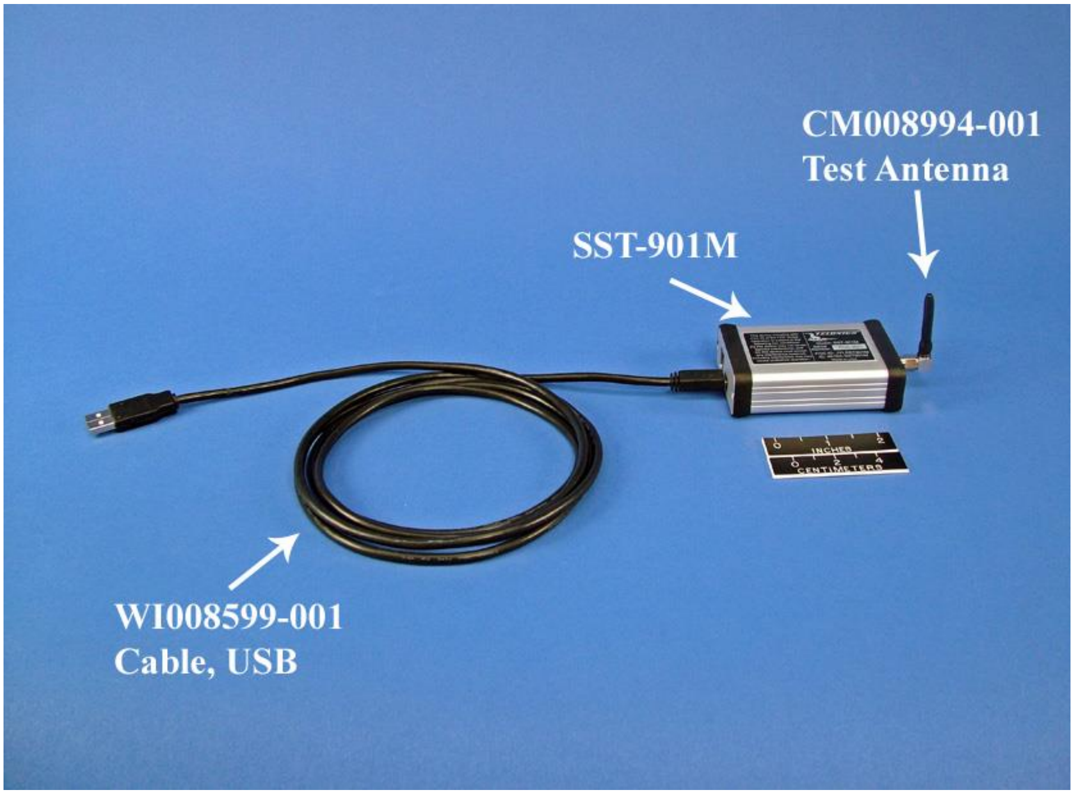
The units should be tested to evaluate the performance of the VHF beacon with the receiving equipment that will be used to monitor the beacon during the study. When evaluating the test results, be aware that VHF range performance can vary dramatically. The VHF beacon on the unit, the receiving equipment, and the surrounding environment all affect the actual VHF range. The typical range performance from a collar mounted unit is 1-3 km when monitored from the ground and 10 + km when monitored from the air. A range performance of only a few hundred meters would tend to indicate a problem, so be sure to consult Telonics before deploying any units with severely limited VHF range.

SST Link Tests

The units should undergo a test of the SST data-transfer component using the procedure described in detail in the following section.

13.4 Recovering Data over Spread-Spectrum link

The procedure described below can be used to test the SST data transfer link prior to deployment of the units. The test involves a setup procedure for TDC and connecting the SST-901M to an antenna and a laptop computer. As described below, the system can be tested using the test antenna (CM-008994-001) at short range (10 meters). The test setup is shown with short range test antenna connected directly to the SST-901M and a USB cable that will be connected to a laptop computer running TDC to download data.



The same test could be run with the approved handheld antennas, or the antenna installed on the aircraft. The hardware setup for actual field data collection is described in Appendix 9 Section 3.0. When recovering data from deployed units, the VHF transmitter is typically used to locate the unit in the field and move close enough to download data using the spread spectrum data link. This distance may vary under field conditions from a few hundred meters to 10+ miles.

To set up TDC to convert Argos DS files, use the procedure below.

1. Set Options.
   From the Options Menu, select "File Locations..." to view the Options Window. Set your preferred directory for spread-spectrum files and your report destination folder by typing the full path in the provided field. The spread-spectrum files directory will hold all of the data that you downloaded over the SST link (e.g., TSF files, statistics files, diagnostic information). The report directory will hold your final converted reports. You can also select a directory by pressing the "Browse" button next to the field. From the Options Window, you can view different groups of options by clicking the tabs near the top of the window. Once you have finished adjusting the program options, press the "OK" button to save your changes.

2. Import or Add SST Units.
   From the SST tab in the Main Window, press the "Configure unit and session settings" link or alternatively select "Unit & Session Settings..." from the "Spread Spectrum" menu to launch the Spread Spectrum Unit & Session Settings Window. From this window, press the "Import..." button and then browse to the TPF file that was used to program your SST units. TDC will then import the connection settings for each unit in that TPF file. If you do not have a TPF file for the units, you can also add units by selecting "[Add new unit]" from the list of units and then manually type in the connection settings.

3. Specify Tasks to Perform in Next SST Transfer Session.
   From the Spread Spectrum Unit & Session Settings Window, select an SST unit from the list. The "Next Transfer Session" section of the window lists all optional tasks that you can perform during the next SST session with the selected unit. Be sure to specify the tasks for each unit to which you plan to connect. Consider planning and selecting these tasks ahead of time (in the office) before heading out to download data in the field. When you are finished importing SST units and selecting tasks for the next transfer session, press the OK button to close the Spread Spectrum Unit & Session Settings Window and save your changes.

4. Connecting Hardware and Preparing to Test.
   Connect the SST-901M to the PC using the supplied USB cable. Note that the first time you connect the SST-901M you may be prompted to install a driver. Connect the test antenna to the SST-901M and separate the SST-901M and the units under test by at least 20 meters. To begin the download test, remove the magnet prior to attempting communications. Once you remove the magnet, the unit will enter a predeployment period (typically 4 hours) in which you will be able to conduct SST transfer sessions. During predeployment, the unit will also collect GPS and/or QFP locations (typically once an hour). When the unit is actively trying to collect a GPS or QFP location, you will not be able to conduct an SST session and the VHF beacon will be silent

5. Download SST Data.
   From the SST tab in the Main Window, press the "Download file over spread-spectrum link" hyperlink or select "Transfer Session..." from the "Spread Spectrum" menu to launch the Spread Spectrum Transfer Session Window. Select a unit from the list and press the Connect button. TDC will attempt to connect to the unit and complete the tasks that you have previously specified for this unit. If TDC has stored a TPF tile for the selected unit, the SST Active and VHF Active fields will tell you the next time the selected unit is scheduled to listen for SST communications. During an SST transfer session, the window displays progress for each task and the signal strength and transfer rate of the link. After completing an SST session, TDC displays a message indicating whether the session was successful. If the session was successful, TDC updates the Results tabs to show information about the results of the last transfer session. The "Downloaded Data" tab shows the name of the file that contains your downloaded data (including GPS/QFP locations). See the next step for instructions on converting this .tsf file into a report. If the session failed, please try to connect to the unit again.

6. Convert SST Data.
   From the Spread Spectrum Unit & Session Settings Window, select the unit for which you would like to convert data (if you have not already done so). The "Downloaded Data" tab will list the SST file (.tsf) that you downloaded during the last SST transfer session with that unit. Click the filename of the downloaded file and TDC will offer to convert the file. The Main Window displays conversion progress in the Results field of the SST tab. After TDC has finished converting the file, the Results field displays the name of the generated report. TDC stores the final report (.csv file) in the reports directory that you specified in the File Locations tab of the Options Window.
   If your unit supports QFP locations, be sure that your PC is connected to the Internet when you convert the data (.tsf file). You do not need an Internet connection to download the SST data.

14 Service Commitment

Since 1970, Telonics has built a reputation based on product quality, product support, service, and customer satisfaction. Telonics strives to produce the highest quality products, and to support those products accordingly.

Because of extreme conditions and the unpredictable nature associated with most telemetry applications, problems occasionally arise. Most problems can be resolved quickly. In all cases, we hope to be able to work in partnership with users to resolve problems to the user's satisfaction and to uphold our demonstrated commitment to excellence. If problems should arise, all products must be returned to our factory for failure analysis.

14.1 Acceptance of Equipment and Warranty

All warranty information is also available on the website and your acceptance of the units and use of the equipment constitute the acceptance of the warranty and its restrictions and limitations.

If you have any questions concerning the operation of the units please contact Telonics prior to deploying units on animals so we can help resolve any confusion and thus assure a successful experiment.

Telonics warrants its products to be free from defects in material and workmanship for a period of one year from the date acquired. Telonics does not warrant batteries.

If a defect occurs, return the equipment to us within the proper time frame at the following address: TELONICS, 932 E. IMPALA AVENUE, MESA AZ USA 85204-6699. Damage to any equipment resulting from misuse, accidents, unauthorized service, electrostatic discharge, extreme conditions, or other causes, is excluded from this warranty. Telonics does not assume responsibility for loss or damage to equipment during shipment. Telonics does not assume responsibility for delays resulting from shipment on commercial or private carriers. We insure all equipment shipped from our facility and suggest that shipments to Telonics also be insured.

Upon the timely return to our facility, if defective, the product will be replaced or repaired at our discretion at no cost to the customer. This remedy is the exclusive remedy. This product is supplied without any further warranties or conditions, expressed or implied, including warranties of merchantability, quality or fitness for particular reason or those arising by laws, statutes or trade usage or course of dealing.

The entire risk, as to the results and performance of the product, is assumed by the customer. Neither Telonics, nor its suppliers, shall have any liability to the customer or any other person or entity for any indirect, incidental, special, or consequential damage whatsoever, regardless whether Telonics has been told of the possibility of such damages or that such damages might be foreseeable. Telonics has no responsibility or liability for the claims of any third party. The maximum aggregate to the customer, of Telonics and its suppliers, shall not exceed the amount paid by the customer for the product.

APPENDIX 1: GPS-Argos and GPS-SOB System Specifications

TGE-4xx(H)-x Oceanographic and Meteorological Electronics Only Configurations

GENERAL SYSTEM SPECIFICATIONS

INPUT VOLTAGE RANGE: Option 450 2.50 Vdc to 5.50 Vdc standard
2.70 Vdc to 5.50 Vdc during log-memory download

Option 460 6.00 Vdc to 28.0 Vdc

QUIESCENT CURRENT: Option 450 <12 µA. Standard

Option 460 1 mA at 6.0 Vdc, 600 µA at 14.0 Vdc, 500 µA at 28.0 Vdc

TIMING ACCURACY: Timing is synchronized to GPS time when available. If the GPS time is not available then internal timing accuracy is:
6 min/year at 25˚ C
30 min/year -20 to +40˚ C
47 min/year -40 to +70˚ C

MEMORY CAPACITY: Capable of storing 100K fixes in nonvolatile flash memory in association with other sensor data.

ARGOS TRANSMISSIONS: System can be operated in a mode where unit transmits only during satellite overpasses based on the GPS location and the orbital parameters installed prior to deployment.

GPS RECEIVER SPECIFICATIONS

	TGE-4xx(H) µGPSI-20 electronics	**TGE-4xx(H)-2 µGPSI-22 electronics**	**TGE-4xx(H)-3 µGPSI-23 electronics**
Number of channels	12	20	Dynamically Adaptive
Tracking sensitivity	-156 dBm	-159 dBm	-163 dBm
Acquisition sensitivity	-142 dBm	-145 dBm	-147 dBm
Time to First Fix (TTFF)	40 seconds	35 seconds	35 seconds
Quick Fix Pseudoranging (QFP)	N/A	5 seconds typical	3 seconds typical
Option 450 Navigation Current			
5.50Vdc Vin	50mA avg, 60mA peak	40mA avg, 48mA peak	25mA avg, 30mA peak
3.40Vdc Vin	50mA avg, 60mA peak	40mA avg, 48mA peak	35mA avg, 42mA peak
3.00Vdc Vin	62mA avg, 74mA peak	50mA avg, 60mA peak	37mA avg, 45mA peak
2.50Vdc Vin	70mA avg, 84mA peak	55mA avg, 66mA peak	43mA avg, 52mA peak
Option 460 Navigation Current			
6.00Vdc Vin	50mA avg, 60mA peak	40mA avg, 48mA peak	25mA avg, 30mA peak
14.00Vdc Vin	27mA avg, 33mA peak	22mA avg, 27mA peak	14mA avg, 17mA peak
28.00Vdc Vin	18mA avg, 22mA peak	15mA avg, 18mA peak	9mA avg, 11mA peak

RF INPUT IMPEDANCE: 50 Ω

Datum: WGS-84

ARGOS CERTIFIED TRANSMITTER SPECIFICATIONS:

RF OUTPUT IMPEDANCE: 50 Ω

OPERATING FREQUENCY: ARGOS Frequencies
401.6300MHz to 401.6800MHz in 1kHz Steps
Brazilian SCD-1, Channels C1 to C9
401.6180MHz to 401.6220MHz in 500Hz Steps

FREQUENCY STABILITY: ± 0.5 ppm maximum from -30˚ to +70˚ C
± 2.0 ppm maximum from -40˚ to -30˚ C

INITIAL FREQUENCY ERROR: ± 0.5 ppm maximum at +23˚ C, ± 2˚ C

AGING: ± 2.0 ppm maximum after 1 year

RF POWER OUT: Standard Power Versions:

400mW (+26dBm) or 500mW (+27dBm) nominal into 50 Ω
(User selectable using TPP programming software)

High Power Version (H VERSION):

800mW (29 dbm) ±1dB nominal into 50 Ω

TRANSMIT CURRENT:

	TGE-4xx(H) **µGPSI-20 electronics**	**TGE-4xx(H)-2** **µGPSI-22 electronics**	**TGE-4xx(H)-3** **µGPSI-23 electronics**
Option 450			
400mW (+26dBm) at +25°C into 50 Ω			
5.50Vdc Vin	440mA typical, 490mA max	250mA typical, 285mA max	250mA typical, 285mA max
3.80Vdc Vin	520mA typical, 580mA max	370mA typical, 410mA max	370mA typical, 410mA max
3.65Vdc Vin	520mA typical, 580mA max	385mA typical, 425mA max	385mA typical, 425mA max
3.00Vdc Vin	550mA typical, 610mA max	475mA typical, 525mA max	475mA typical, 525mA max
2.50Vdc Vin	690mA typical, 760mA max	580mA typical, 640mA max	580mA typical, 640mA max
500mW (+27dBm) at +25°C into 50 Ω			
5.50Vdc Vin	530mA typical, 560mA max	285mA typical, 560mA max	285mA typical, 560mA max
3.80Vdc Vin	625mA typical, 675mA max	420mA typical, 470mA max	420mA typical, 470mA max
3.65Vdc Vin	625mA typical, 675mA max	440mA typical, 490mA max	440mA typical, 490mA max
3.00Vdc Vin	675mA typical, 740mA max	540mA typical, 600mA max	540mA typical, 600mA max
2.50Vdc Vin	845mA typical, 925mA max	660Ma typical, 730mA max	660mA typical, 730mA max
800mW (+29dBm) at +25°C into 50 Ω			
5.50Vdc Vin	800mA typical, 880mA max	510mA typical, 560mA max	510mA typical, 560mA max
3.80Vdc Vin	940mA typical, 1030mA max	710mA typical, 780mA max	710mA typical, 780mA max
3.65Vdc Vin	940mA typical, 1030mA max	745mA typical, 820mA max	745mA typical, 820mA max
3.00Vdc Vin	1035mA typical, 1135mA max	930mA typical, 1030mA max	930mA typical, 1030mA max
2.50Vdc Vin	1250mA typical, 1350mA max	1215mA typical, 1315mA max	1215mA typical, 1315mA max
Option 460			
400mW (+26dBm) at +25°C into 50 Ω			
6.00Vdc Vin	450mA typical	250mA typical	250mA typical
14.00Vdc Vin	185mA typical	125mA typical	125mA typical
28.00Vdc Vin	100mA typical	70mA typical	70mA typical
500mW (+27dBm) at +25°C into 50 Ω			
6.00Vdc Vin	535mA typical	285mA typical	285mA typical
14.00Vdc Vin	220mA typical	150mA typical	150mA typical
28.00Vdc Vin	120mA typical	80mA typical	80mA typical
800mW (+29dBm) at +25°C into 50 Ω			
6.00Vdc Vin	765mA typical	525mA typical	525mA typical
14.00Vdc Vin	315mA typical	220mA typical	220mA typical
28.00Vdc Vin	170mA typical	120mA typical	120mA typical

Note 1: At +70°C, transmit current will increase by approximately 10% from the +25˚ C measurement. Conversely, at -40°C it will decrease by approximately 10% from the +25˚ C measurement.

