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Is This Thing Really Going To Work?

Whether you design and construct your own telemetry or purchase equipment from commercial sources, the question of how to check out the equipment is paramount for most researchers seriously interested in recovering usable data. The question of testing and the validity of testing protocols is at the heart of this newsletter issue.

No matter how much faith you have in your equipment, we all acknowledge that the real world is an uncontrolled environment with extremes of temperature, vibration and shock among the factors which influence the performance of your telemetry systems. What you want to know before you deploy is simple – will the system work as well as can reasonably be expected? The answer is often complicated.

"Simple tests" can't always tell us what we want to know about the system. They can even provide confusing results if the test design is invalid. On the other hand, many of us conduct various tests on our equipment (often using questionable procedures) and sometimes we even uncover real problems. Hopefully, this issue will help sort out some of the tests you can realistically perform on telemetry systems and, perhaps, point out some limitations to testing procedures that are commonly being used by researchers.

In any case, it is critically important to recognize a well-accepted view in the quality assurance field. ***Quality cannot be tested into a product.*** It must be designed in at the beginning and built in during the manufacturing process!

Range Testing

Practical results can be obtained.

Range testing of VHF and UHF transmitters is an excellent example of how a very simple question (i.e. "How good is my transmitter?") can require complex methodology to derive meaningful data, which can then be evaluated to arrive at a very simple answer.

The Problem

Outwardly, it would seem that range testing could involve placing several transmitting subsystems (i.e. a fully packaged transmitter with antenna and power source) on a stump or fencepost, moving away some considerable distance, tuning to the specific operating frequency for each transmitter, and determining which transmitter produces the strongest (or weakest) signal. Practically, we can do these things and obtain a result. Unfortunately, the conclusions which can be drawn in most cases will be incorrect!

Theoretical Approach

From a theoretical standpoint, we should conduct "range" tests in a controlled laboratory environment. The proper methodology is to place a transmitter with known output power and a carefully oriented antenna within an electrically large, totally radio reflection-free anechoic chamber. Then, using a calibrated receiving system (consisting of a circularly polarized receiving antenna connected to the receiver with loss-calibrated coaxial cabling and a display unit calibrated in either microvolts/meter or another standard measure of electromagnetic field strength intensity), measure and record the actual received radio frequency energy level.

Once the anechoic chamber is thus calibrated, we would place a single transmitting subsystem (with known/controlled antenna orientation), in place of the known laboratory signal source and antenna. By substitution, we could then compute the actual radiated energy for the Device Under Test (DUT) in that singular placement, within that particular alignment plane.

Since telemetry transmitting subsystems exhibit widely varying signal strengths dependent upon antenna orientation (variations of as much as 3 orders of magnitude or 30 decibels are not uncommon), it follows that one should measure the Effective Radiated Power (ERP) patterns in three planes (the X, Y, and Z planes) to fully define the shape and intensity of the total radiation envelope.

At higher operating frequencies (above 400 Mhz), the DUT is mounted on a motorized test pedestal made of a material which is essentially inert at the radio frequencies in question, such as fiberglass or teflon. This pedestal is then further covered with anechoic absorbent material to preclude reflections which would adversely influence test results. A series of ERP plots is then made while the DUT is rotated in each of the three planes, producing a data model which clearly depicts radiated energy patterns.

