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The Global Positioning System

Is It The Future Yet?

If you have been involved with telemetry over the past two decades, you have witnessed dramatic advances in technology used for tracking wildlife. While the advancements occur continually in existing systems, only rarely does a technology come along which radically revolutionizes the way in which we conduct wildlife research. The ARGOS system was such a development. In the early 1980's, prototype ARGOS transmitters known as PTT's were used to track and recover data from caribou and polar bears; by the close of that decade, projects on eagles, cranes, and geese were underway. Wildlife applications utilizing ARGOS will continue their developmental course through the 1990's.

ARGOS is not the only satellite-based system revolutionizing wildlife research. The new kid on the block is Global Positioning System (GPS). Unlike ARGOS, the subject carries a GPS receiver and the transmitters are onboard the satellite. GPS presents a potential for increased position accuracy to a level never before possible utilizing a satellitebased system. Media coverage concerning the new system has been extensive with exposure on the evening news, in popular magazines and trade journals, and in scientific literature. A number of detailed papers in the popular and technical publications explain the operation of GPS. Exhaustive explanations can also be found in CPS World, a magazine devoted solely to the new technology. At Telonics, we receive dozens of calls inquiring about GPS and its potential role in wildlife research and this article focuses on the current status of the system as a tool for tracking wildlife.

GPS began in 1973 when the Department of Defense decided to develop a 24-hour system with worldwide coverage capable of providing threedimensional positioning principally for military applications. The system is designed around an 18-satellite constellation (15 satellites are currently in place) orbiting at an altitude of 20,215 kilometers. The initial design called for four satellites to be in view of any position on the earth's surface at any time. Each satellite continuously broadcasts digital information which can be received by specialized GPS receivers on earth. With transmissions from four satellites, it is possible to calculate latitude and longitude, as well as the altitude of a receiver on the earth's surface by measuring the time of arrival of the signals at the receiver. Precise time is also provided. The usefulness of GPS is limited in tracking applications, however, as GPS does not contain a component allowing the information to be relayed to another location.

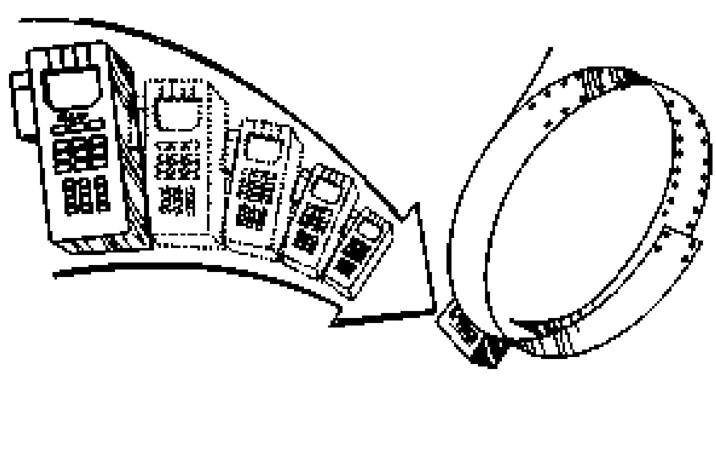
The initial design specifications resulted in two levels of accuracy: the Precise Positioning Service (PPS) and the Standard Positioning Service (SPS). PPS offers accuracy of 20 to 30 meters and is only available to the military. SPS offers accuracy of 100+ meters and is available to anyone. This concept of selective availability is best defined as the military's exclusive ability to interject a purposeful jitter in the clock designed to degrade the accuracy for non-military applications. The military GPS receiver contains the exclusive capability to decode a segment of the downlinked data containing the information on how to "unjitter" the clock data and recover full accuracy. There is great debate today as to whether the military should continue to retain "selective availability" and whether it should be enabled during peace time. To circumvent selective availability, a technique has been developed called "Differential GPS," wherein a GPS receiver at a known location is used to assess the effect of the clock jitter on the position and translate the detected error as a correction factor for a GPS receiver in an "unknown position."

Applications for GPS in the private sector include land surveying, as well as the monitoring of truck, train, and air traffic. Initially, the GPS receivers for these applications were too large to be deployed on animals. Current technology, however, has reduced the size of the "receiver engines" to approximately 4" x 2" in the soon-to-be-released smallest versions. While in operation, the receiver engines still require substantial power. These engines provide not only the capability to receive the satellite signal, but also contain the microprocessor capability to calculate the position based upon time of arrival of the signal and digital information about satellite orbitography downlinked from the satellites. This downlinked information known as "ephemeris data," is stored in an almanac in the microprocessor of the receiver engine.