Note 2: Transmit current and RF power out are sensitive to VSWR. Both can be degraded significantly if the antenna or antenna coax are of poor quality or not correctly tuned and matched to 50 Ω in the ARGOS/Brazilian frequency band.

SPURS AND HARMONICS: <-40dBc -60dBc typical (Coherent Spurious)
<-50dBc, -60dBc typical (Non-coherent spurious)

VHF TRANSMITTER COMPONENT SPECIFICATIONS (TGE-401, TGE-401-2, and TGE-401-3 only)

AVAILABLE FREQUENCY OPTIONS:
Option 702 134-139 MHz
Option 705 140-154 MHz
Option 707 146-160 MHz
Option 715 156-172 MHz
Option 720 160-177 MHz
Option 740 174-192 MHz
Option 750 191-210 MHz
Option 760 210-237 MHz

Note: The frequency can be programmed in 100Hz steps within a given frequency range.

FREQUENCY STABILITY: Better than ±3ppm at room temperature
±5 ppm total tolerance over full temperature range

OPERATING TEMPERATURE: -40˚ to + 70˚ C

PULSE WIDTH: Programmable (10 to 250 msec)

PULSE PERIOD: Programmable (560 to 5000 msec)

5 separate pulse period values selectable:
- Period 1 (indicates last GPS fix successful)
- Period 2 (indicates last GPS fix QFP, if equipped)
- Period 3 (indicates last GPS fix unsuccessful)
- Mortality period (if no motion for selected time)
- Dead Battery period

AVAILABLE SENSORS: Mortality Sensor (parameters are user programmable)

TRANSMITTER TIMING: Programmable seasons and duty cycles.

POWER OUTPUT: Programmable Low/Medium/High power
Effective Isotropic Radiated Power (EIRP) varies, depending on packaging, antenna configuration, and immediate environmental conditions.
* California Users: This transmitter meets the California requirement of EIRP <0.009W for all configurations.

EMISSION DESIGNATOR: 2k00P0N

HARMONIC SUPPRESSION: Better than 30dB (>40 dB typical)

SPURIOUS EMISSIONS: <-35 dBc at 10kHz offset from carrier

PEAK TRANSMIT CURRENT: Med/Hi: Medium = 25mA High = 34mA

FREQUENCY: Aging: <2ppm/year
Shock: <1ppm 3000g x 0.3ms x ½ sine x 3 dir

VSWR: RF output stable to 10:1 VSWR, all phases
Radiated harmonic levels are degraded with poor load VSWR.
Spurious emission specification maintained for >10:1 VSWR

PROGRAMMING Transmitter parameters programmable via antenna "1-pin" interface and Telonics TPP software.

PACKAGING SPECIFICATIONS Electronics-only packages for oceanography and meteorology are in hermetically sealed metal canisters containing the electronics, batteries, and all interconnects. Glass to metal feedthru technology is used to exit antennas and power. This packing is hermetic and can be tested utilizing a helium leak bomb test for hermeticity to assure < 1 part in 10^6 atmospheric CC per second.

TGW-xxx(H)-x Terrestrial Wildlife Configurations

These TGW-xxx(H)-x specifications are applicable to both GPS-Argos and GPS-SOB Store on Board Systems, but specifications relating to Argos do not apply to GPS-SOB systems (as noted below).

GENERAL SYSTEM SPECIFICATIONS

TIMING ACCURACY: Timing is synchronized to GPS time when available. If the GPS time is not available then internal timing accuracy is:
6 min/year at 25˚ C
30 min/year -20 to +40˚ C
47 min/year -40 to +70˚ C

AVAILABLE SENSORS: Mortality, Activity, Temperature, Low Voltage

MEMORY CAPACITY: Capable of storing 100K fixes in nonvolatile flash memory in association with other sensor data.

ARGOS TRANSMISSIONS: System can be operated in a mode where unit transmits only during satellite overpasses based on the GPS location and the orbital parameters installed prior to deployment. (GPS-Argos systems only).

GPS RECEIVER SPECIFICATIONS

	TGW-4xx(H) µGPSI-20 electronics	**TGW-4xx(H)-2 µGPSI-21 or µGPSI-22**	**TGW-4xx(H)-3 µGPSI-23 electronics**
Number of channels	12	20	Dynamically Adaptive
Tracking sensitivity	-156 dBm	-159 dBm	-163 dBm
Acquisition sensitivity	-142 dBm	-145 dBm	-147 dBm
Time to First Fix (TTFF)	40 seconds	35 seconds	35 seconds
Quick Fix Pseudoranging (QFP)	N/A	5 seconds typical	3 seconds typical

RF INPUT IMPEDANCE: 50 Ω

Datum: WGS-84

ARGOS CERTIFIED TRANSMITTER SPECIFICATIONS: (GPS-Argos systems only)

RF OUTPUT IMPEDANCE: 50 Ω

OPERATING FREQUENCY: ARGOS Frequencies
401.6300MHz to 401.6800MHz in 1kHz Steps
Brazilian SCD-1, Channels C1 to C9
401.6180MHz to 401.6220MHz in 500Hz Steps

FREQUENCY STABILITY: ± 0.5 ppm maximum from -30˚ to +70˚ C
± 2.0 ppm maximum from -40˚ to -30˚ C

INITIAL FREQUENCY ERROR: ± 0.5 ppm maximum at +23˚ , ± 2˚ C

AGING: ± 2.0 ppm maximum after 1 year

RF POWER OUT: Standard Power Version:
400mW (+26dBm) or 500mW (+27dBm) nominal into 50 Ω
(User selectable using TPP programming software)

High Power Version (H):
800 mW (+29 dBm) ±1dB nominal into 50 Ω
(User selectable using TPP programming software)

Note 1: Transmit current will increase by approximately 10% from the +25˚ C measurement. Conversely, at -40˚ C it will decrease by approximately 10% from the +25˚ C measurement.

Note 2: Transmit current and RF power out are sensitive to VSWR. Both can be degraded significantly if the antenna or antenna coax are of poor quality or not correctly tuned and matched to the ARGOS/Brazilian frequency band 50 ohm RF output impedance.

SPURS AND HARMONICS: <-40dBc minimum, -60dBc typical (Coherent Spurious)
<-50dBc minimum, -60dBc typical (Non-coherent spurious)

VHF TRANSMITTER COMPONENT SPECIFICATIONS

AVAILABLE FREQUENCY OPTIONS:
Option 702 134-139 MHz
Option 705 140-154 MHz
Option 707 146-160 MHz
Option 715 156-172 MHz
Option 720 160-177 MHz
Option 740 174-192 MHz
Option 750 191-210 MHz
Option 760 210-237 MHz

Note: The frequency can be programmed in 100Hz steps within a given frequency range.

FREQUENCY STABILITY: Better than ±3ppm at room temperature
±5 ppm total tolerance over full temperature range

OPERATING TEMPERATURE: -40˚ to + 70˚ C

PULSE WIDTH: Programmable (10 to 250 msec)

PULSE PERIOD: Programmable (560 to 5000 msec)

5 separate pulse period values selectable:
- Period 1 (indicates last GPS fix successful)
- Period 2 (indicates last GPS fix QFP, if equipped)
- Period 3 (indicates last GPS fix unsuccessful)
- Mortality period (if no motion for selected time)
- Dead Battery period

AVAILABLE SENSORS: Mortality Sensor (parameters are user programmable)

TRANSMITTER TIMING: Programmable seasons and duty cycles.

POWER OUTPUT: Programmable Low/Medium/High. Effective Isotropic Radiated Power (EIRP) varies, depending on packaging, antenna configuration, and immediate environmental conditions. * California Users: This transmitter meets the California requirement of EIRP<0.009W for all configurations.

EMISSION DESIGNATOR: 2k00P0N

HARMONIC SUPPRESSION: Better than 30dB (>40 dB typical)

SPURIOUS EMISSIONS: <-35 dBc at 10kHz offset from carrier

FREQUENCY: Aging: <2ppm/year
Shock: <1ppm 3000g x 0.3ms x ½ sine x 3 dir

VSWR: RF output stable to 10:1 VSWR, all phases
Radiated harmonic levels are degraded with poor load VSWR.
Spurious emission specification maintained for >10:1 VSWR

PROGRAMMING Transmitter parameters programmable via antenna “1-pin” interface and Telonics TPP software.

PACKAGING/HOUSING SPECIFICATIONS Electronics are sealed in hermetic metal canisters containing the electronics, batteries, and all interconnects. Glass to metal feed-thru technology is used to exit antennas and power. This packing is hermetic and can be tested utilizing a helium leak bomb test for hermeticity to assure < 1 part in 10^6 atmospheric CC per second.

GPS ANTENNA SPECIFICATIONS In collar mounted wildlife configurations The GPS antenna is designed to be mounted on the dorsal surface of the neck. The GPS antenna is installed in a high impact nonconductive plastic housing. The form of the housing presents sloping sides so that it will be impervious to chewing and gnawing as is possible. A highly armored antenna cable connects the GPS antenna to the instrument package.

COLLAR SPECIFICATIONS Collar designs are species specific.

TMT-xxx(H)-x Towable Tag and TGM-xxx(H)-x Marine Mammal Configurations

GENERAL SYSTEM SPECIFICATIONS

TIMING ACCURACY: Timing is synchronized to GPS time when available. If the GPS time is not available then internal timing accuracy is:
6 min/year at 25˚ C
30 min/year -20 to +40˚ C
47 min/year -40 to +70˚ C

AVAILABLE SENSORS: Mortality, Activity, Temperature, Low Voltage, Saltwater (Conductivity) Sensor

MEMORY CAPACITY: Capable of storing 100K fixes in nonvolatile flash memory in association with other sensor data.

ARGOS TRANSMISSIONS: System can be operated in a mode where unit transmits only during satellite overpasses based on the GPS location and the orbital parameters installed prior to deployment.

GPS RECEIVER SPECIFICATIONS

	TMT- and TGM-xxx(H) μGPSI-20 electronics	**TMT- and TGM-xxx(H)-2 μGPSI-22 electronics**	**TMT- and TGM-xxx(H)-3 μGPSI-23 electronics**
Number of channels	12	20	Dynamically Adaptive
Tracking sensitivity	-156 dBm	-159 dBm	-163 dBm
Acquisition sensitivity	-142 dBm	-145 dBm	-147 dBm
Time to First Fix (TTFF)	40 seconds	35 seconds	35 seconds
Quick Fix Pseudoranging (QFP)	7 seconds typical	5 seconds typical	3 seconds typical

RF INPUT IMPEDANCE: 50 Ω

Datum: WGS-84

ARGOS CERTIFIED TRANSMITTER SPECIFICATIONS:

RF OUTPUT IMPEDANCE: 50 Ω

OPERATING FREQUENCY: ARGOS Frequencies
401.6300MHz to 401.6800MHz in 1kHz Steps
Brazilian SCD-1, Channels C1 to C9
401.6180MHz to 401.6220MHz in 500Hz Steps

FREQUENCY STABILITY: ± 0.5 ppm maximum from -30˚ to +70˚ C
± 2.0 ppm maximum from -40˚ to -30˚ C

INITIAL FREQUENCY ERROR: ± 0.5 ppm maximum at +23˚ C, ± 2˚ C

AGING: ± 2.0 ppm maximum after 1 year

RF POWER OUTPUT: Standard Power Version:
400 mW (+26dBm) or 500 mW (+27dBm) nominal into 50 Ω
(User selectable using TPP programming software)

High Power Version (H):
800 mW (+29 dBm) ±1dB nominal into 50 Ω

Note 1: At +70˚ C, transmit current will increase by approximately 10% from the +25˚ C measurement. Conversely, at -40˚ C it will decrease by approximately 10% from the +25˚ C measurement.

Note 2: Transmit current and RF power out are sensitive to VSWR. Both can be degraded significantly if the antenna or antenna coax are of poor quality or not correctly tuned and matched to the ARGOS/Brazilian frequency band 50 Ω RF output impedance.

SPURS AND HARMONICS: <-40dBc, -60dBc typical (Coherent Spurious)
<-50dBc, -60dBc typical (Non-coherent spurious)

VHF TRANSMITTER COMPONENT SPECIFICATIONS:

AVAILABLE FREQUENCY OPTIONS: Option 702 134-139 MHz
Option 705 140-154 MHz
Option 707 146-160 MHz
Option 715 156-172 MHz
Option 720 160-177 MHz
Option 740 174-192 MHz
Option 750 191-210 MHz
Option 760 210-237 MHz

Note: The frequency can be programmed in 100Hz steps within a given frequency range.

FREQUENCY STABILITY: Better than ±3ppm at room temperature, ±5 ppm total tolerance over full temperature range

OPERATING TEMPERATURE: -40˚ to + 70˚ C

PULSE WIDTH: Programmable (10 to 250 msec)

PULSE PERIOD: Programmable (560 to 5000 msec)

5 separate pulse period values selectable:
- Period 1 (indicates last GPS fix successful)
- Period 2 (indicates last GPS fix QFP, if equipped)
- Period 3 (indicates last GPS fix unsuccessful)
- Mortality period (if no motion for selected time)
- Dead Battery period

AVAILABLE SENSORS: Mortality Sensor (parameters are user programmable)

TRANSMITTER TIMING: Programmable seasons and duty cycles.

POWER OUTPUT: Programmable Low/Medium/High power. Effective Isotropic Radiated Power (EIRP) varies, depending on packaging, antenna configuration, and immediate environmental conditions.
* California Users: This transmitter meets the California requirement of EIRP <0.009W for all configurations.

EMISSION DESIGNATOR: 2k00P0N

HARMONIC SUPPRESSION: Better than 30dB (>40 dB typical)

SPURIOUS EMISSIONS: <-35 dBc at 10kHz offset from carrier

PEAK TRANSMIT CURRENT: Med/Hi

FREQUENCY: Aging: <2ppm/year
Shock: <1ppm 3000g x 0.3ms x ½ sine x 3 directions

VSWR: RF output stable to 10:1 VSWR, all phases
Radiated harmonic levels are degraded with poor load VSWR.
Spurious emission specification maintained for >10:1 VSWR

PROGRAMMING Transmitter parameters programmable via antenna "1-pin" interface and Telonics TPP software.

PACKAGING/HOUSING SPECIFICATIONS

TGM-xxx Marine Configurations Designed for application to most pinnipeds and most marine turtles are enclosed in a polymeric casting to withstand pressures of 1000 psi. The external casting shell is of a contoured design to minimize hydrodynamic drag. Saltwater sensors are installed in the housing to allow the unit to detect diving behaviors. The Argos antenna assembly employs a strain-relief to avoid breakage. The GPS antenna assembly is inside the cast housing.

TMT-xxx Manatee/Dugong Configurations. Constructed from high impact plastic cylinders with specially designed nose cones for attachment to a tether and a custom designed antenna end cap that contains the saltwater sensor, antenna, and a place for the magnet used to shut down the unit. These units are not internal cast and were not designed for depths exceeding 100 ft.

APPENDIX 2: GPS-Globalstar System Specifications

TGW-xxxx Terrestrial Wildlife Configurations

GENERAL SYSTEM SPECIFICATIONS

TIMING ACCURACY:	Timing is synchronized to GPS time when available. If the GPS time is not available then internal timing accuracy is: 6 min/year at 25˚ C 30 min/year -20 to +40˚ C 47 min/year -40 to +70˚ C
AVAILABLE SENSORS:	Mortality, Activity, Temperature, Low Voltage
MEMORY CAPACITY:	Capable of storing 100K fixes in nonvolatile flash memory in association with other sensor data.

GPS RECEIVER SPECIFICATIONS

PERFORMANCE:	-163 dBm tracking sensitivity -147 dBm acquisition sensitivity
Datum:	WGS-84
Time to First Fix (TTFF):	35 sec typical (with clear view of sky) Quick Fix Pseudoranging (QFP): 3 sec typical (with clear view of sky)

GLOBALSTAR TRANSMITTER MODULE SPECIFICATIONS

GENERAL:

FCC ID	UQR-CMDCSTM3
Industry Canada ID	8863A-CMDCSTM3
Frequency Range	1610 - 1620 MHz.
Applicable FCC Rules	Part 15 (15.247)
Power Output	100mW

MECHANICAL / ENVIRONMENTAL:

Operating Temperature Range	-30 to +60 ˚C

GLOBALSTAR ANTENNA SPECIFICATIONS In collar-mounted wildlife configurations the Globalstar antenna is mounted on the dorsal surface of the neck. The antenna is installed in a high impact nonconductive plastic housing. The form of the housing presents sloping sides so that it will be impervious to chewing and gnawing as is possible. A highly armored antenna cable connects the antenna to the instrument package.