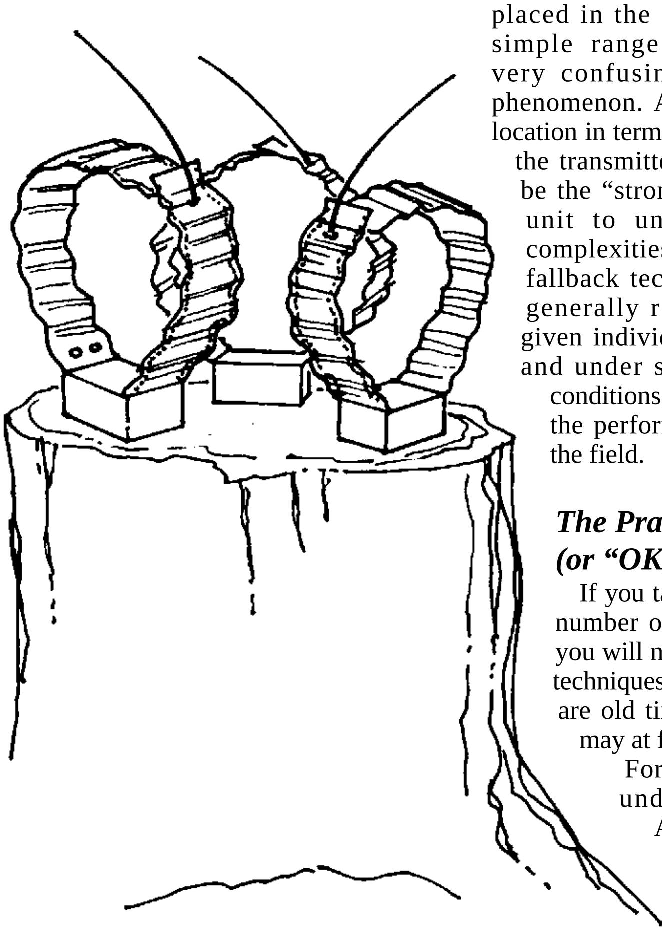
This radiated signal strength pattern is automatically plotted on a graph or polar plot in realtime as the pedestal turns relative to the receiving antenna. The DUT is removed and the reference signal producing equipment is re-installed in the anechoic chamber and the calibration tests repeated. If the re-calibration data agrees with the initial readings, the DUT data results are considered valid. When the results from the DUT are computed against the reference readings, the radiation envelope model is transformed to actual measured field intensity values.

Utilizing these data, and assuming that the electrical characteristics of the receiving equipment to be utilized in the field are known, (i.e. receiving antenna. gain, coaxial cable and connector losses, and receiver sensitivity for the temperature range to be encountered during tests), the total free-space system range performance for a particular set of transmitter and receiver antenna orientations can be computed (utilizing standard free-space "path loss" formulas).

The Real World (or "Why it won't work!")

From a practical standpoint, there are two basic problems with the aforementioned technically correct approach. First, the anechoic chamber techniques described will only work with a chamber of sufficiently large physical dimensions for the wavelengths involved. In the two meter wavelength region (150 MHz), such chambers are very rare and are both difficult and quite costly to access. Most anechoic chambers provide increasingly erroneous results at frequencies below 400 MHz because they are physically too small .

Second, even if anechoic chamber measurements are correctly acquired, things don't work the same way in the real world. Instead of the theoretical free-space path, we typically have trees and other foliage blocking the path of the signal. Sometimes the vegetation is wet, thereby significantly increasing attenuation of the signals. Due to the irregular envelope shape of the electromagnetic wave front formed by the transmitter package and antenna, we see the effect of not one, but many signals emanating from transmitting subsystems in the field. This multiplicity of signals reflects from every possible surface (ground, rock outcroppings, banks of dense wet foliage, surfaces of existing water, etc.) to the extent that stronger signals are sometimes received from a direction other than that of the transmitter! *(Note: The reader may wish to review past articles in the newsletter dealing with multi-path and signal propagation.)*



Over the years you have undoubtedly seen antennas with one element (vertical "whips" on vehicles), antennas with 2 elements (our RA-2AK "H" antennas), and antennas with many elements (TV antennas on homes). The reason for the varying number of elements on different types of antennas is that multiple elements effectively channel the signal strength applied to a given antenna in a particular direction, providing the effect of "gain." A person placing two or more transmitters on a stump together, or hanging transmitters on a metal (or wet wood) fence post, near a fence with metal wire, near a metal vehicle, or next to a metal dart gun, etc., etc.) inadvertently forms a directional antenna with respect to the transmitter(s) under test.