A GPS receiver pinpoints its own location and if it's on an elk, the elk is also positioned. If we can teach the elk to read positions from a liquid crystal display and jot them down on small tablets throughout the forest, then we, too, will know the position of the elk. Since this approach may prove an inadequate link by which to relay information, we may have to provide a technology that does not place so much responsibility on the cooperation of the animal.

A relay system is the next step to recovering meaningful GPS data from animals and the recovery link for GPS data is still undefined. In fact, there may be multiple approaches to data recovery to satisfy various study requirements. You may have already considered the first approach—storing the data onboard the animal and not relaying it at all. Since it's not always possible to recover the animal and equipment, the data in memory could be lost. A second alternative is to relay the information through a direct transmission from a transmitter on the animal to a receiver. Any modulation format could be considered for this application including FM, AM, and Phase Modulation. The difficulty here is the limitation of range and the fact that either

you and



your receiver, your receiver and data acquisition system, or a repeater must be present in order to recover the information. Yet a third avenue to be considered is the use of a low polar orbiting satellite such as ARGOS to recover GPS data. This idea has been bandied about for several years and may present one of the more reliable ways of recovering these data. GPS information could be incorporated into the ARGOS data stream and uplinked. This approach has been implemented successfully in a non-wildlife application utilizing the Transit Positioning System. With this technique, the information could contain an entire history of GPS animal positions over a specified period of time. GPS, in concert with ARGOS, could provide a 24hour positioning capability which is not available via the ARGOS system today.

While GPS is already available for commercial use, in our opinon receivers are not yet small enough in size or low enough in power requirements to be practically incorporated into wildlife transmitting subsystems. Because of the large commercial market, it appears that GPS receivers will continue to diminish in size, power consumption, and cost. Boardlevel technology is soon to be available in the $400 to $500 price range.

It should be emphasized that we arejust beginning to develop a technology which allows us to obtain precise locations of animals under field locations. Like so many technologies we see hit the forefront, we are proceeding cautiously to properly evaluate the right time and implementation of that technology for application to wildlife. I cannot help remembering the developmental days of the ARGOS system. During the late 1970's, we were very much aware that the technology for ARGOS was becoming available. Others were attempting to implement the technology in the form of crude electronics and awkward packaging which had little chance of successful deployment on animals. We took a lot of "heat" in those early days trying to tell the wildlife research community that the technology was not yet ready. And we waited. We have always felt that was the right decision because when we finally incorporated the technology, it was done successfully—he first truly operational scenario for the implementation of ARGOS technology to wildlife. We feel the same way about GPS. It is "here" for many applications, but it is not quite ready for wildlife. We will continue to work with the technology and develop the components necessary for utilization of GPS when it "arrives." After all, we must have collars, packaging, power supplies, antennas, and all the other associated technology to ensure GPS can make the transition to an operational wildlife research tool. More later!

San Tomlaewicz

Here Comes Old Man... Person...Winter Again

It's Time to Get Ready

Now that the days are getting shorter, everyone knows it might be a good idea to check the antifreeze in their vehicles. Unfortunately, not many people give as much thought to preventive maintenance for their electronic equipment. Personally, I would rather experience equipment problems in the summer when the weather is beautiful and my outdoor experience will not be totally destroyed by the mysterious malfunctioning of some obscure component buried deep within a litle box. Conversely, I hate problems when it is cold, dark, wet and muddy. Accordingly, I am willing to invest a reasonable amount of time to preclude, insofar as possible, the untimely demise of my electronic systems.

At Telonics, we don't really hear much from people who have the foresight to look ahead to the rigors of winter and perform the necessary equipment checks. Unfortunately, we do see some evidence of equipment malfunction and damage which might have easily been averted with a few minutes of pre-season check out.