VHF TRANSMITTER COMPONENT SPECIFICATIONS

OPERATION INTERLOCK: All elements of the VHF transmitter component are forced off whenever the Globalstar transmitter module is on. This interlock device forcibly prevents simultaneous operation of the two transmitters, thus they are not considered to be co-located under FCC regulations.

AVAILABLE FREQUENCY OPTIONS:

Option 702 134-139 MHz
Option 705 140-154 MHz
Option 707 146-160 MHz
Option 715 156-172 MHz
Option 720 160-177 MHz
Option 740 174-192 MHz
Option 750 191-210 MHz
Option 760 210-237 MHz

Note: The frequency can be programmed in 100Hz steps within a given frequency range.

FREQUENCY STABILITY: Better than ±3ppm at room temperature
±5 ppm total tolerance over full temperature range

OPERATING TEMPERATURE: -40˚ to + 70˚ C

PULSE WIDTH: Programmable (10 to 250 msec)

PULSE PERIOD: Programmable (500 to 5000 msec)

5 separate pulse period values selectable:
- Period 1 (indicates last GPS fix successful)
- Period 2 (indicates last GPS fix QFP, if equipped)
- Period 3 (indicates last GPS fix unsuccessful)
- Mortality period (if no motion for selected time)
- Dead Battery period

AVAILABLE SENSORS: Mortality Sensor (parameters are user programmable)

TRANSMITTER TIMING: Programmable seasons and duty cycles.

POWER OUTPUT: Programmable Low/Medium/High. Effective Isotropic Radiated Power (EIRP) varies, depending on packaging, antenna configuration, and immediate environmental conditions. * California Users: This transmitter meets the California requirement of EIRP<0.009W for all configurations.

EMISSION DESIGNATOR: 2k00P0N

HARMONIC SUPPRESSION: Better than 30dB (>40 dB typical)

SPURIOUS EMISSIONS: <-35 dBc at 10kHz offset from carrier

FREQUENCY: Aging: <2ppm/year
Shock: <1ppm 3000g x 0.3ms x ½ sine x 3 dir

VSWR: RF output stable to 10:1 VSWR, all phases
Radiated harmonic levels are degraded with poor load VSWR.
Spurious emission specification maintained for >10:1 VSWR

PROGRAMMING: Transmitter parameters programmable via antenna "1-pin" interface and Telonics TPP software.

PACKAGING/HOUSING SPECIFICATIONS Electronics are sealed in hermetic metal canisters containing the electronics, batteries, and all interconnects. This packing is hermetic and can be tested utilizing a helium leak bomb test for hermeticity to assure < 1 part in 10^6 atmospheric CC per second.

COLLAR SPECIFICATIONS Collar designs are species specific.

Notice to United States Users

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesirable operation.

The user is cautioned that changes or modifications not expressly approved by Telonics could void the user’s authority to operate the equipment.

This device contains FCC ID: UQR-CMDCSTM3 *(µGPSI-23 systems)*

This device contains FCC ID: L2V-STX3 *(µGPSI-27 systems)*

To satisfy FCC RF Exposure requirements for mobile and base station transmission devices, a separation distance of 20cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended.

Notice to Canadian Users

Under Industry Canada regulations, this radio transmitter may only operate using the antenna integrated into the device.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This device contains IC ID: 8863A-CMDCSTM3 *(µGPSI-23 systems)*

This device contains IC ID: 3989A-STX3 *(µGPSI-27 systems)*

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

APPENDIX 3: GPS-Iridium System Specifications

TGW-xxxx Terrestrial Wildlife Configurations

GENERAL SYSTEM SPECIFICATIONS

TIMING ACCURACY:	Timing is synchronized to GPS time when available. If the GPS time is not available then internal timing accuracy is: 6 min/year at 25˚ C 30 min/year -20 to +40˚ C 47 min/year -40 to +70˚ C
AVAILABLE SENSORS:	Mortality, Activity, Temperature, Low Voltage
MEMORY CAPACITY:	Capable of storing 100,000 fixes in nonvolatile flash memory in association with other sensor data.

GPS RECEIVER SPECIFICATIONS

PERFORMANCE:	-163 dBm tracking sensitivity -147 dBm acquisition sensitivity
Datum:	WGS-84
Time to First Fix (TTFF):	35 sec typical (with clear view of sky) Quick Fix Pseudoranging (QFP): 3 sec typical (with clear view of sky)

IRIDIUM TRANSMITTER MODULE SPECIFICATIONS

GENERAL:

FCC ID	Q639602 (μGPSI-24 systems), Q639603N (μGPSI-25 systems)
Industry Canada ID	4629A-9602 (μGPSI-24 systems), 4629A-9603N (μGPSI-25 systems)
Frequency Range	1616 – 1626.5 MHz.
Applicable FCC Rules	Title 47 parts 2, 15, and 25
Average Power Output	1.6 W (max, during a transmit slot)

MECHANICAL / ENVIRONMENTAL:

Operating Temperature Range	-30 to +60 ˚C

IRIDIUM ANTENNA SPECIFICATIONS

In collar-mounted wildlife configurations, the Iridium antenna is mounted on the dorsal surface of the neck. The antenna is installed in a high impact nonconductive plastic housing. The form of the housing presents sloping sides so that it will be as resistant to chewing and gnawing as is possible. A highly armored antenna cable connects the antenna to the instrument package.

VHF TRANSMITTER COMPONENT SPECIFICATIONS

OPERATION INTERLOCK:	All elements of the VHF transmitter component are forced off whenever the Iridium transmitter module is on. This interlock device forcibly prevents simultaneous operation of the two transmitters, thus they are not considered to be co-located under FCC regulations.
AVAILABLE FREQUENCY OPTIONS:	Option 702 134-139 MHz Option 705 140-154 MHz Option 707 146-160 MHz Option 715 156-172 MHz Option 720 160-177 MHz Option 740 174-192 MHz Option 750 191-210 MHz Option 760 210-237 MHz Note: The frequency can be programmed in 100 Hz steps within a given frequency range.
FREQUENCY STABILITY:	Better than ±3 ppm at room temperature ±5 ppm total tolerance over full temperature range
OPERATING TEMPERATURE:	-40˚ to + 70˚ C
PULSE WIDTH:	Programmable (10 to 250 msec)
PULSE PERIOD:	Programmable (500 to 5000 msec) 5 separate pulse period values selectable: Period 1 (indicates last GPS fix successful) Period 2 (indicates last GPS fix QFP, if equipped) Period 3 (indicates last GPS fix unsuccessful) Mortality period (if no motion for selected time) Dead Battery period
AVAILABLE SENSORS:	Mortality Sensor (parameters are user programmable)
TRANSMITTER TIMING:	Programmable seasons and duty cycles.
POWER OUTPUT:	Programmable Low/Medium/High. Effective Isotropic Radiated Power (EIRP) varies, depending on packaging, antenna configuration, and immediate environmental conditions. * California Users: This transmitter meets the California requirement of EIRP<0.009 W for all configurations.
EMISSION DESIGNATOR:	2k00P0N
HARMONIC SUPPRESSION:	Better than 30 dB (>40 dB typical)
SPURIOUS EMISSIONS:	<-35 dBc at 10 kHz offset from carrier
FREQUENCY:	Aging: <2 ppm/year Shock: <1 ppm 3000g x 0.3ms x ½ sine x 3 dir
VSWR:	RF output stable to 10:1 VSWR, all phases Radiated harmonic levels are degraded with poor load VSWR. Spurious emission specification maintained for >10:1 VSWR
PROGRAMMING:	Transmitter parameters programmable via antenna "1-pin" interface and Telonics TPP software.

PACKAGING/HOUSING SPECIFICATIONS Electronics are sealed in hermetic metal canisters containing the electronics, batteries, and all interconnects. This packing is hermetic and can be tested utilizing a helium leak bomb test for hermeticity to assure < 1 part in 10^6 atmospheric CC per second.

COLLAR SPECIFICATIONS Collar designs are species specific.

Notice to United States Users

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesirable operation.

The user is cautioned that changes or modifications not expressly approved by Telonics could void the user's authority to operate the equipment.

This device contains FCC ID: Q639602 *(µGPSI-24 systems)*

This device contains FCC ID: Q639603N *(µGPSI-25 systems)*

To satisfy FCC RF Exposure requirements for mobile and base station transmission devices, a separation distance of 20cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended.

Notice to Canadian Users

Under Industry Canada regulations, this radio transmitter may only operate using the antenna integrated into the device.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This device contains IC ID: 4629A-9602 *(µGPSI-24 systems)*

This device contains IC ID: 4629A-9603N *(µGPSI-25 systems)*

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

APPENDIX 4: GPS-SST System Specifications

TGW-xxxx Terrestrial Wildlife Configurations

GENERAL SYSTEM SPECIFICATIONS

TIMING ACCURACY:	Timing is synchronized to GPS time when available. If the GPS time is not available then internal timing accuracy is: 6 min/year at 25˚ C 30 min/year -20 to +40˚ C 47 min/year -40 to +70˚ C
AVAILABLE SENSORS:	Mortality, Activity, Temperature, Low Voltage
MEMORY CAPACITY:	Capable of storing 100K fixes in nonvolatile flash memory in association with other sensor data.

GPS RECEIVER SPECIFICATIONS:

STANDBY CURRENT:	0µA
PERFORMANCE:	12 channels -156 dBm tracking sensitivity -142 dBm acquisition sensitivity
Datum:	WGS-84
Time to First Fix (TTFF):	40sec typical (with clear view of sky) Quick Fix Pseudoranging (QFP): 7sec typical (with clear view of sky)

SST-901 SPREAD SPECTRUM RADIO MODEM SPECIFICATIONS:

GENERAL:

FCC ID Industry Canada ID	JYLSST901 4610A-SST901
Frequency Range	902.102 - 927.908 MHz.
Spread Spectrum Type	Frequency Hopping FSK
Applicable FCC Rules	Part 15 (15.247)
Number of RF Frequency Sets	4 sets, non overlapping
	Set 1: 902.102 - 907.100 MHz
	Set 2: 908.120 - 913.220 MHz
	Set 3: 915.260 - 920.360 MHz
	Set 4: 922.808 - 927.908 MHz
Nominal Channel Frequency Spacing	102 kHz
Data Interface	Logic-Level Clocked Serial

TRANSMITTER:

Power Output	500 mW (+27dBm) nominal
Frequency Stability	± 0.5 ppm @ 25˚C
	± 1.0ppm -30 < T < +60 ˚C
Modulation Data Rate	19.2 kbps
Modulation Type	FSK
Modulation Bandwidth (99%)	40 kHz typ
Load Impedance	50 Ω

RECEIVER:

Noise Figure	<3.0 dB
Sensitivity for 10^{-4} BER @ 19.2 kbps	<-110 dBm typ

MECHANICAL / ENVIRONMENTAL:

Operating Temperature Range	-40 to +70 ˚C

VHF TRANSMITTER COMPONENT SPECIFICATIONS

AVAILABLE FREQUENCY OPTIONS:

Option 702 134-139 MHz
Option 705 140-154 MHz
Option 707 146-160 MHz
Option 715 156-172 MHz
Option 720 160-177 MHz
Option 740 174-192 MHz
Option 750 191-210 MHz
Option 760 210-237 MHz

Note: The frequency can be programmed in 100Hz steps within a given frequency range.

FREQUENCY STABILITY: Better than ±3ppm at room temperature
±5 ppm total tolerance over full temperature range

OPERATING TEMPERATURE: -40˚ to + 70˚ C

PULSE WIDTH: Programmable (10 to 250 msec)

PULSE PERIOD: Programmable (560 to 5000 msec)

5 separate pulse period values selectable:
- Period 1 (indicates last GPS fix successful)
- Period 2 (indicates last GPS fix QFP, if equipped)
- Period 3 (indicates last GPS fix unsuccessful)
- Mortality period (if no motion for selected time)
- Dead Battery period

AVAILABLE SENSORS: Mortality Sensor (parameters are user programmable)

TRANSMITTER TIMING: Programmable seasons and duty cycles.

POWER OUTPUT: Programmable Low/Medium/High. Effective Isotropic Radiated Power (EIRP) varies, depending on packaging, antenna configuration, and immediate environmental conditions. * California Users: This transmitter meets the California requirement of EIRP<0.009W for all configurations.

EMISSION DESIGNATOR: 2k00P0N

HARMONIC SUPPRESSION: Better than 30dB (>40 dB typical)

SPURIOUS EMISSIONS: <-35 dBc at 10kHz offset from carrier

FREQUENCY:	Aging: <2ppm/year Shock: <1ppm 3000g x 0.3ms x ½ sine x 3 dir
VSWR:	RF output stable to 10:1 VSWR, all phases Radiated harmonic levels are degraded with poor load VSWR. Spurious emission specification maintained for >10:1 VSWR
PROGRAMMING	Transmitter parameters programmable via antenna “1-pin” interface and Telonics TPP software.

PACKAGING/HOUSING SPECIFICATIONS Electronics are sealed in hermetic metal canisters containing the electronics, batteries, and all interconnects. Glass to metal feed-thru technology is used to exit antennas and power. This packing is hermetic and can be tested utilizing a helium leak bomb test for hermeticity to assure < 1 part in 10^6 atmospheric CC per second.

GPS ANTENNA SPECIFICATIONS In collar mounted wildlife configurations The GPS antenna is designed to be mounted on the dorsal surface of the neck. The GPS antenna is installed in a high impact nonconductive plastic housing. The form of the housing presents sloping sides so that it will be impervious to chewing and gnawing as is possible. A highly armored antenna cable connects the GPS antenna to the instrument package.

COLLAR SPECIFICATIONS Collar designs are species specific.

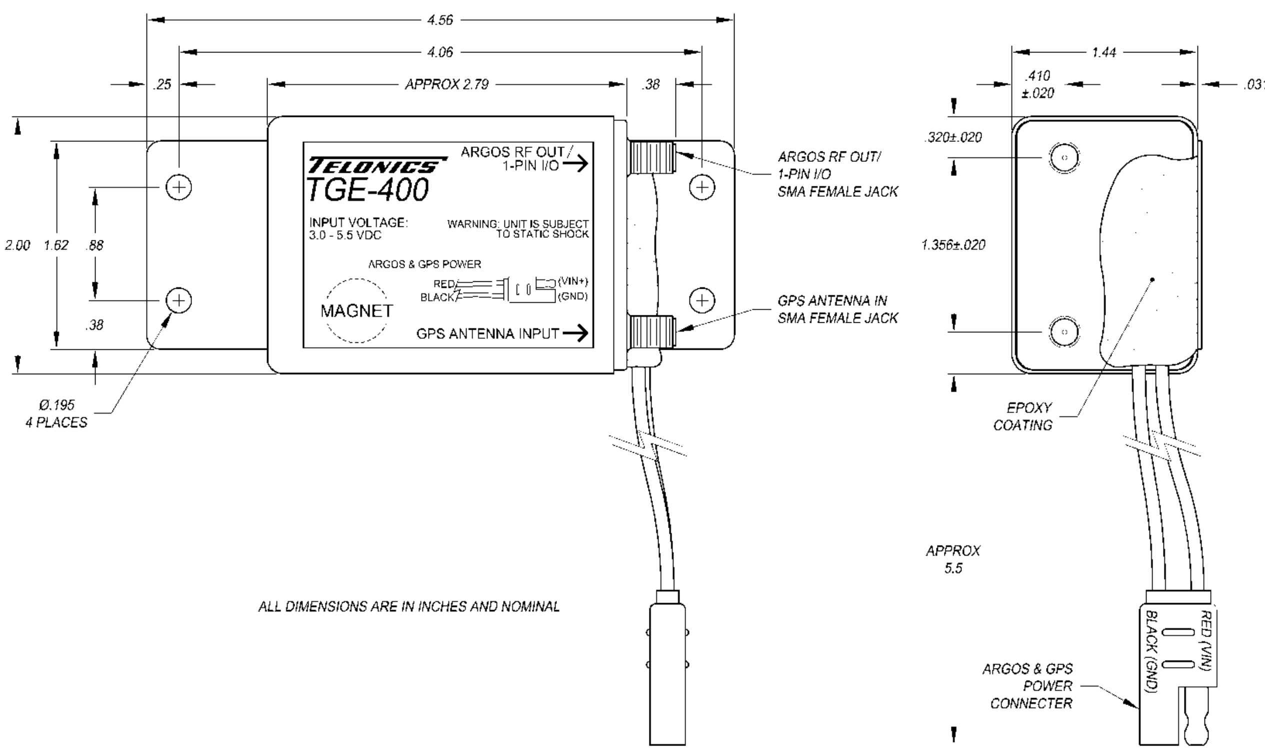
APPENDIX 5: Models TGE-400 & TGE-401 Physical Dimensions and Connection Diagrams

The TGE-400 and TGE-401 models are designed for deployment on oceanographic buoys, meteorological balloons, parachutes and other payload-bearing research platforms. These models are typically procured as “electronics only” configurations, and the user supplies the battery pack(s) required to power the various components of the system. The user assumes responsibility for engineering the compatibility of the power pack with the electronics specifications for voltage, current and capacity over the expected operating temperature range. External antennas and cabling are also selected or provided by the user based on the appropriateness to the application.