By virtue of the nearby naturally occurring conductive "elements," an array of elements is thus formed which will, without fail, result in undefined and undesirable directivity of the radiated signal from the transmitters.

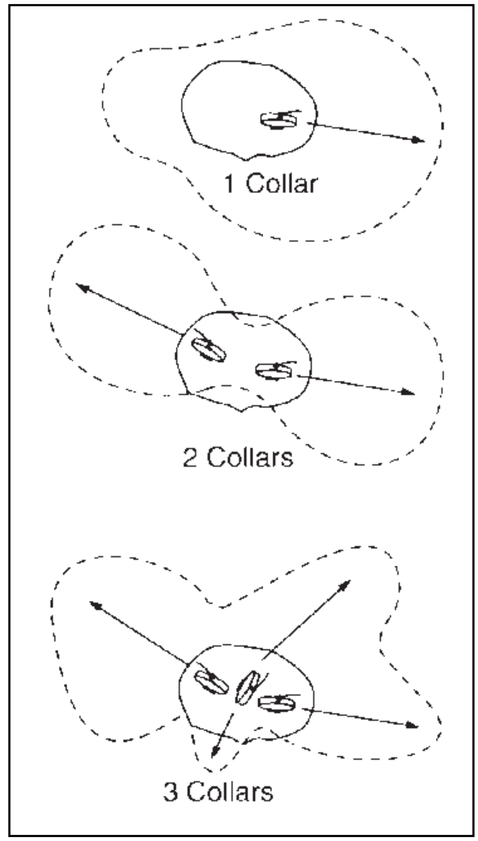
In the case of multiple transmitters placed in the same location, making simple range comparisons can be very confusing indeed due to this phenomenon. As the observer changes location in terms of bearing and distance, the transmitter which is perceived to be the "strongest" will change from unit to unit. Because of these complexities, we must work with a fallback technique which produces generally repeatable results for a given individual, in a specific place and under specific environmental conditions, in order to approximate the performance of transmitters in the field.

The Practical Approach (or "OK, so waddawe do?")

If you take the time to speak to a number of old-timers in the field, you will note that there are as many techniques for range testing as there are old timers, and the techniques may at first seem almost random. Fortunately there are some underlying consistencies. After much experimentation (and unfortunate re-invention of the proverbial wheel), most researchers find that in order to achieve anything like reliable test results, they need a control (whaddaya know!) and somewhat consistent test conditions. In application, a person generally experiments with available implements in his/her particular area. The theoretical anechoic chamber is replaced with the wide out-of-doors, the calibrated signal source and transmitting antenna replaced with a "good-ol" transmitter which exhibits apparently consistent performance. The function of the nonreflective pedestal in the anechoic chamber is accomplished by finding a nice stump (hopefully dry), a shovel handle which can be stuck in the ground, a favorite tree limb or the top of an old, wood shingle-covered out-building (with little or no metal around).

The "good-ol" reference transmitter (our control) is placed on the stump in a known, consistent position, typically with the antenna straight up initially (the X plane). Instead of rotating the transmitter in each axis, the observer moves in a large circle at considerable distance, either listening to the received signal strength with headphones or taking note of the signal strength reading on some type of indicator at the receiver. Very accurate results can be obtained using the TDP-2 Digital Data Processor in the Amplitude mode. The transmitter

Figure 1 – Radiation Patterns



is then placed in a second, then a third orientation (the remaining two planes – Y and Z), and the circle of readings is repeated and recorded in each case.

Having successfully produced a baseline with the known reference transmitter, an unknown DUT unit(s) is then placed similarly on the stump, etc. and the process repeated and recorded. *(Note: One cannot place the known and unknown transmitters on the stump simultaneously or erroneous results will be obtained due to lobing of the radiated signal pattern from the undesirable multi-element antenna array thus formed. See figure 1.)*

A statistical mean of the readings for various units will then provide the answer to the original question of which transmitter is stronger. In point of fact, the output power from well-designed modern transmitters seldom varies significantly from unit to unit, unless battery life is within the end-of-life decline. In general, this decline occurs at approximately 90% of predicted useful life with most lithium chemical systems at moderate temperatures, and 75-80% of predicted useful life at extremely cold temperatures. The vast majority of difference that is encountered in field situations results from differences in transmitting antennas and how the antenna reacts with respect to nearby objects (e.g., the animal itself).