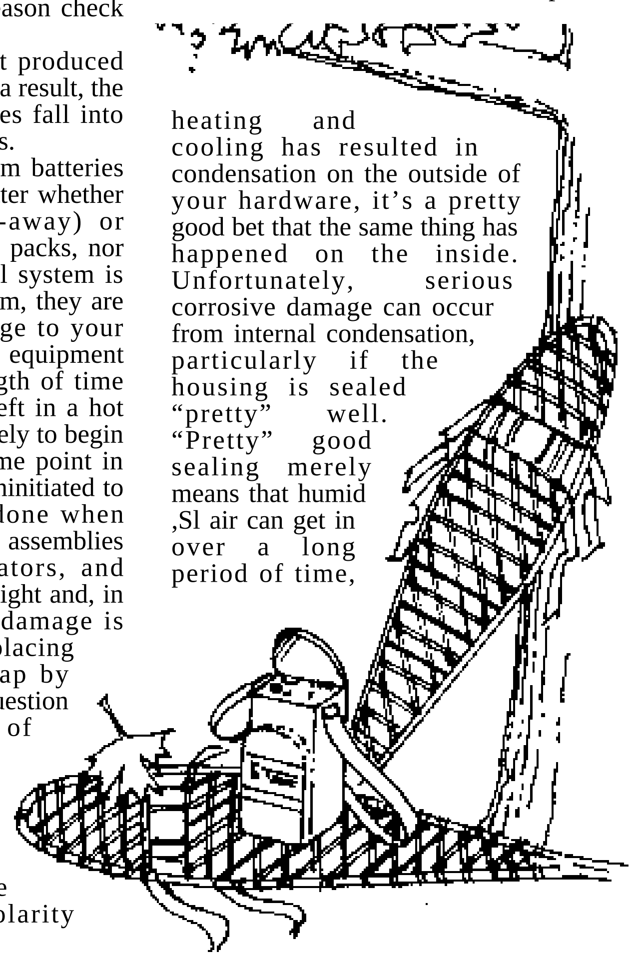
Most receiving equipment produced these days is fairly robust. As a result, the primary problems and failures fall into one of the following categories.

Batteries: Receiving system batteries are a problem! It doesn't matter whether they are primary (throw-away) or secondary (rechargeable) cell packs, nor does it matter what chemical system is under consideration. Long-term, they are a potential source of damage to your equipment. If your receiving equipment has been stored for any length of time where it is quite warm (or left in a hot vehicle), your batteries are likely to begin leaking a caustic ooze at some point in the future. It is hard for the uninitiated to imagine what damage is done when batteries leak on circuit board assemblies operating controls, indicators, and connectors. It is not a pretty sight and, in many cases, the resultant damage is irreparable. The cost of replacing batteries regularly is cheap by comparison. If there is any question regarding the condition of primary batteries, replace them and keep a few fresh spares handy when

you are in the field. If ya_ are using our TR-4 Receiver, install one of the two batteries with the polarity reversed (it will not discharge). It can simply be reversed when the other battery runs down.

If your equipment utilizes rechargeable batteries (such as NiCad's), you might simply replace them annually on general principle as NiCad's really dislike sitting for extended periods of time whether hot or cold, and regardless of whether or not they are being charged during storage. Alternatively, you might remove the cells and accurately measure and record the noload terminal voltage of each cell. If they all measure within +0.1 volt of each other they are probably either all good or all bad (how is that for technical assistance). If any cells measure low with regard to the others, discard it/them. If they measure all over the map with respect to each other discard them all. Install replacement cells charge them for 14 to 16 hours, and then operate (or turn on) the hardware for five hours. Turn it off and let it set overnight repeat the comparative no-load voltage measurements of each cell the next day, and discard cells which exhibit deviate voltage indications. As an aside, while you can string along a set of batteries using this approach, it is good practice to replace all the cells at the same time with a matched set. This will ensure that they will all charge and discharge at approximately the same rate.

Water: You do not have to totally submerge your receiving equipment to sustain serious water damage. If it has been stored in a location where repeated heating and cooling has resulted in condensation on the outside of your hardware, it's a pretty good bet that the same thing has happened on the inside. Unfortunately, serious corrosive damage can occur from internal condensation, particularly if the housing is sealed "pretty" well. "Pretty" good sealing merely means that humid ,Sl air can get in over a long period of time,



condense, then take a very long time to dry out—just the conditions you do not want.

Take out the batteries, open your housing and look for corroded areas (white residue, black mold, etc.) If it is wet, make certain things have an opportunity to dry out slowly before closing it up and installing batteries. (Remember there are lots of little places in components that must be dry before power is applied.) If it has been wet but still acts "funny" when you turn it on, send it in for repair. We will let you know the problem, repair it, and you will be on your way.