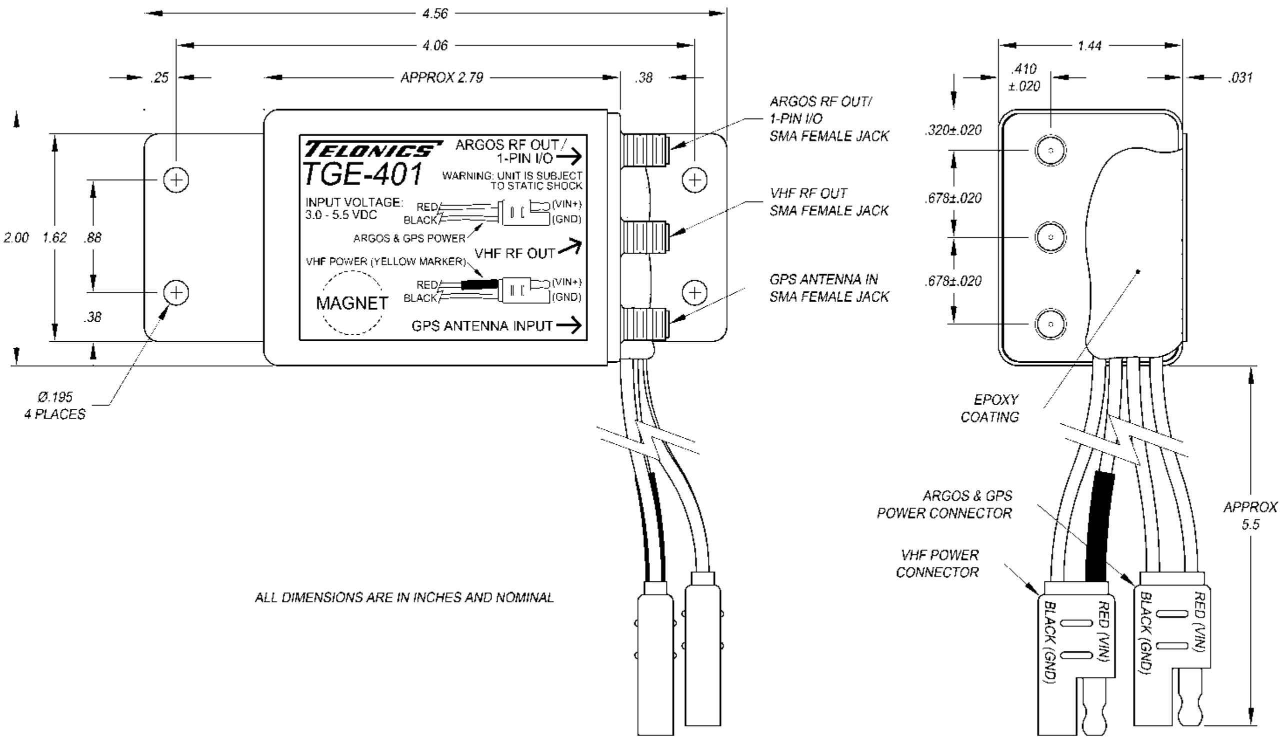
IMPORTANT: The system initialization is valid as long as the power supply remains connected. Disconnecting the power supply voids the initialization and requires that user re-initialize the unit prior to deployment. The Initialization Procedure is detailed in Section 6, Initializing Gen4 GPS Systems*.*

The TGE-400 and TGE-401 models are sealed in hermetic housings that protect the electronics from moisture but do not protect the external power components or the antennas from the environment. The user must ensure that any external components are suitably protected in the user’s application. This includes protection for all cables and connections to antennas and power. Because there are many possible configurations of the final system with each specifically adapted to the user’s application, the following examples of connections should serve as guidance for the general manner in which the system is put together for deployment with some of its possible peripherals.

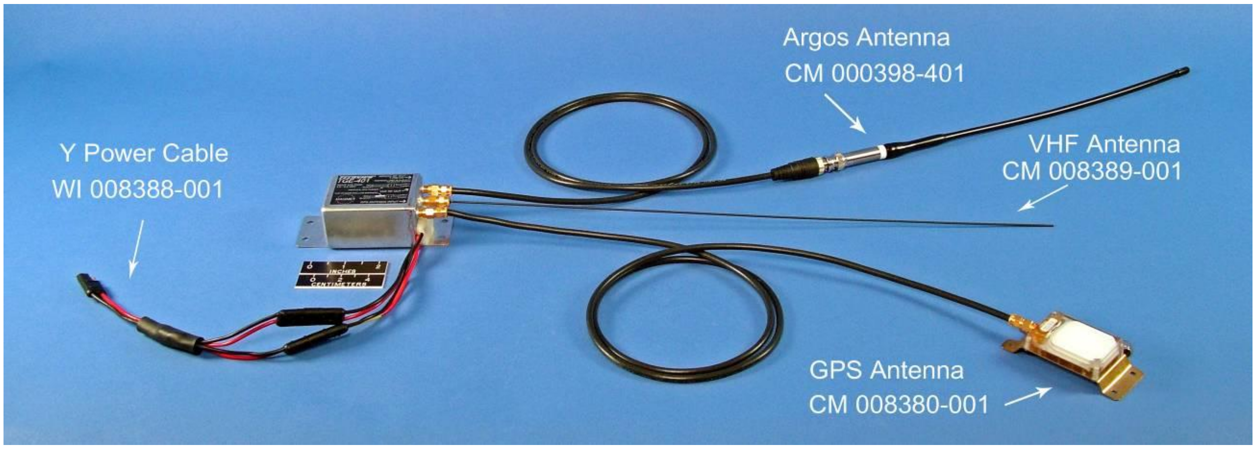
TGE-400 Outline drawing – The following outline drawing provides dimensioning and shows the interface connectors. The label also displays the voltage input option selected by the user and the positioning of where to place the shutdown magnet to turn the unit off.



TGE-401 Outline drawing – The following outline drawing provides dimensioning and shows the interface connectors. The label also displays the voltage input option selected by the user and the positioning of where to place the shutdown magnet to turn the unit off.



TGE-401 Connection photo – The following photo shows an example of the general connections between the TGE-401 and the main accessory components including the power cables, GPS, Argos, and VHF antennas. Note that different antennas may have been selected for a given application. Also note that a Y-cable (WI-008388-001) is shown for applications where the VHF transmitter and the GPS-Argos system are powered from a single power supply. To apply independent power sources, remove the Y-cable adapter. Note that the same basic connections apply to the TGE-400 except the VHF power and antenna connections. No external environmental protection is shown in this photo but is required to prevent moisture from penetrating cable connections and some antenna configurations. For questions about providing environmental protection for the completed assembly, please call Telonics to discuss these issues prior to deploying units.



APPENDIX 6: Battery Replacement Instructions for Terrestrial Replaceable Battery Pack Configurations. Applicable to Models TGW-4501 and TGW-4601

TGW-4501 Battery Replacement Instructions

1. Clean all dirt and debris from the removable cover plate of the electronics housing. Using a small Phillips head screwdriver, remove the four (4) 2-56 flat-head screws and lift off the cover with attached foam padding from the housing. **(Fig. 1)** Ensure that no debris enters the housing.

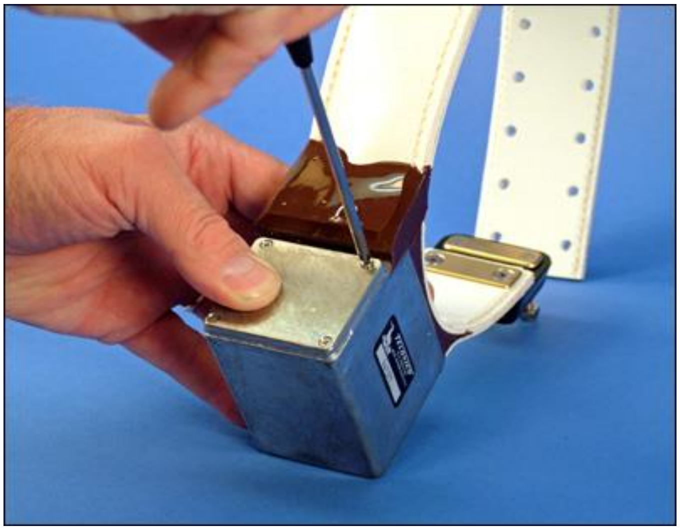


Fig. 1 Removing screws from TGW-4501

2. Gently tug on the wires and connectors and carefully separate (but do not disconnect) the leads and connectors for each battery pack **(Fig. 2)**. Note: there are two battery packs with connectors. One pack **PS007368-001** with a black connector powers the GPS unit and the battery pack with a blue connector **PS007369-001** powers the VHF transmitter.

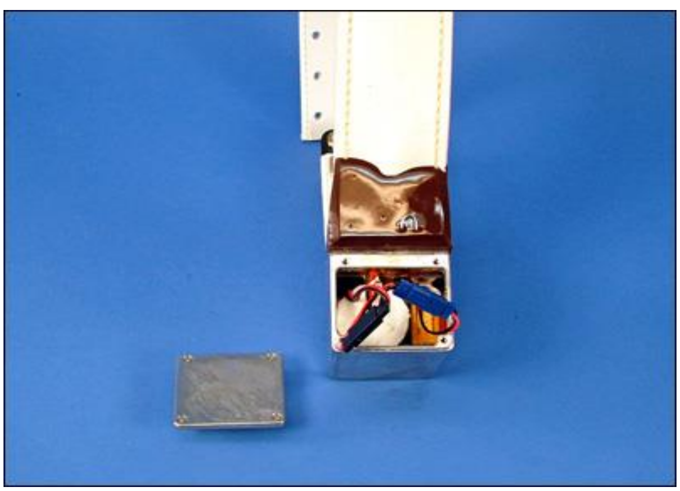


Fig. 2 Cover removed, ready to disconnect batteries

3. Disconnect the blue connector for the VHF battery pack, **(Fig. 3)** and then disconnect the black connector of the GPS battery pack. Each of the packs can now be removed from their respective battery compartments with a gentle pull on the battery leads. **(Fig. 4)**

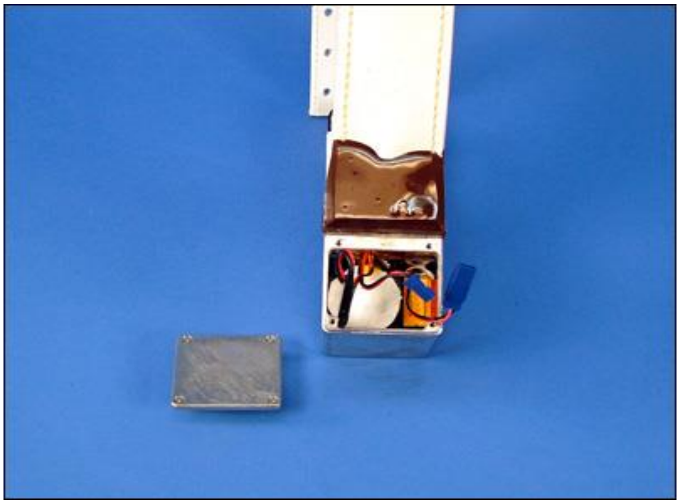


Fig. 3 Battery packs disconnected and ready to be removed.

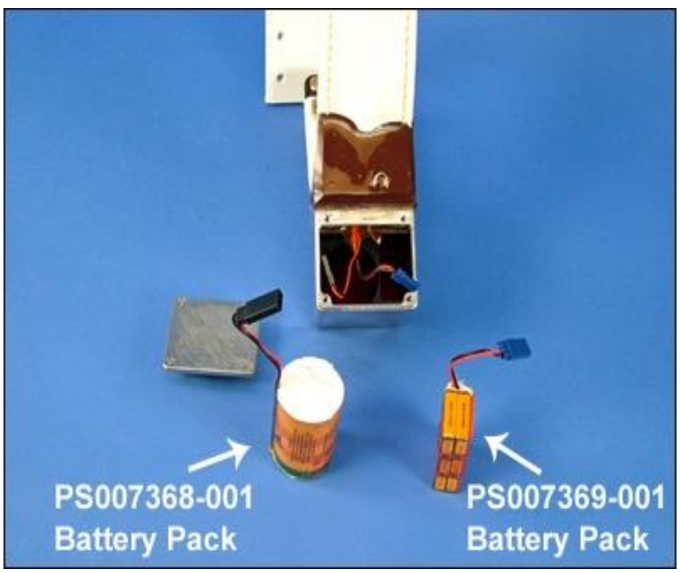


Fig. 4 Battery packs removed

Replace the Battery Packs as Follows:

1. Obtain a new VHF battery pack **PS007369-001** with a blue connector and slide it into the VHF battery position. Mate the blue battery pack connector with the blue VHF power connector. Also obtain a new GPS battery pack **PS007368-001** with a black connector and insert it into the GPS battery position. **(Fig. 5)** Mate the black battery pack connector with the black GPS power connector **(Fig. 6)**.

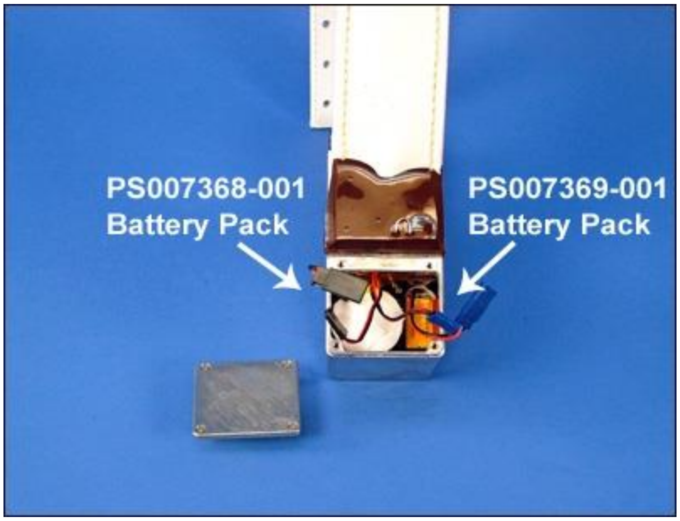


Fig. 5 Battery packs replaced and ready to be connected

2. Dress and fold the power leads and battery pack connectors on the top of the VHF battery pack **(Fig. 6)**. Make sure to tuck all power leads, and connectors **<u>inside the opening and below</u>** the sealing edge of the housing. Make sure the sealing edge of the housing and the cover plate are clean and free of contamination. Debris trapped between the housing and cover plate will result in moisture penetration and premature failure.

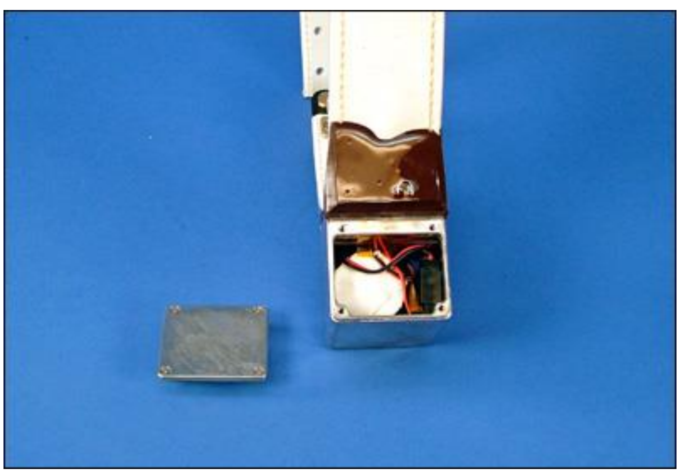


Fig. 6 Batteries installed, leads and connectors in place

3. Replace the cover plate making sure that the pattern of the gasket sealing area is properly aligned with the sealing edge pattern of the enclosure. Gently press the cover plate and attached foam into place in the housing. Visually align the holes in the cover plate with the holes in the housing. **(Fig. 7)** Insert a screw into one of the holes and partially tighten it. Insert the rest of the screws and partially tighten them. Inspect to make sure the power leads are not pinched between the cover plate and the housing. Tighten all 4 screws. **<u>DO NOT</u>** over-tighten. The cover plate will sit flush on the housing when properly installed and tightened.