Functional testing of modern VHF telemetry transmitters can therefore only be approximated in the field, but with perseverance and a little scientific methodology using controls, usable results can be obtained and reasonable conclusions drawn. If you have questions regarding these techniques, give us a call – we can share some techniques we have encountered that are a real hoot. (Be sure and mention horses, midgets and thieves!)

Dave Beaty

Receiver Testing

Some things you can do in the field.

ARGH! I have to deploy 40 transmitters and need to make sure my receiver's working properly. Ever heard that before? If you have ever experienced anxiety over the performance of your receiving system, we'd like to present a few things you can do in the field to check out your TR-2 or TR-4.

Many researchers have found that a reference transmitter is an invaluable tool in evaluating performance. The reference transmitter should have an antenna that won't "flop around" when the wind blows and it should be placed in a location free of obstructions to provide as uniform a radiation pattern as possible. Your receiving system should be located at another fairly distant location, line-of-sight to the reference.

Remember that if your transmitting antenna is mounted vertically, your test receiving antenna should also be mounted vertically and if one is horizontal, the other should also be horizontal. If the transmitting and receiving antennas are not both oriented in the same plane, your receiving range will be reduced dramatically. If you consistently test your receiving system at the same location and *take good notes*, you can have reasonable confidence that any changes in performance you may see are equipment related (i.e. antenna, cables, receiver, batteries) rather than due to environmental effects (i.e. weather, vegetation, mountains, etc.).

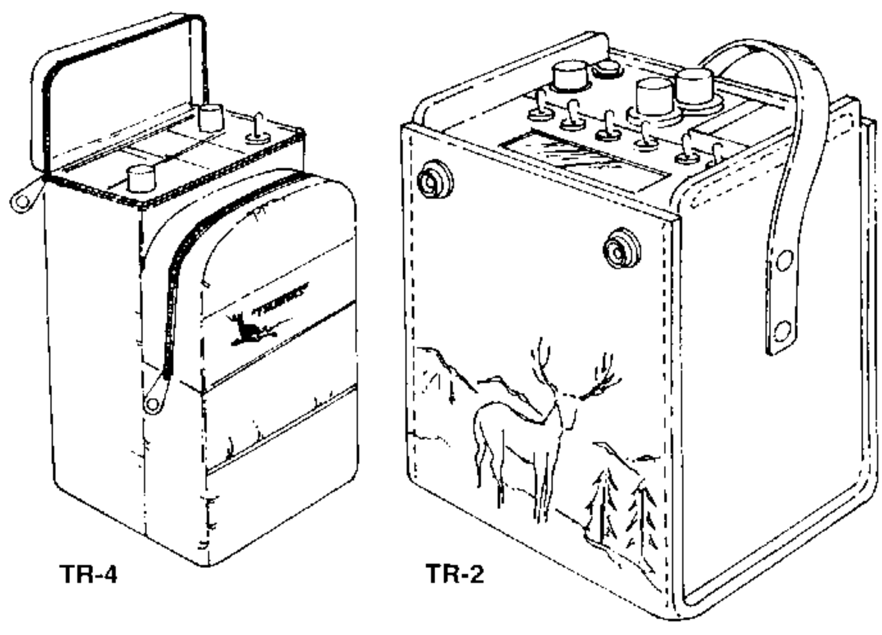
Now, let's look at that receiving system! Since you rely on the antenna and connecting cable to catch the tiny signals emitted by the transmitter and bring them to the connector of your receiver, this is the first place to look for problems. Examine the antenna and any mounting hardware to make sure they are assembled correctly and show no signs of physical damage or corrosion.