Wires: Wires break, coaxial cables become deformed, and connectors break, corrode, and bend. Wires are a problem! If there were a practical and effective way to eliminate them, there would be no wires in Telonics' systems. However, until we discover a better way to get signals from here to there in receiving systems, it is a good idea to do the following:

- Carefully inspect all wires and cables for cuts, chafing, and deformations caused by pinching.
- Go over all connectors with a magnifying glass. Look for trapped dirt and mud, corroded areas, bent pins, entrapped flakes of metal and plating. Watch for loose connector bodies, fatigues in wire braid/shielding on coaxial cables. Be especially wary of connectors which turn freely on coaxial cables, and plugs which flex too easily on ribbon cable— they may be badly fatigued and will let you down later in the winter. Be sure to check your spare coaxial cables; if you cannot find them, replace them. If you find flat spots on your cables where they may have been clamped in windows or doors of vehicles, replace them. We will be happy to give you some tips on how to solve such problems.

Controls: Sometimes after storage, volume and tuning controls get "noisy" due to intermittent wiping of the moveable contact during its rotation. An accumulation of dust and moisture on the resistive element (along with normal wear), will make things even worse. In some cases, you can "clean" the contact through simple usage; remove the battery(ies) and operate the control 25 to 50 times. In more severe cases, it may be necessary to replace the control.

Front Panel Connectors: Check each mating connector on your systems, looking for deformed shells, bent or missing pins, entrapped foreign material, etc. prior to mating cables to the system (using the same criteria as described for connectors on cables).

In summary, this can either be a good wintcr or a bad winter. A few minutes invested early can prevent hardware problems. When you have a good winter, we have a good winter! *Dave Beaty*

Battery Basics

Nothing Is Ever Simple

Great news! ! ! We just found out that we can buy bare transmitters from Telonics (or company X), add our own batteries, package them ourselves and save a bundle of money! !

A look at the battery rack in a large number of chain stores or your local Radio Shack would seem to indicate that there are almost endless possibilities for providing power for the small transmitters used in wildlife tracking. After all, these transmitters are small, run for a long time and so shouldn't require anything too special in the way of power. There are mercury cells available, silver oxide cells, alkalines, nickel-cadmiums, carbon zinc cells, sealed lead acid cells, and, yes, a vast array of lithium cells. Everyone knows that lithium cells are the ultimate power source for use in this business. A closer look will show what a wide diversity of form factors are also available. There are cylindrical cells, buttons, ovals, flat ones, and even some that are flexible. In addition to the local supermarket battery rack with its wide selection, there are stores that sell batteries almost exclusively, advertising that they have a battery for "any application you can come up with." There are catalogs available from manufacturers that list an even more formidable array of power sources to choose from with even more form factors.

Picking the right battery should be easy. The cell's capacity is usually on the label (in milliampere hours), so it's a simple calculation to determine which celis will last long enough by dividing the battery rating by the average current drain of the transmitter, the result being the number of hours the transmitter would be expected to operate. Truly, it would seem that finding a battery to run a micropower transmitter should be about as simple as sitting down on the floor!

Alas, as we here at Telonics—and some of you too—have found, it is not nearly that simple. There are a number of questions that should be answered and a battery (pun intended) of tests that need to be run before a cell can be considered acceptable for use in wildlife elemetry.

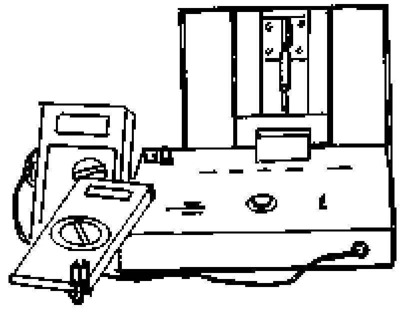
One of the most basic problems associated with the transmitters used for tracking is the fact that while the average current required is very low, it is achieved only by what is referred to as duty-cycling the transmitter. In other words, the transmitter doesn't transmit continuously but emits very short bursts of energy spaced by fairly long quiescent times. During the transmit portion of the cycle, the current drain may be as low as a few milliamperes for a small VHF transmitter or as much as one ampere or more in the case of a satellite transmitter. During the quiescent time, the unit may only draw a few microamperes. Satellite transmitters may be further duty-cycled by suspending transmissions for periods of hours and, in some instances, for months. Thus, by taking duty-cycling into account, the transmitter is drawing only a few tenths of a milliampere on the average. In fact, it is entirely possible that a VHF and satellite transmitter could draw the same average current, and therefore consume the same and seemingly adequate battery capacity over a period of time. However, one particular battery could successfully power one transmitter type and totally fail with the second. It is also just as possible that the cell might not power either because many of the cells available arc designed to provide only microampere current levels, which could be orders of magnitude below what even the smallest transmitters require during the transmission pulse. So, a battery must be able to supply what is called "pulse current" to be useful in powering a transmitter.