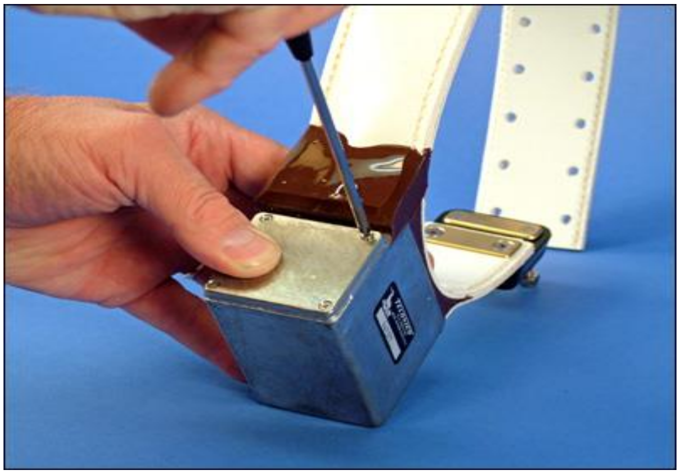


Fig. 7 Cover plate in place and screws being installed

4. Apply the magnet to shut down the unit.

IMPORTANT: The system now requires re-initialization prior to deployment according to the Initialization Procedure detailed in Section 6, **Initializing Gen4 GPS Systems**. Be sure to consider issues specific to redeployment as identified in Section 6.2, **Special Considerations for Redeployment**.

TGW-4601 Battery Replacement Instructions

1. Clean all dirt and debris from the removable cover plate of the electronics housing. Using a small Phillips head screwdriver, remove the six (6) 2-56 flat-head screws and remove the cover with attached foam padding from the housing. **(Fig. 1)** Ensure that no debris enters the housing.

Fig. 1 Removing screws from TGW-4601

2. Gently tug on the wires and connectors and carefully separate (but do not disconnect) the leads and connectors for each battery pack. Note: there are four battery packs with connectors. Three packs with black connectors **PS008210-010** power the GPS unit, and one battery pack with a blue connector **PS008210-110** powers the VHF transmitter.
3. For clarity, **(Fig. 2)** the battery packs are designated #1 through #4. #1 is located in the lower left hand corner of the housing, #2 is the middle pack and # 3 is located in the lower right hand corner. Battery pack # 4 is located in the upper left hand corner of the housing.
4. Disconnect the black connector for battery pack #1. **(Fig. 2)** Grab the white knotted cord attached to the battery pack and gently tug the battery pack up and out of the housing.

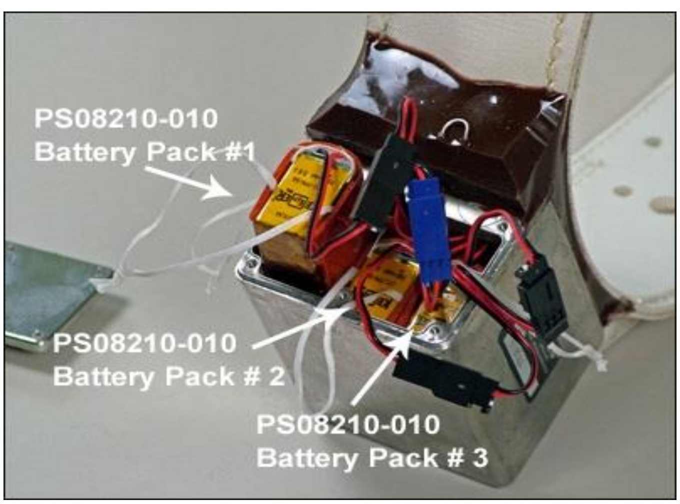


Fig. 2 Pack #1 ready to be removed from housing

5. Disconnect the black connectors for battery packs #2 and #3. Grab the white knotted cord attached to the battery packs and gently push the battery packs to the left where pack #1 was located. Gently tug and lift each pack in turn, up and out of the housing.
6. Disconnect the blue connector for the VHF battery pack #4 located in the upper left hand corner of the housing. Grab the white knotted cord attached to the battery pack and gently pull the battery pack down and out of the housing.

Replace the Battery Packs as Follows:

1. Take a new battery pack with a blue connector **PS008210-110**, and mate it with the blue VHF power connector. Insert the pack into the upper left hand corner of the housing, in position #4. **(Fig. 3)** Take three battery packs with black connectors **PS008210-010**, and mate them with the three black GPS power connectors. Insert the first pack into the lower right hand corner of the housing, in position #3, the second pack into position #2, and place the last pack in position #1.

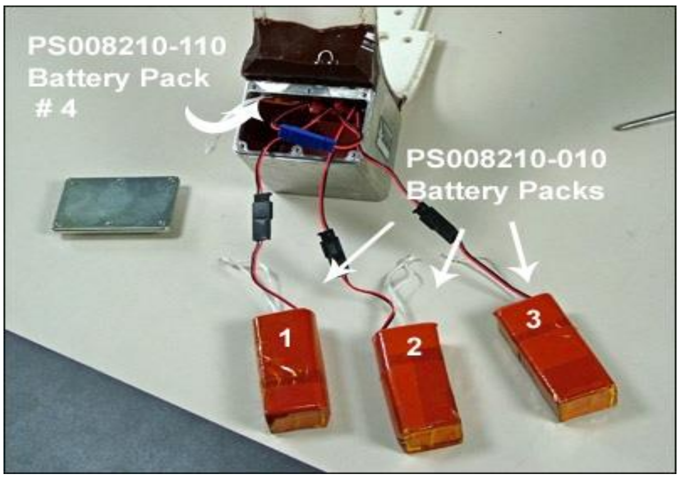


FIG. 3 VHF Pack #4 installed

2. Dress and fold the knotted white cords, the power leads, and battery pack connectors across the tops of the packs. **(Fig. 4)** Make sure to tuck all power leads, connectors, and knotted white cords **<u>inside and below</u>** the sealing edge of the housing. Make sure the sealing edge of the housing and the cover plate are clean and free of contamination. Debris trapped between the housing and cover plate will result in moisture penetration and premature failure of the unit.

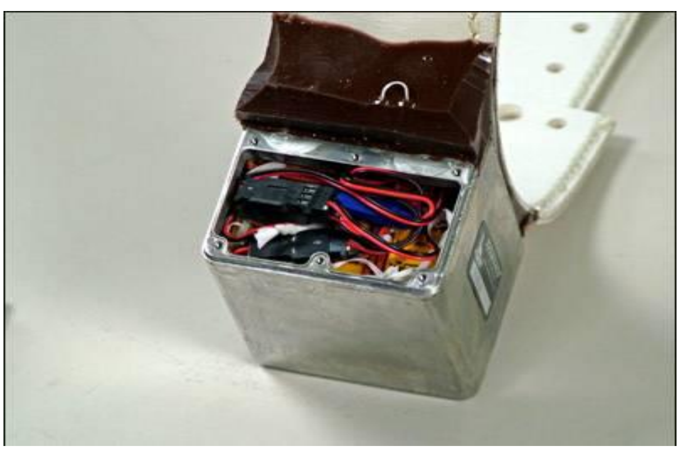


Fig. 4 All packs installed, Power leads folded down

3. Replace the cover plate making sure the pattern of the gasket sealing area is properly aligned with the sealing edge pattern of the enclosure. Reinstall the cover plate by gently pressing the cover plate and attached foam in place on the housing. Align the holes in the cover plate with the holes in the housing. **(Fig. 5)** Insert a screw into one of the holes and partially tighten it. Insert the rest of the screws and partially tighten them. Inspect to make sure the power leads are not pinched between the cover plate and the housing.

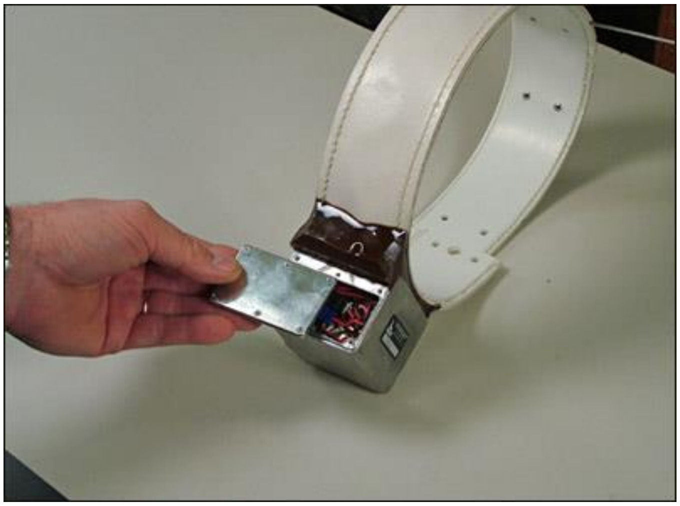


Fig. 5 Aligning Cover plate

4. Tighten all six screws by starting with the two middle screws and then tightening the screws in the corners. **(Fig. 6)** **DO NOT** over-tighten the screws. The cover plate will sit flush on the housing when properly installed and tightened.

Fig. 6 Tightening screws, middle first

5. Apply the magnet to shut down the unit.

IMPORTANT: The system now requires re-initialization prior to deployment according to the Initialization Procedure detailed in Section 6, **Initializing Gen4 GPS Systems**. Be sure to consider issues specific to redeployment as identified in Section 6.2, **Special Considerations for Redeployment**.

APPENDIX 7: Battery Replacement Instructions for TMT-462 Towable Tag (Manatee/Dugong) Replaceable Battery Pack Configurations

Please Note:

Effective 2017.01.05, battery connectors have changed due to availability from manufacturers/suppliers. Connectors on battery packs are no longer keyed and will now accept either black or blue connectors.
Inspection of the assembled connectors is required to make sure that red and red as well as black and black or black and brown wires are connected to each other as shown.
If you have any questions call Telonics @ 480-892-4444

Remove Batteries from Battery Pack nose cone assembly:

1. Clean all debris from the removable nose cone/tube assembly of the electronics housing. Using a 7/64" Allen wrench, remove the six (6) 6-32 socket-head cap screws and remove the nose cone with attached battery packs from the housing. **(Fig. 1)** Ensure that no debris enters the housing.

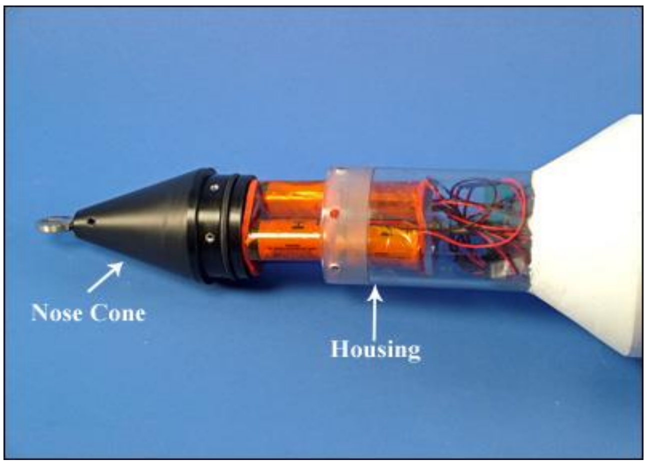


Fig. 1 Screws removed and nose cone disengaged from TMT-462

2. Gently tug on the wires and connectors and carefully separate (but do not disconnect) the leads and connectors for each battery **(Fig. 2)**. Note: there are six batteries with connectors. Five batteries with black connectors power the GPS unit, and one battery with a blue connector powers the VHF transmitter. Disconnect the blue connector for the VHF battery. **(Fig. 2)** Then disconnect the 5 black connectors for each of the other batteries.

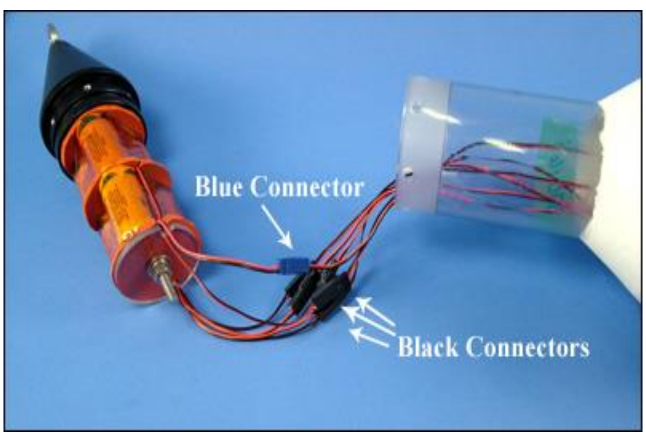


Fig. 2 Batteries ready to be disconnected from TMT-462

3. Obtain a 7/16" wrench and remove the lock nut and washer assembly. Remove the polycarbonate plate, silicone pad and expose the batteries **(Fig. 3)** which are now free to be removed from the nose cone assembly. Slide the batteries off of the threaded rod. Retain all silicone padding to be used with the new battery assemblies that will be installed.

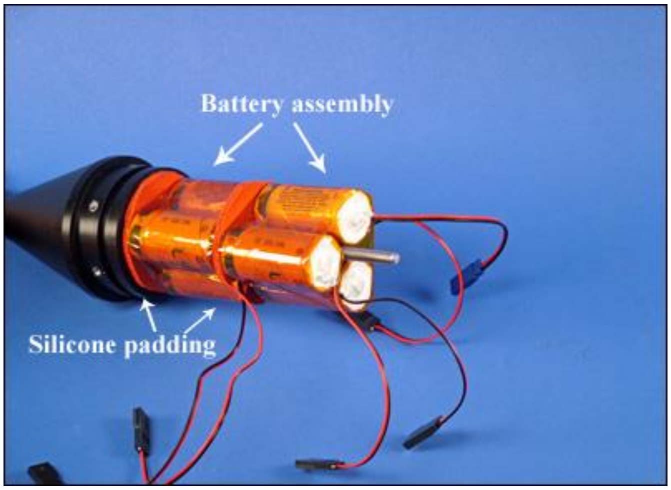


Fig. 3 Lock nut, polycarbonate plate and silicone pad removed. Batteries ready to be removed from nose cone assembly.

Replace the Battery Packs as Follows:

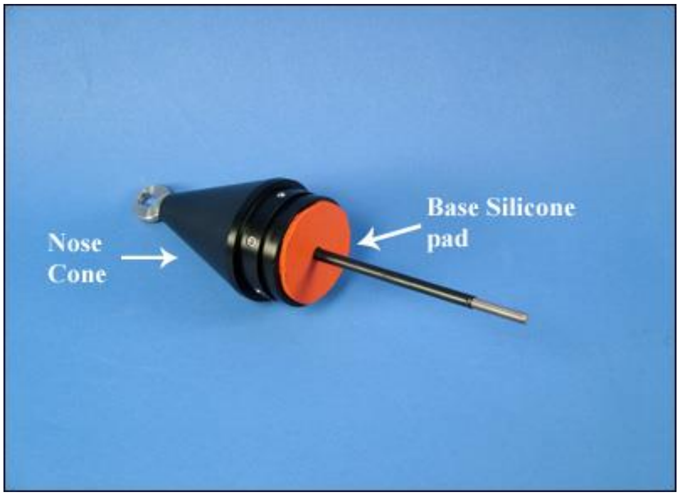


Fig. 4 Nose cone ready to receive battery assemblies

Connectors on battery packs are no longer keyed and will now accept either black or blue connectors.
Inspection of the assembled connectors is required to make sure that red and red as well as black and black or black and brown wires are connected to each other as shown.

1. Take a new battery assembly **PS008348-065** comprised of three batteries with black connectors with 6.5” leads and slide the battery assembly down over the threaded rod. **(Fig. 5)**

Fig. 5 Nose cone and battery assembly with black connectors installed

2. Install the silicone padding over the threaded rod, and then take the battery assembly **PS008530-045** comprised of two batteries with black connectors with 4.5” leads and one battery with a blue connector with 4.5” leads and slide it down over the threaded rod. **(Fig. 6)**

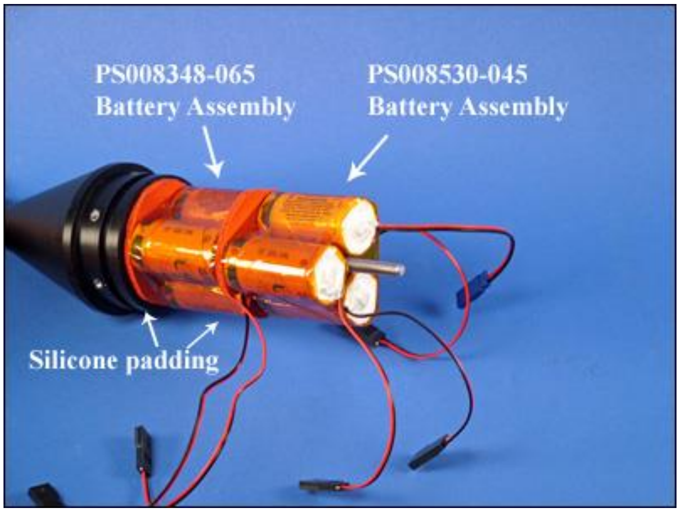


Fig. 6 Nose cone with both battery assemblies installed

3. Align battery assemblies such that the connector leads are dressed and secured together. Install silicone padding and polycarbonate plate. Install the flat washer, lock washer, locking nut and tighten securely. **(Fig. 7)**

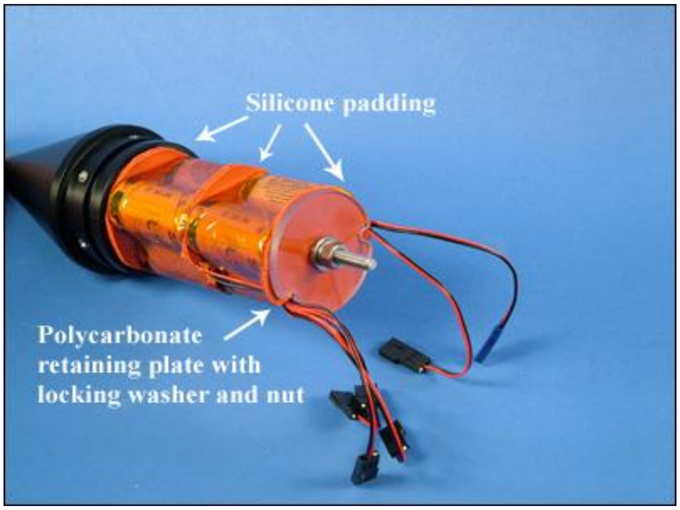


Fig. 7 Battery assemblies with leads properly dressed, silicone padding, polycarbonate retaining plate and locking nut and washer assembly in place.