Now follow the coaxial cable to the receiver, looking for loose or corroded connections, pinched or kinked spots (may have been caught in car door?) and any other damage. Check connectors for any signs of wear. Don't hesitate to wiggle connectors or cables while listening to the receiver. If you hear static or the signal strength varies dramatically, you have probably located a bad connector or cable.

Look just as closely at the headphone connections and cables. If you have extra antennas, cables, or receivers, it is a good idea to swap components (one at a time) and listen for a difference.

Next, let's make sure the receiver is in good order. Are the batteries in good condition? The charge indicator on the TR-2 should be well into the green. On the TR-4, the low battery indicator should be off. Connecting an external power source will ensure that you are getting sufficient power. *(Note: For more on the care and feeding of rechargeable batteries, see your user's manual.)*

It is also important that the receiver settings are correct. First, verify that you are listening to the signal on the "high frequency side" of "zero beat" – that is, while listening to the transmitter signal, slowly turn the delta tuning control clockwise. The tone should increase in pitch if the receiver is tuned correctly. *(Note: Listening to a signal on the low*



The Telonics TR-2 is the industry workhorse. It can be used with or without a scanner, and has become the standard for aircraft tracking studies around the world. Smaller, lighter and lower in cost, the TR-4 is an inexpensive channelized receiver developed for ground tracking. Telonics anticipates that the TR-5, a highly advanced microprocessor-controlled scanner/receiver being developed for aircraft tracking in the future, will be available late in 1993. It will offer full data acquisition capabilities and promises to deliver everything that researchers have been asking for in a receiver.

frequency side of zero beat will reduce the receiver's effective operational range by up to a factor of 4!)

Your user's manual explains the use of the delta tune control in detail. The cleanest signal is obtained with the gain control turned just high enough that you begin to hear an increase in the background noise. Turning the gain control higher than this will only result in a distorted audio tone and more noise.

Sometimes an interfering signal can "drown out" your transmitters. Interference is generally external to your equipment. However, at specific places in the band, you may hear a solid tone – if this tone remains constant with or without the antenna connected, it is probably a "birdie" (a result of intermodulation products of oscillator signals inside the receiver). Birdies are a fact of life, especially in this type of receiver. We have "blackballed" (do not use) transmitter frequencies that coincide with birdies, but if you purchased transmitters from another vendor, conflicts with birdies are possible.

The environment (both man-made and natural) also affects the performance of any receiving system. First, the environment can affect performance. Transmitted signals propagate most easily through the vacuum of space. Unfortunately, when we add humidity, vegetation, rocks, hills, animals, storms, etc. to the path between transmitter and receiver, the signal strength can be greatly reduced.

Second, the environment can damage your receiver. The TR-2 and TR-4 are sensitive and designed to "listen" for extremely weak signals. This means that strong signals can overload and perhaps even damage the receiver. Lightning, static shock, and even vehicle-based two-way radio equipment can produce sufficiently strong signals to overload and potentially damage the input. Thus it is a good idea to disconnect your receiver during thunderstorms, near Van De Graff Generators (while dragging your feet on shag carpeting), or while operating two-way radios.

If your receiver has been in very cold, humid, or rainy weather, corrosion may form on the electronic components. Left unchecked, it will slowly degrade your receiver's performance.

By the way – if your receiver does get wet inside, it is important to open the case as soon as possible to allow the electronics to dry. The TR-2 can be opened by removing the front panel screws and sliding the electronics out of the metal housing. The TR-4 is opened by removing four screws in the case and separating the "clamshell" housing.

If your system is working fine now, CONGRATULATIONS ! ! and happy tracking. However, if you find problems that you are unable to resolve in the field, we are always happy to answer any questions you may have. To keep your receiving system in top condition, it's important that you take advantage of our preventive maintenance program.