Another important consideration in selecting a cell is its ability to perform over the temperature extremes encountered in wildlife telemetry. Many of the cells that are readily available are designed for use in a relatively benign environment. Some are used to power wristwatches which frequently work in very cold surroundings. Keep in mind, however, that they are almost always strapped to a rather effective heat sink and, if that heat sink gets too cold., it is almost certain that action will be taken to remedy the situation! The effect of cold temperatures on cells is usually two-fold: not only is its capacity significantly reduced but also its ability to deliver the above mentioned pulse current is much lower. A cell which performs admirably at room and higher temperatures can be a total failure even at freezing.

Questions of battery safety during transmitter assembly, shipment and field use should be addressed. Some cells literally become bombs if they are carelessly stored or handled during testing and installation in the transmitter subsystem. Problems concerning safe shipment of equipment employing cells which contain lithium are no secret and DOT regulations applying to these shipments sometimes create difficulties in shipping equipment to customers. It is almost certain that these regulations will become more stringent in the future.

With all of these factors to consider, the quest for a battery suitable for wildlife telemetry work can seem more like chasing a greased pig than simply sitting down on the floor. The quest for a "good" battery usually begins by reviewing data sheets and talking to manufacturers. Most battery data sheets don't give us any pulse current information. By looking at the battery's continuous current capacity and any temperature data that may be already available, we can get a feel for whether a battery is worth investigating further.

Once we find a potentially suitable battery, the fun begins! We now need to test the batteries under simulated operating conditions. As you read earlier in order to qualify for use in wildlife telemetry systems, the battery must supply "pulse current" over a wide temperature range for extended periods of time. Because it is necessary to monitor the battery performance in a variety of conditions over a long period of time, it is a little impractical to have a person "sit and watch" the batteries. Utilizing computer technology and a little of our own engineering, we have developed a computer controlled battery tester that can simultaneously pulse several batteries, dynamically measure how well the battery supplies (and recovers from) the desired "pulse current," and record the data for analysis. By combining this computerized battery tester with a temperature chamber, we can take large quantities of data over extended periods of time at any current or temperature range—and all without having to consign some poor soul to months of tedious "battery watching."



Once we find a battery of the right size that can supply the necessary pulse current searing desert heat, you'd think our work is done...not so! Each battery we use has unique characteristics and we implement precise testing and handling procedures customized for each type of cell.

Here's an example: Most of the batteries we use employ some form of lithium-based chemistry because of their exceptional energy density. However, as lithium batteries sit unused for extended periods of time, a"passivation layer" tends to build up on their electrodes. This passivation inhibits current flow and must be removed in order for the battery to supply the pulse currents required by a transmitter. (We recommend that transmitters using lithium batteries be "exercised" every few months to keep this passivation layer from forming on the j electrode.) When we receive batteries from the manufacturer, they are generally passivated. In order to remove the passivation layer, these batteries are "started"—or subjected to critical loads for precise periods of time. Thus, each battery type has a specific procedure to adequately remove the passivation without damaging the battery. In addition to removing passivation, it is necessary to test a battery for capacity. While it is impossible to measure the capacity of a lithium battery without exhausting it, each battery is tested to assure that it can supply its rated pulse current.

It would seem with all the above mentioned care in selecting and testing a battery that one could be assured of the best power source available. This is not necessarily the case. Some problems show up only after extended times in the field. One particular example of this is how well a cell will stand up to repeated mechanical shock—one cell may prove to be particularly rugged and another vulnerable to even low level stress. It is at this point that a long history of actual field experience with various cell types and designs can make the difference between success and failure. We try and apply that experience to every project we undertake.

Boyd & Timo Hansen

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