4. Connect the blue VHF connector of the battery assembly **PS008530-045** to the blue VHF connector of the electronics package. Then connect the black connectors of both battery assemblies **PS008348-065** and **PS8530-045** to the black connectors of the electronics package. **(Fig. 8) (Fig. 9)**

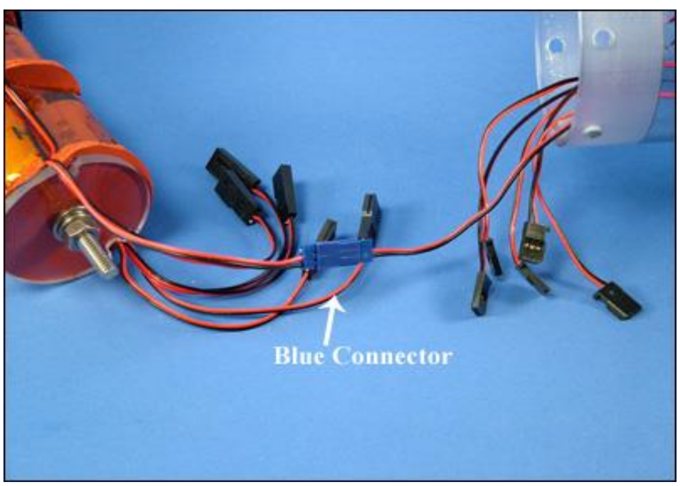


Fig. 8 Blue VHF connectors mated

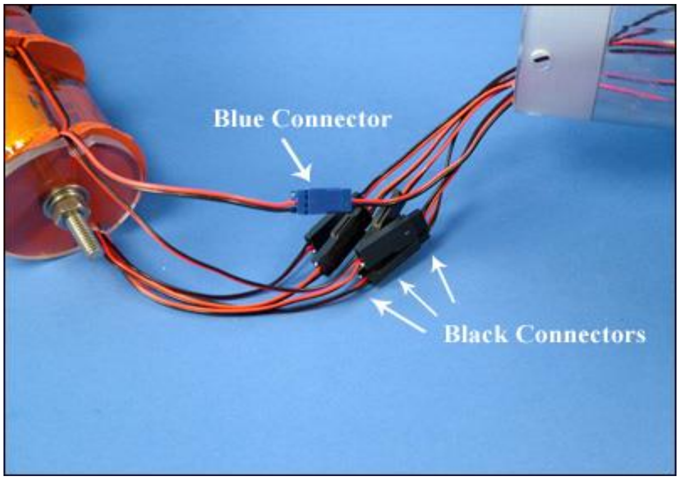


Fig. 9 Connectors mated and ready for installation in housing.

5. Gather battery leads together and carefully insert the assembled connectors and leads back into the housing. **(Fig. 10)** Inspect to make sure the power leads are not pinched between polycarbonate battery retainer plate and the housing. Coat the O-ring and the sealing surface of the housing with a thin coating of high vacuum grease to ensure a good seal. Apply a small amount of anti-seize compound into each of the nose cone screw holes. At this point the nose cone battery assembly can be pressed into the housing. Align the screw holes of the nose cone with the holes in the housing and install the 6-32 x ¼" socket head cap screws and snug them securely in place.

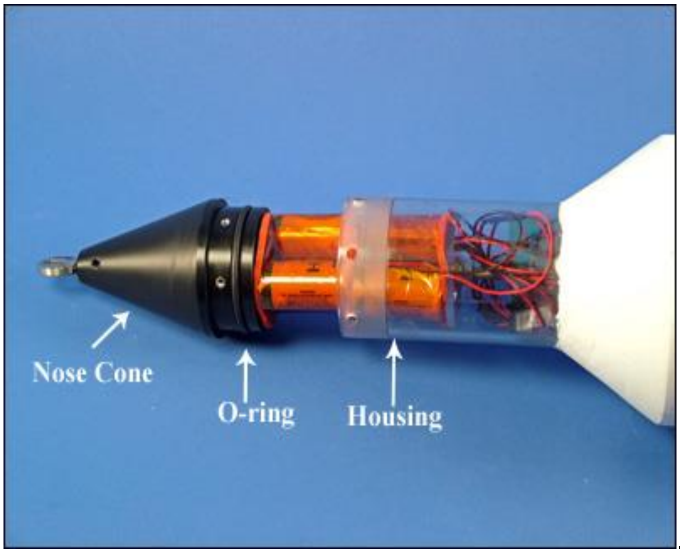


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Fig. 10 Nose cone and battery assemblies ready to be installed in the housing.

6. Apply the magnet to shut down the unit.

IMPORTANT: The system now requires re-initialization prior to deployment according to the Initialization Procedure detailed in Section 6, **Initializing Gen4 GPS Systems**. Be sure to consider issues specific to redeployment as identified in Section 6.2, **Special Considerations for Redeployment**.

APPENDIX 8: Battery Replacement Instructions for TMT-464-2 and TMT-464-3 Towable Tag (Manatee/Dugong) Replaceable Battery Pack Configurations

Please Note:

Effective 2017.01.05, battery connectors have changed due to availability from manufacturers/suppliers. Connectors on battery packs are no longer keyed and will now accept either black or blue connectors. **Inspection of the assembled connectors is required to make sure that red and red as well as black and black or black and brown wires are connected to each other as shown.**
If you have any questions call Telonics @ 480-892-4444

Remove nose cone assembly:

1. Clean all debris from the removable nose cone/tube assembly of the electronics housing. Using a 7/64" Allen wrench, remove the four (4) 6-32 socket-head cap screws and remove the nose cone **HD008978-001** with attached battery VHF battery pack from the housing. **(Fig. 1)**

Fig. 1 Screws removed and nose cone disengaged from TMT-464-2 and TMT-464-3

2. There are two battery systems with connectors. One battery pack with two connectors that have black ground (-) wires that power the GPS-ARGOS unit, and one battery pack with a connector that has a brown ground (-) wire that powers the VHF transmitter. Disconnect the VHF battery pack, and then disconnect the 2 black connectors from the GPS-ARGOS battery pack. **(Fig. 2)** The connectors for both the GPS-ARGOS and VHF battery packs are keyed differently so that they will only match the corresponding connecters.

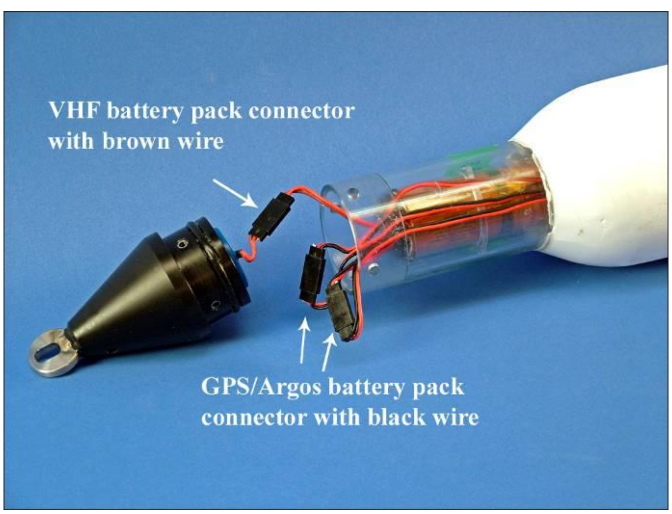

Fig. 2 Battery packs ready to be disconnected from TMT-464-2 and TMT-464-3

Fig. 3 Battery packs disconnected and removed from housing and nose cone showing GPS-ARGOS battery holder assembly protruding from the housing.

Replace the Battery Packs as Follows:

1. Obtain a **VHF** battery pack **PS008980-001** and a **GPS-ARGOS** battery pack **PS008640-030** in preparation for battery pack replacement. Take the new GPS-ARGOS battery pack and slide it into the battery holder assembly **HD008997-001** **(Fig. 4) NOTE:** The connectors for both the GPS-ARGOS and VHF battery packs are keyed differently so that they will only match the corresponding connecters.

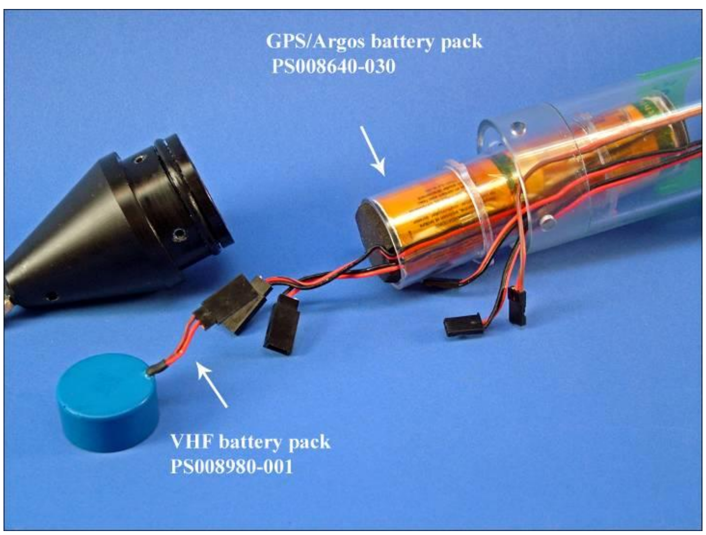

Fig. 4 GPS-ARGOS battery pack installed in battery holder assembly with VHF battery pack ready for installation in nose cone.

2. Slide the battery holder assembly tube and GPS-ARGOS battery pack into the housing. Connect the GPS-ARGOS battery pack to the matching connectors attached to the electronics.

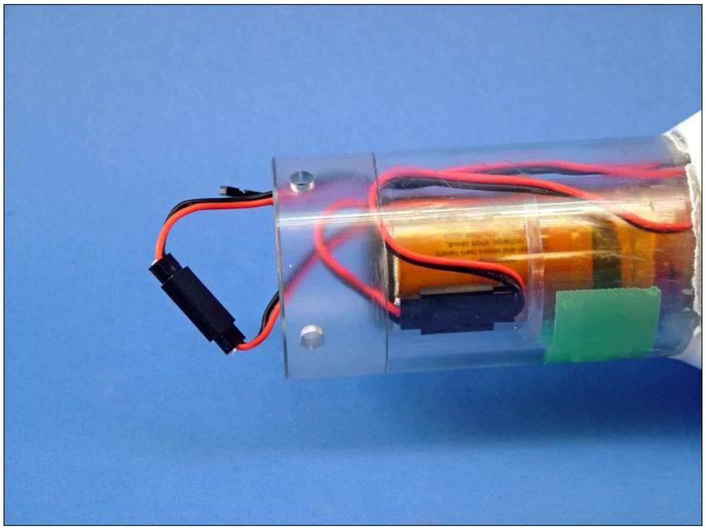

Fig. 5 GPS-ARGOS battery pack connected to electronics

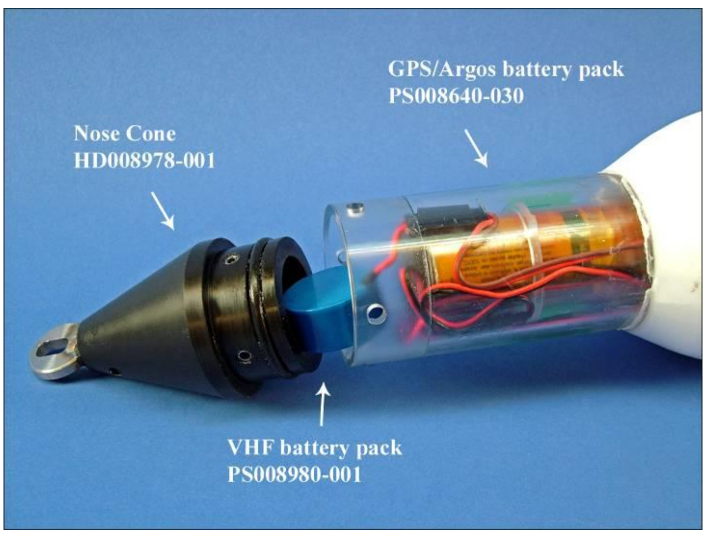

Fig. 6 VHF battery pack connected to matching connector.

3. Battery connectors must be connected and placed in the space between the battery holder assembly and the inside wall of the housing. Connectors and wires must be below or at the same height of the foam padding on the end of the GPS-ARGOS battery pack. **(Fig. 7)**

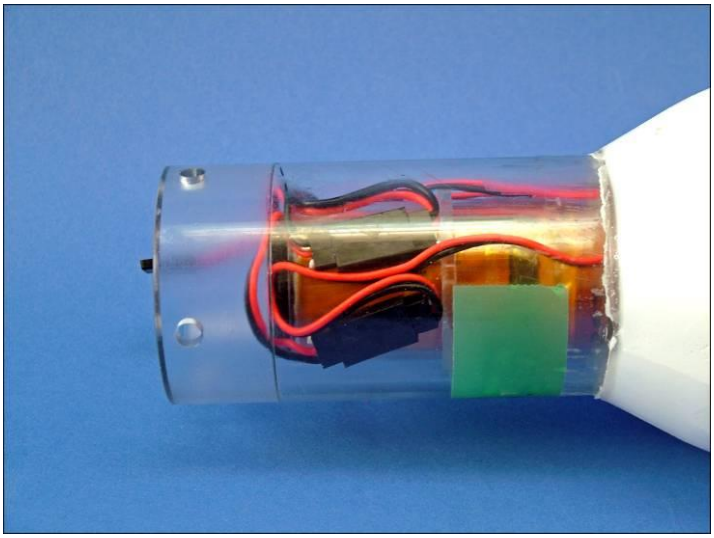

Fig. 7 GPS-ARGOS battery pack installed with connectors properly placed between battery holder assembly and housing.

4. Battery connectors must be connected and placed in the space between the battery holder assembly and the inside wall of the housing. Make sure the wires are not captured or crimped between the GPS-ARGOS battery pack and the VHF battery pack or the nose cone assembly. **(Fig. 8 and Fig. 9)**

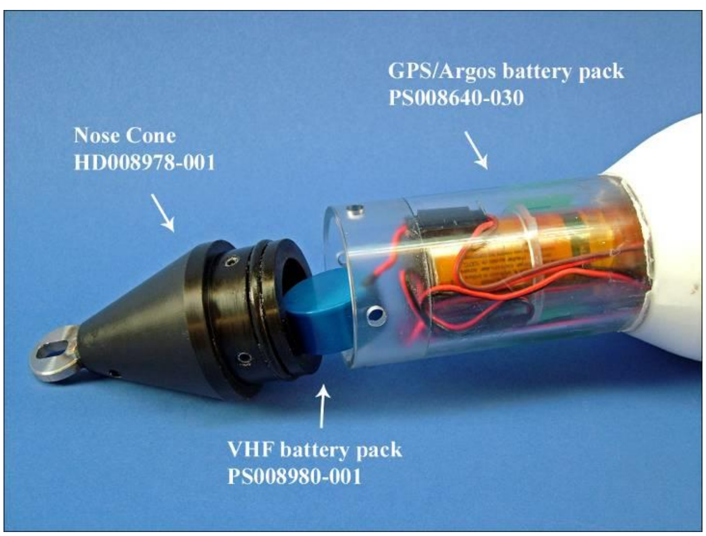

Fig. 8 VHF battery pack connected with connector properly placed between battery holder assembly and housing, ready to insert into nose cone cavity.