Normal communications test equipment (such as that found in a typical radio repair shop) cannot be used to align and test these specialized high sensitivity receivers. When you send your receiver to Telonics for maintenance, we use specially designed equipment to adjust the sensitivity and ensure that it is equal over its frequency range. We also adjust the receiver to factory specifications, check for proper operation at high and low voltages, verify proper function of charge circuitry and battery indicator, and check and recharge the batteries. We clean accumulated dirt and foreign material from all critical circuitry, front panel controls, and switches. If, for some reason, your equipment has been damaged, we'll give you a call and provide an estimate of the damage. If you have a scanner, it can be checked out at the same time.

The receiving system is the only link we have to the instrumented animal in the field. The system is complex and must be hardworking and durable to handle the field work. As with other quality issues discussed elsewhere in this edition of the newsletter, reliable high performance from a receiver comes from solid design and good manufacturing procedures – and when something does break, from people who can understand and fix the problem properly.

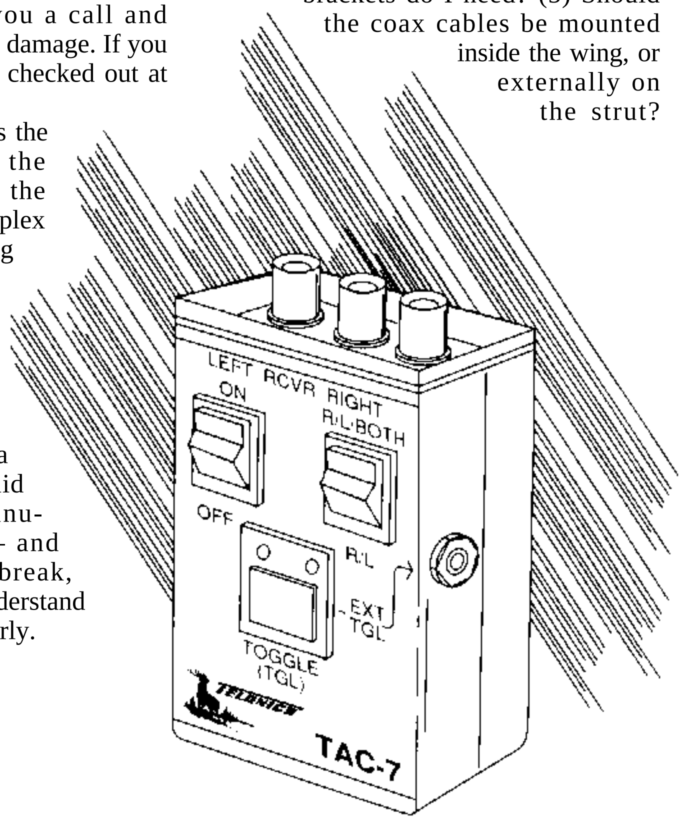
Timo Hansen and
Scott Ray

What Does It Take For A Successful Flight?

Planning ahead can make all the difference

The day dawns bright and clear with all the trappings of a good day for getting in the airplane and doing some location work. It has been a couple of weeks since the transmitters were installed on that bighorn herd up north, and it's time for them to be stirred up again! The anticipation mounts as the aircraft is readied for flight. This is the maiden voyage for this new equipment, and the question arises – will everything work as it is supposed to?

A successful flight starts long before take-off. The following questions should be asked before a flying project is undertaken. (1) Which aircraft will do the job I need done? (*Note: This article will deal specifically with issues related to fixed-wing aircraft.)* (2) Does it have struts that I can use to mount the antennas? (3) What kind of antennas should I use? (4) What mounting brackets do I need? (5) Should the coax cables be mounted inside the wing, or externally on the strut?



The TAC-7 is the first in a new generation of combiners/antenna switching units currently under development at Telonics.

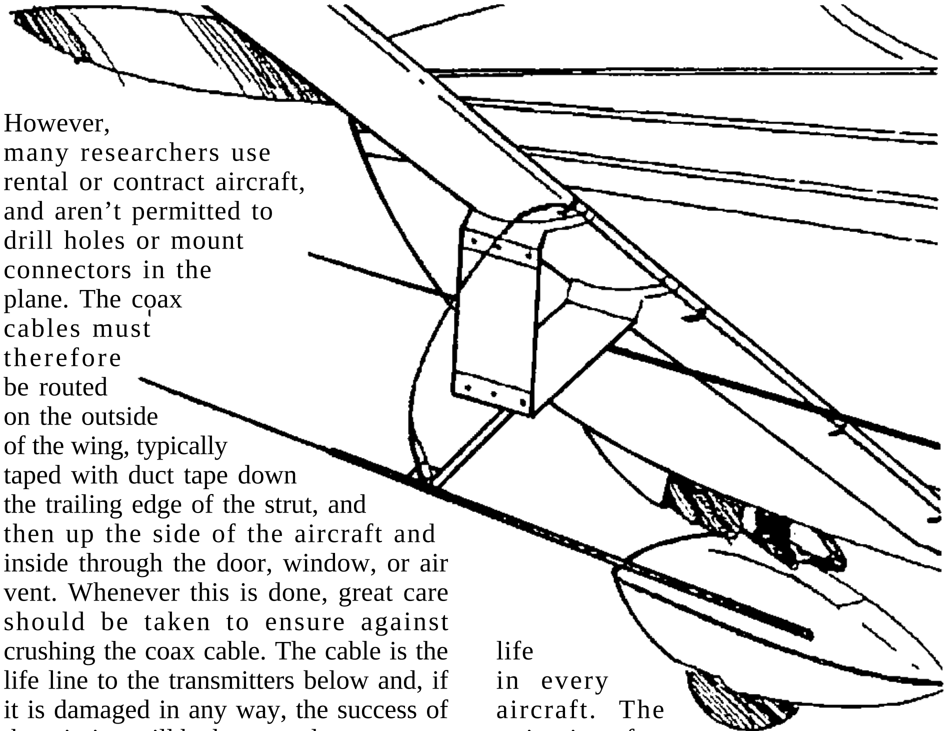
(6) How do I know the switch box works? (7) Does the airplane have an integral intercom system that will accommodate audio input from the telemetry system? Or will I need to supply one that can interface with my telemetry equipment? (8) What do I do if there is engine noise? The questions could become lengthy, but the point is that careful consideration will make for a successful flight.

Selecting an aircraft is usually a matter of budget and availability. (Hopefully, low bid is not the controlling factor in the choice.) Preferably, the plane has a high wing with struts, for ease of bracket and antenna installation (as well as for observer visibility). As for the choice of antenna, we recommend the RA-2A antenna because its small size presents minimum wind drag, and its performance can be maintained even in relatively close proximity to the metal of the aircraft. Although some folks use larger 3 and 5 element antennas, they are more easily detuned, degrading performance to the point that no advantage is realized from their relatively large physical dimensions, and they are more difficult if not dangerous to mount on aircraft. We really don't recommend them!

We do recommend the TAB series of brackets because they have been designed and built by certified A&P technicians specifically for safety and stability with the RA-2A antenna. Installation of brackets, antennas, and cables is a primary concern. When installing the brackets, make sure they are centered on the strut, and securely clamped in place. It's always better to check it twice than to have something come loose and possibly damage the aircraft (and you) while in flight.

After the antennas are installed on the brackets, make sure the elements are tightened securely. Then take a small piece of vinyl electrical tape and tape each joint. *(Note: Regulations governing the attachment of equipment to aircraft vary depending on ownership, use and location. Users should check with appropriate authorities regarding requirements. The International Association of Resource Plots is one source with suggestions based on practical experience.You may also want to refer to the Federal Aviation Regulations for any questions concerning certification requirements.)*

Next comes the dressing of the coax cables. The preferable way to dress the cables is inside the wing; by so doing, you ensure the longest operational life of the cables since they won't be exposed. However, many researchers use rental or contract aircraft, and aren't permitted to drill holes or mount connectors in the plane. The coax cables must therefore be routed on the outside of the wing, typically taped with duct tape down the trailing edge of the strut, and then up the side of the aircraft and inside through the door, window, or air vent. Whenever this is done, great care should be taken to ensure against crushing the coax cable. The cable is the life line to the transmitters below and, if it is damaged in any way, the success of the mission will be hampered.