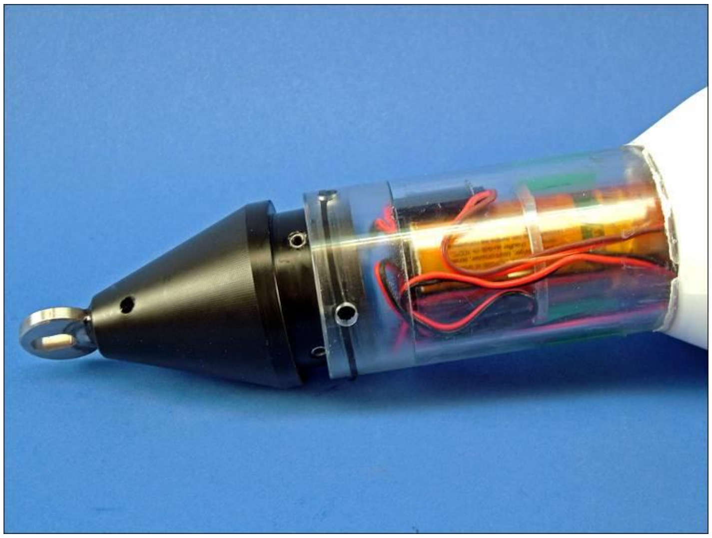

Fig. 9 VHF battery pack in nose cone cavity with nose cone ready to be inserted in housing.

5. Make sure the O-ring and the mating surface on the inside of the housing are clean. Coat the O-ring and the sealing surface of the housing with a thin coating of high vacuum grease to ensure a good seal. Apply a small amount of anti-seize compound into each of the nose cone screw holes. At this point the nose cone battery assembly can be pressed into the housing. Align the screw holes of the nose cone with the holes in the housing and install the (4) 6-32 x ¼” socket head cap screws then snug them securely in place.

6. Apply the magnet to shut down the unit.

IMPORTANT: The system now requires re-initialization prior to deployment according to the Initialization Procedure detailed in Section 6, **Initializing Gen4 GPS Systems**. Be sure to consider issues specific to redeployment as identified in Section 6.2, **Special Considerations for Redeployment**.

APPENDIX 9: SST-901M Manual

This appendix includes a user manual for the operation of the SST-901M and the antennas used with the system. The manual was written as part of the FCC/IC submissions and includes the appropriate notices and warning for the use of the equipment in compliance with FCC/IC certification. Read this manual to be sure that the equipment is used in compliance with certification. This manual deals only with the certified spread-spectrum transceiver portion of the Gen4 SST system. For complete instructions on using the Gen4 SST system, see the help system in Telonics Data Converter (TDC). The TDC help system includes up-to-date instructions for the user interface, provides context-sensitive help, and duplicates the information contained in this appendix.

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Model SST-901M Spread Spectrum Radio Modem User's Guide

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1.0 Notice to United States Users

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesirable operation. In normal operation the unit and approved antenna is positioned several feet from the user but under no circumstance should the antenna be positioned less than 20 cm from the operator.

The user is cautioned that changes or modifications not expressly approved by Telonics could void the user's authority to operate the equipment. This restriction includes the use of specified antennas which have been certified for use with the SST-901M. See Antenna Configurations section below.

2.0 Notice to Canadian Users

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

The SST-901M (IC: 4610A-SST901M) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Approved Antenna Type	Telonics P/N	Max Gain	Required Impedance
Collinear Vertical w/ ground plane	CM007724-900	7.2dBi	50Ω
Collinear Vertical w/ ground plane	CM008828-900	5.4dBi	50Ω
Aircraft Blade Antenna	CM007462-001	4.0dBi	50Ω

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

3.0 Hardware Setup

The SST-901M is a portable radio modem allowing field data transfer from a deployed Spread Spectrum Unit to a portable laptop computer. Before the system will function properly, the SST-901M must be properly connected to a laptop computer and an antenna. There are three connectors on the SST-901M. Their function and proper connection are described below and diagrammed in figures 1 and 2:

1. RF connector: Connect this jack to the external antenna with the supplied coaxial cable assembly. See the Antenna configurations section for more information about approved antennas and cabling.

2. USB Jack: Connect the SST-901M to the laptop computer with the supplied USB cable. The unit derives power from the laptop via the USB cable.

3. External Power Jack (optional): The SST-901M is normally powered by the laptop via the USB cable. When the radio link is in use, the laptop battery will be depleted much faster than normal. Laptop battery life can be extended by connecting the optional 12V Auto Charge Cord (Telonics P/N PS000338-001) to the external power jack. Note that the charge cord only supplies power to the SST-901M – it does not supply power to the laptop computer.

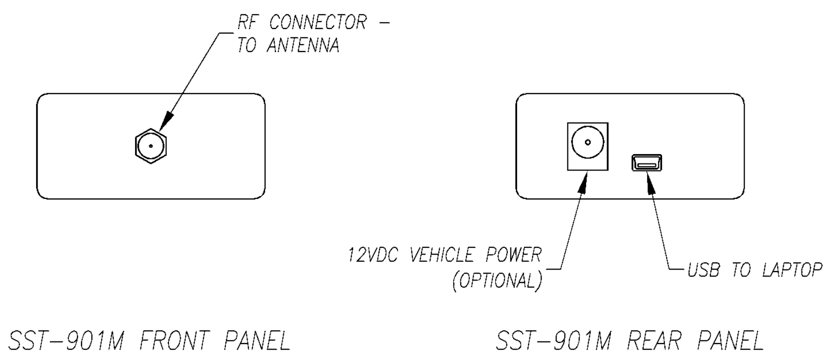


Figure 1 – SST-901M Front and Rear Panel Connections

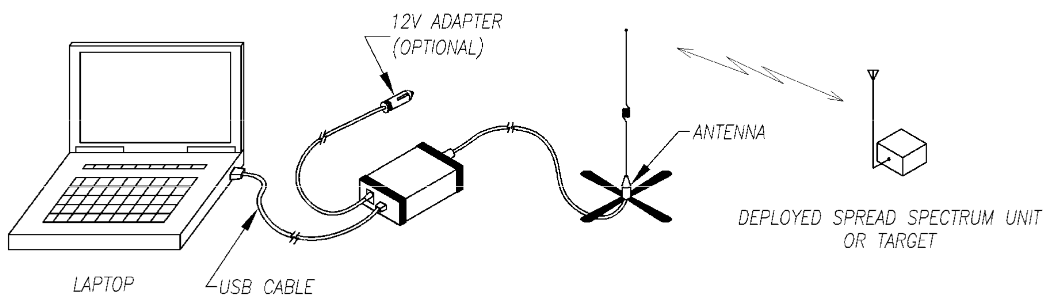
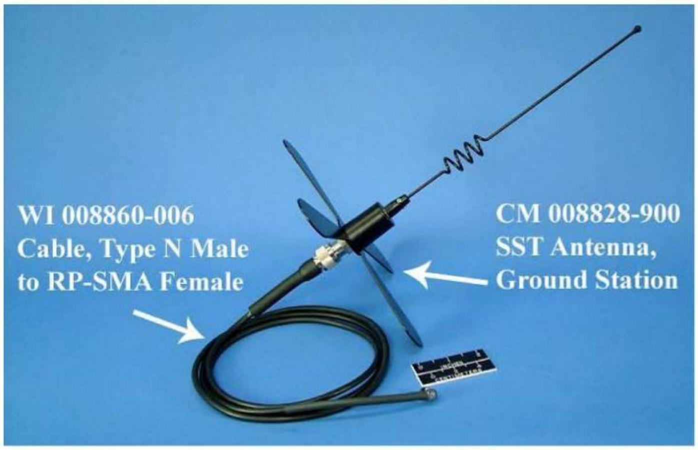
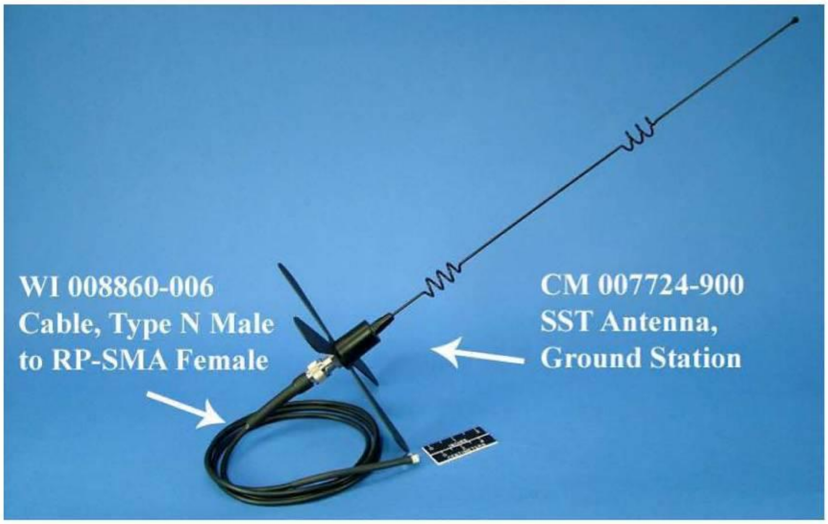


Figure 2 – SST-901M Typical Installation

The following antennas have been specifically designated and certified for use with the SST-901M. Use of other antennas voids the user's authority to operate the equipment.





4.0 Telonics Data Converter (TDC)

Telonics Data Converter (TDC) is the software user-interface that controls the SST-901M RF Modem to download data over the spread-spectrum link. TDC can manage the RF connection settings for each deployed SST unit allowing users to download data from units in the field with minimal interaction. In addition to downloading log memory, TDC also provides the ability to test the RF link, download diagnostic information, initiate a blackout period to save battery life, and convert downloaded data into standard CSV reports. TDC is compatible with any PC with an available USB port running Windows 2000 or newer, including many ultra-mobile PCs and tablet PCs.

4.1 Quick Start Guide

Enter your Authorization Code(s)

The first step to using TDC is to download the utility from the Telonics website. The utility is immediately useable in the evaluation or demonstration mode. In evaluation mode you will not be able to download SST data, download datalogs, or generate reports. This demonstration mode allows you to evaluate TDC and see how you will use TDC during your study. In order for TDC to be fully functional, you must purchase a license. Contact Telonics with your purchase order or credit card information to obtain your Authorization Code. The Authorization Code can be provided to you over the phone, by FAX, email, or postal mail.

Once you have obtained your Authorization Code(s) from Telonics, select the "About Telonics Data Converter" choice under the "Help" menu in TDC. Click the "Add..." button. Enter your Authorization Code and press the "OK" button. If you were given more than one Authorization Code, press the "Add..." button again and repeat for each remaining Authorization Code.

For additional information see the Authorization Codes section of help.

Set your Options

TDC must be configured for use. From the Options Menu, select "File Locations..." to view the Options Window. Set your preferred directory for spread-spectrum files and your report destination folder by typing the full path in the provided field. The spread-spectrum files directory will hold all of the data that you downloaded over the SST link (e.g. TSF files, statistics files, diagnostic information). The report directory will hold your final converted reports. You can also select a directory by pressing the "Browse" button next to the field. From the Options Window, you can view different groups of options by clicking the tabs near the top of the window. Once you have finished adjusting the program options, press the "OK" button to save your changes.

For additional information see the Options section of help

Import or Add SST Units

TDC uses TPF files that describe the unit's identity and operational behavior. These files are typically provided to you as attachments in an email from Telonics. From the SST tab in the Main Window, press the "Configure unit and session settings" link or alternatively select "Unit & Session Settings..." from the "Spread Spectrum" menu to launch the Spread Spectrum Unit & Session Settings Window. From this window, press the "Import..." button and then browse to the TPF file that was used to program your SST units. TDC will then import the connection settings for each unit in that TPF file.

If you do not have a TPF file for the units, you can also add units by selecting "[Add new unit]" from the list of units and then manually type in the connection settings.

Specify Tasks to Perform in Next SST Transfer Session

From the Spread Spectrum Unit & Session Settings Window, select an SST unit from the list. The "Next Transfer Session" section of the window lists all optional tasks that you can perform during the next SST session with the selected unit. Be sure to specify the tasks for each unit to which you plan to connect. Consider planning and selecting these tasks ahead of time (in the office) before heading out to download data in the field.

When you are finished importing SST units and selecting tasks for the next transfer session, press the OK button to close the Spread Spectrum Unit & Session Settings Window and save your changes. For additional information see the SST Unit and Session Settings section of help.

Download SST Data

Connect the SST-901M to the PC using the supplied USB cable. Note that the first time you connect the SST-901M you may be prompted to install a driver. See the USB Driver Installation section of help if you need assistance installing the USB driver. Connect the antenna to SST-901M. Specific antennas have been approved for use in ground monitoring applications and for use in aircraft monitoring. When testing the spread-spectrum link, separate the SST-901M and the units under test by at least 20 meters.

To begin the download test remove the magnet prior to attempting communications. Once you remove the magnet, the unit will enter a predeployment period (typically 4 hours) in which you will be able to conduct SST transfer sessions. During predeployment, the unit will also collect GPS and/or QFP locations (typically once an hour). When the unit is actively trying to collect a GPS or QFP location, you will not be able to conduct an SST session.

From the SST tab in the Main Window, press the "Download file over spread-spectrum link" hyperlink or select "Transfer Session..." from the "Spread Spectrum" menu to launch the Spread Spectrum Transfer Session Window. Select a unit from the list and press the Connect button. TDC will attempt to connect to the unit and complete the tasks that you have previously specified for this unit. If TDC has stored a TPF tile for the selected unit, the SST Active field will tell you the next time the selected unit is scheduled to listen for SST communications.

During an SST transfer session, the window displays progress for each task and the signal strength and transfer rate of the link. After completing an SST session, TDC displays a message indicating whether the session was successful. If the session was successful, TDC updates the Results tabs to show information about the results of the last transfer session. The "Downloaded Data" tab shows the name of the file that contains your downloaded data (including GPS/QFP locations). See the next step for instructions on converting this .tsf file into a report. If the session failed, please try to connect to the unit again.

For additional information see the SST Transfer Session section of help.

Convert SST Data (.tsf file)

The file that is downloaded from the unit under test is not in a readable form and it is necessary to convert the recovered file. From the Spread Spectrum Unit & Session Settings Window, select the unit for which you would like to convert data (if you have not already done so). The "Downloaded Data" tab will list the SST file (.tsf) that you downloaded during the last SST transfer session with that unit. Click the filename of the downloaded file and TDC will offer to convert the file. The Main Window displays conversion progress in the Results field of the SST tab. After TDC has finished converting the file, the Results field displays the name of the generated report. For detailed conversion instructions, see the Main Window (SST) section of help.

Note that you can also select the SST data to convert from the Main Window in TDC. Select the SST tab and then press the "Select File..." button. Browse to the SST file (.tsf) that you would like to convert. Note that TDC downloads all SST files to the spread-spectrum files directory that you specified in the File Locations tab of the Options Window. TDC automatically names the files to include the CTN of the unit and date/time of the SST session.

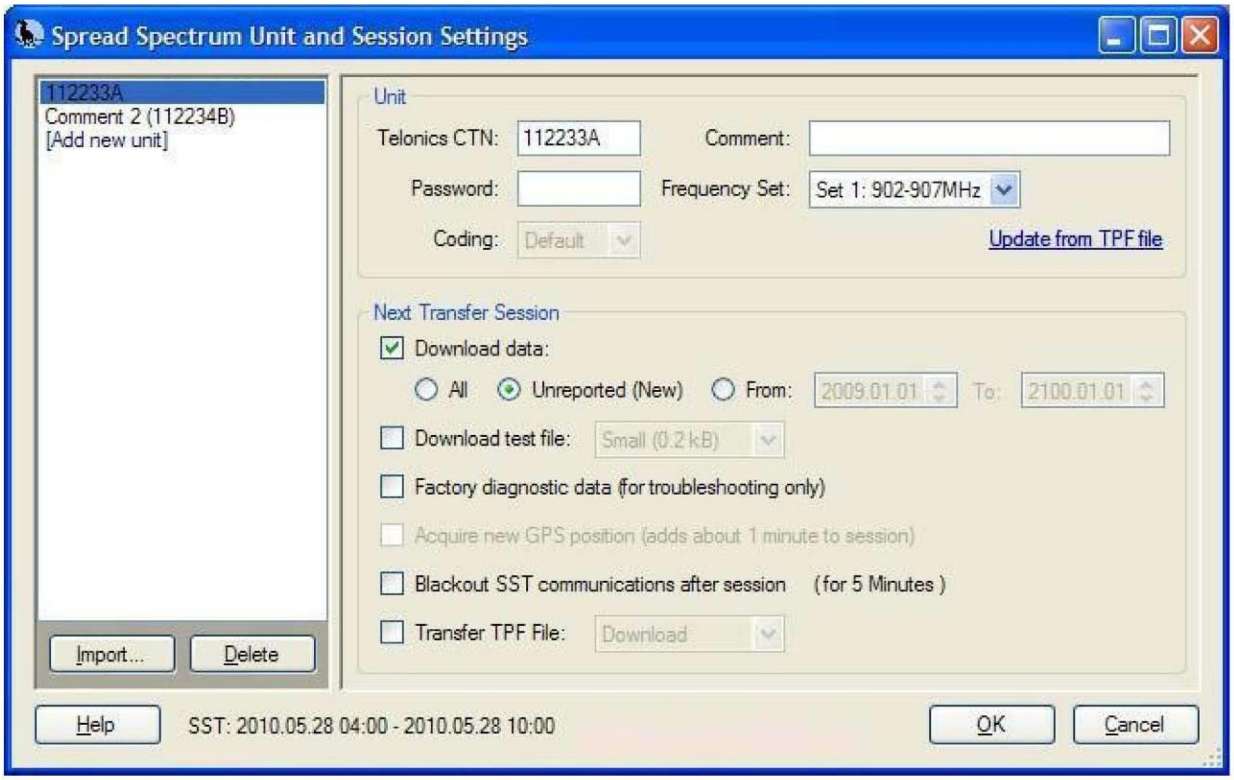
After converting the SST file (.tsf), TDC stores the final report (.csv file) in the reports directory that you specified in the File Locations tab of the Options Window.

If your unit supports QFP locations, be sure that your PC is connected to the Internet when you convert the data (.tsf file). You do not need an Internet connection to download the SST data.

4.2 SST Unit and Session Settings Window

The SST Unit and Session Settings Window allows you to perform the following tasks:

- Import new SST units from a TPF file
- Delete an existing SST unit
- Add a new SST unit by manually specifying connection settings
- Update connection settings and assign a comment to a unit
- Specify the tasks to perform during the next SST transfer session



Unit Selection

The left section of this window lists all SST units known to TDC. To select a unit, click on that unit in the list. To add a new unit manually, select the last entry in the list ("[Add New Unit]") and then type in the connection parameters in the upper-right section of the window.

Import Button

Press the Import Button to add new SST units from a TPF file. TDC prompts you to select the TPF file. Note that this window manages only SST units, so TDC will not find any units if you select a TPF file for a store-on-board.

Delete Button

Press the Delete Button to delete the currently selected SST unit from TDC. If you have previously had an SST transfer session with the selected unit, TDC displays a warning message before deleting the unit so that you have an opportunity to cancel the deletion. The Delete Button is disabled when "[Add New Unit]" is selected.

Unit

The Unit group is located in the upper-right section of this window. It lists the connection settings for the currently selected unit.

Telonics CTN

The CTN uniquely identifies the unit. TDC uses the CTN during the connection process of an SST session. TDC also uses the CTN to name the files downloaded during an SST transfer session.

Comment

The Comment field allows you to assign a comment to the selected unit. Using the Comment field allows you to assign a unit name that you can easily identify later. This is particularly useful when you have several SST units listed in TDC.

Password

The Password field specifies the connection password for the unit. If the unit does not have a password, leave this field blank.

Frequency Set

The Frequency Set field specifies the frequency set that will be used for communication between the SST-901M and the remote units. Each set consists of 50 separate frequencies, nominally spaced at 102 kHz intervals. Frequency Set limits are listed in Section 5.0 of this document.

The choice of which frequency set(s) to use is left to the discretion of the Telonics SST system user. The decision of which set(s) to use must be made before the study begins so that remote units can be programmed appropriately prior to deployment. The paragraphs below provide information that may aid in the decision of which frequency set(s) to use for a given study:

- In studies involving multiple deployed (remote) units, all units in close proximity on a given frequency set will be aware that communications are occurring. Only the SST-901M and the addressed remote unit will be involved in the communication, however all units that can hear the communication will repeatedly spend small amounts of energy receiving and decoding the communication packets only to discover that they are not involved in the communication. By using multiple frequency sets, this unnecessary energy expense in the remote units can be reduced (extending operational life).
- There is a known source of interference in the area and it is severe enough to prevent successful communications.
- There are multiple studies being run in close proximity and two or more SST-901M units may be in use at the same time.
- Operation of the SST-901M and associated remote units is causing harmful interference in the proper operation of some other system or equipment.

Coding

The Coding field specifies the coding type for the unit. For now, SST units support only one coding type so this field is disabled.

Update from TPF File Link

Clicking this hyperlink lets you update the connection settings (password, frequency set, and coding) for the currently selected unit. Clicking this link does not cause TDC to import new units or update the connection settings for other units listed in the TPF file.

Next Transfer Session

The Next Transfer Session group is located in the lower-right section of this window. It specifies the action to perform during the next SST transfer session.

Download Data

This setting specifies whether to download all data, new data, by date range, or not to download any data from the unit.

Download Test File

Use this setting to download a test file. The drop-down list lets you specify the size of the test file. Downloading a test file is useful for testing the performance (range, transfer rate, and signal strength) of the spread-spectrum link.

Factory Diagnostic Data

Use this setting if you are experiencing problems with the unit and Telonics instructs you to download diagnostic data. You will then need to send your data file (TSF) to Telonics for analysis.

Acquire New GPS Position

Use this setting to instruct the unit to acquire a new GPS position. TDC will then wait for the unit to acquire the new GPS position, reconnect to the unit, and download the updated position. Depending on how long the unit takes to acquire the GPS fix, this task may add up to 5 minutes to the SST transfer session. Please note that this feature is “grayed out” (not available) in the initial release of the Telonics SST system.

Blackout Period: SST Communications After Session

This energy-saving feature instructs the unit to black out SST communications after the transfer session is complete. TDC displays the duration of the blackout period if that information is available. Otherwise, see the TPF record for the blackout duration.

Transfer TPF File

Use this setting to download the TPF File from the unit.

SST Active Time

The bottom of the window displays the next active time (in UTC) for SST communications if that information is available. The active time for SST communications accounts for the SST schedule and a blackout period that you may have established during your last transfer session.

OK Button

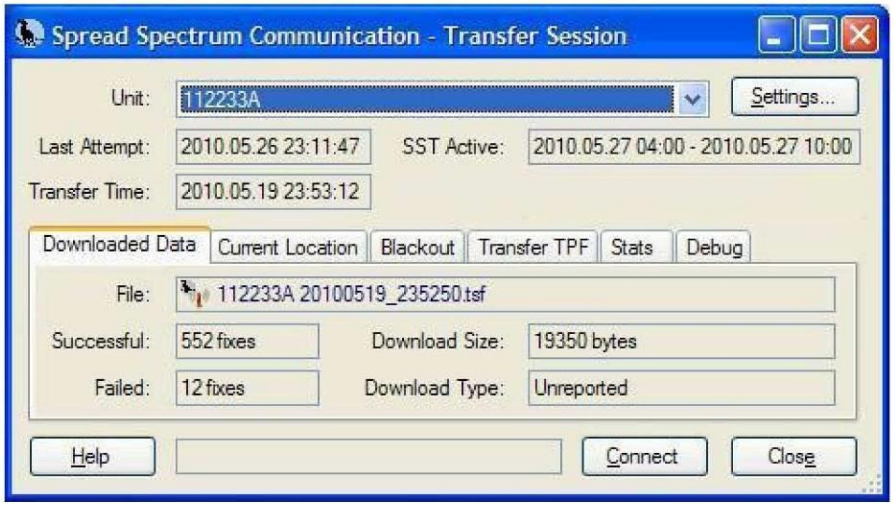
Pressing the OK Button saves any changes that you made within this window.

Cancel Button

This button closes this window without saving your changes. TDC displays a warning message before dropping the changes that you made, giving you a final chance to save your changes.

4.3 SST Transfer Session Window

This program window provides the ability to initiate an SST transfer session, view the status of the current SST transfer session, and view the results from previous transfer sessions.



Unit

The Unit drop-down list allows you to select the unit for the SST transfer session. The results tabs display the results from the last successful transfer session for the selected unit.

Settings

The Settings button opens the SST Unit and Session Settings Window.

Last Attempt

This field displays the time (in UTC) that you last attempted a transfer session with the selected unit. This time is updated as soon as you press the Connect button.

Transfer Time

This field displays the time (in UTC) of your last successful transfer session with the selected unit. This time is updated after a successful session.

SST Active

This field displays the next time (in UTC) that the unit is scheduled to listen for SST communications. This time accounts for the SST schedule and a blackout period that you may have established during your last transfer session.

Results

These tabs display the results from the last successful transfer session. Files listed in the results section are located in your Spread-Spectrum Files directory (set in the File Locations tab of the Options Window). You can access these files from this window by clicking the filename or icon. The results section includes the following tabs:

- **Downloaded Data**
  The File field lists the downloaded data file (TSF), factory-diagnostic data (optionally included inside TSF), and the test file. The Successful and Failed fields summarize the number of fixes included in the downloaded data file. Download Size describes the number of bytes downloaded for the data file (TSF). Download Type displays the selected options for the data download.
- **Current Location**
  This tab displays information from the most-recent successful GPS fix. TDC downloads this information with every SST transfer session. You can optionally instruct the unit to "Acquire a new GPS fix" as part of the SST session (see SST Unit and Session Settings Window).
- **Blackout period**
  Start Time displays the scheduled start of the SST blackout period , accounting for a short grace period after the last SST transfer session. End Time displays the end of the blackout period. The End Time does not account for on/off periods in the SST schedule. If the End Time is in the middle of an off period the unit will not listen for SST communications until the start of the next scheduled on period. See the SST Active field to see the next time that unit will listen for SST communications.
- **Transfer TPF**
  The Type field specifies whether TDC downloaded or uploaded a TPF file. The Size field describes the number of bytes transferred for the TPF file. The File field lists the name of the transferred TPF file.
- **Stats**
  The Statistics tab summarizes the health of the spread-spectrum link in the most-recent SST transfer session. Avg Signal displays the average signal strength of packets received by the SST-901M. Session Duration displays the total length of the transfer session. Tx Rate shows the average transfer rate for sending and receiving files over the spread-spectrum link. The Bytes Received and Sent fields describe the total number of bytes transferred by the SST-901M during the transfer session. The File field lists the detailed statistics file, which includes additional statistics about the spread-spectrum link.
- **Debug**
  The File field lists the Debug and Packet files. Debug Info displays the contents of the Debug file. If you are experiencing difficulties with SST communications, Telonics may ask you to send these files to the factory for analysis.

Connect Button

Press the Connect Button to attempt to connect to the selected unit and conduct an SST transfer session.

Stop Button

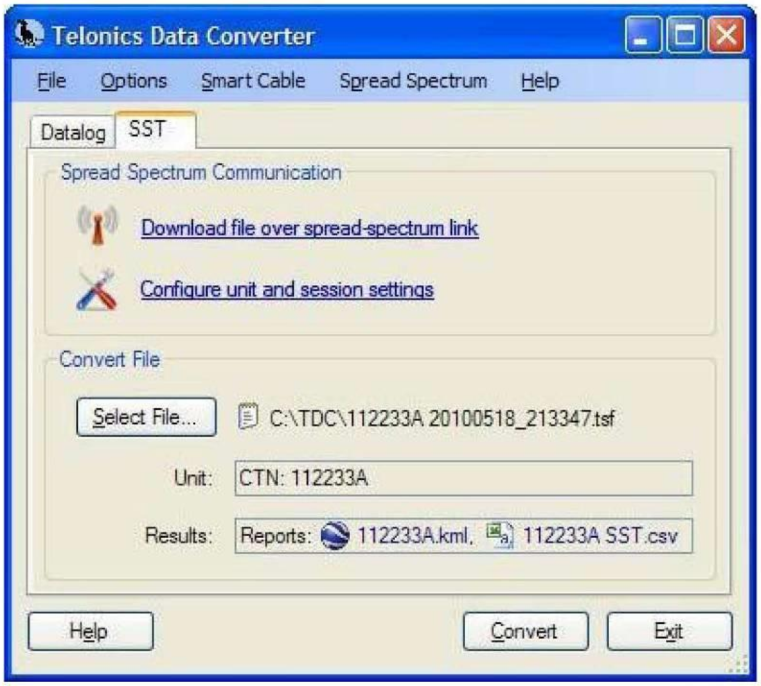
Press the Stop button to cancel a transfer session. If Telonics Data Converter has connected to the unit and is in the middle of the transfer session, TDC will warn you before canceling the session. If TDC has not yet connected to the unit, TDC cancels the session without warning.

Close Button

Pressing the Close Button closes this SST Transfer Session Window. If TDC is in the middle of an SST session, TDC will give you a warning and cancel the session before closing the window.

4.4 Main Window (SST)

The Main Window consists of two separate tabs. To switch to a different tab, click on the name of the tab near the top of the Main Window. This Help page covers the SST Files tab within the Main Window.



Main Menu

Like most applications, the Main Menu in TDC is located at the very top of the Main Window. Choices within the Main Menu allow TDC to perform the following actions:

- Convert Data (File->Convert Data)
- Exit TDC (File->Exit)
- Open the Options Window (Options->File Locations, Options->Report Settings, Options->Data Formats, or Options->Program Operation)
- Open a Download Datalog Window (Smart Cable->Download Datalog...)
- Open a Download TPF File Window (Smart Cable->Download TPF File...)
- Open the Erase Datalog Window (Smart Cable->Erase Datalog...)
- Open the SST Transfer Session Window (Spread Spectrum->Transfer Session...)
- Open the SST Unit and Session Settings Window (Spread Spectrum->Unit & Session Settings...)
- Access the TDC help system (Help->Contents, Help->Index, or Help->Search)
- Open the About TDC Window (Help->About Telonics Data Converter)

Spread Spectrum Communication

The Spread Spectrum Communication box is located near the top of the Main Window. This box provides links to download data and configure communication settings.

Download file over spread-spectrum link

Click this link to open the SST Transfer Session Window. From that window, you can download data from a unit over the spread-spectrum link. If you have already downloaded the SST file, simply use the Convert File box to select and convert the file.

Configure unit and session settings

Click this link to open the SST Unit and Session Settings Window. From that window, you can specify the connection parameters for an SST transmitter and choose the options for the next SST transfer session.

Convert File

The Convert File box allows you to select an SST file. This box displays the selected file, information about that file, and results of the conversion.

Select File...

Pressing the Select File Button allows you to browse your PC and select an SST file for processing. This button is disabled when TDC is in the process of converting data. TDC displays the currently selected file next to the Select File Button.

Unit

This field identifies the transmitter that created the selected spread-spectrum file. This information is extracted from inside the spread-spectrum file (.tsf). This field also displays any comments that have been assigned to SST units.

Results

Telonics Data Converter uses this field to inform you of its progress while it converts the file. After the conversion is finished, this field will contain the name of the generated reports (or state that an error occurred). Click the name or icon of a report listed in the results field to open the CSV or Google Earth file.

Convert Button

Pressing the Convert Button causes TDC to start converting the spread-spectrum file.

Stop Button

Pressing the Stop Button causes TDC to stop converting the file. You cannot resume a data conversion once it has been canceled.

Exit Button

Pressing the Exit Button causes TDC to close all windows and exit. If TDC is converting data when you press the exit button, you will be given a chance to cancel your request to exit.

5.0 SST-901M SPECIFICATIONS

GENERAL

FCC ID	JYLSST901M
Frequency Range	902.102 - 927.908 MHz.
Spread Spectrum Type	Frequency Hopping FSK
Applicable FCC Rules	Part 15 (15.247)
Number of RF Frequency Sets	4 sets, non overlapping Set 1: 902.102 - 907.100 MHz Set 2: 908.120 - 913.220 MHz Set 3: 915.260 - 920.360 MHz Set 4: 922.808 - 927.908 MHz
Nominal Channel Frequency Spacing	102 kHz
Data Interface	USB

POWER REQUIREMENTS

Primary Supply (USB Power)	5.0 V
Auxiliary Supply (Optional Auto/Aircraft Power)	10-16 Vdc
Transmit Current	400 mA typ @ 5V 250 mA typ @ 12V
Receive Current	30 mA typ @ 5V
Stand-by Current	< 5 mA

TRANSMITTER

Power Output	500 mW (+27dBm)
Frequency Stability	± 0.5 ppm @ 25°C
± 1.0ppm -30<T<+60°C	
Modulation Data Rate	19.2 kbps
Modulation Type	FSK
Modulation Bandwidth (99%)	40 kHz typ
Load Impedance	50 Ω

RECEIVER

Noise Figure	<3.0 dB
Sensitivity for 10^{-4} BER @ 19.2 kbps	<-110 dBm typ

MECHANICAL / ENVIRONMENTAL

Dimensions, excluding RF connector	3.40" l x 2.25" w x 1.0" h 86 x 57 x 25 mm
Operating Temperature Range	-30 to +70 °C
Humidity	<95%, non-condensing