If you use one aircraft regularly, you might want to talk with the owner about a more permanent installation. Such an installation can be made by installing a bulkhead connector in an inspection plate in the wing, and then routing the cables through the wing into the fuselage. When this is done, be sure to have an A&P mechanic work with you, and/or inspect the work you have done.

Antenna switch boxes are the boon and bane of aircraft tracking. When they work, the whole world seems rosy. But when they don't work, they become profanity generators! Two things should be done to ensure peace and domestic tranquillity. First, it's a good idea to have a back-up switch box. Second, a beacon transmitter (or a spare collar) should be left at the airport or some other known location so that in the initial moments aloft, you can fly a test pattern around the beacon, and check the function of the switch box before flying 100 miles to the study area.

Intercoms are the icing on the cake. Gone are the days when communication with the pilot was a system of gestures and shouting to be heard above the roar of the engine. Although most factory-installed intercoms don't accommodate low impedance audio input, we do offer the SPO series of intercom systems which are designed specifically to interface with the audio output of the telemetry system.

The pilot can now hear what you hear, and talk with you, as well as use his aircraft radios with ease. Engine noise (radio frequency interference) is a fact of life in every aircraft. The noise interferes with reception of signals from the transmitters because of the high sensitivity of the receiver. There are aircraft which are electrically noisy and some which aren't so noisy. The DeHAVlLLAND Beavers (yes, there are still a few of them around) are usually great noise generators!

For noisier aircraft, an A&P mechanic can install shielded wires, magneto shields and resistor spark plugs on the engine to help reduce the noise. Something else that can be done is to ground, or unground, the antenna. Sometimes this helps, but then again sometimes it doesn't. It may be necessary to change to another aircraft to help solve the problem.

Certainly aircraft tracking is one of the high dollar items in any budget. Planning a flight program well in advance, making sure equipment is functional, and having back-ups for the less costly items will make your flying time worthwhile. It doesn't take much flight time @ $100 to $800 per hour (not to mention the lost data) to make the price of an extra set of cables, an extra switch box, and a spare set of antenna elements a bargain.

Obviously, this isn't an exhaustive list of the items to be considered or checked before a flight, but it should give an idea of the equipment specific to aircraft telemetry, and some common problems experienced by folks in the field.

By the way, were the magnets still on those transmitters when the bighorns ran off into the sunset with their new collars on?

Gary Jones

Editor's Note: Over the years, many of you have had occasion to work closely with Howard Sparks, currently staff engineer of the Service ARGOS U.S. Processing Center in Landover, Maryland. Prior to joining ARGOS in 1986, Howard spent 25 years with the National Environmental Satellite and Data Information Service (NESDIS). During his tenure, he worked with TIROS, GOES and Landsat satellites, and received a Silver Medal from the Department of Commerce for his work in automating the Satellite Operations Control Center.

Our thanks to Howard for the following article. It offers detailed information on ARGOS special processing and, as always, we thank Howard for his involvement and support.

ARGOS Class Zero Location Service

Developed to help users get more than routine information from their PTT's, ARGOS Class Zero Location Service is a diagnostic tool. Originally designed for the animal tracking community, the software has proven valuable to all users with marginal data links. It is a value-added service, however, and must be requested for each applicable PTT. Since Service ARGOS archives processed data, the Class Zero Location must also be requested prior to receipt of the raw data from the satellite. If you are interested in the service, contact your appropriate ARGOS User Office to subscribe.

Once the Class Zero Location Service is activated, additional information is saved for users and there are two commands that will display this information on-line.

The first or original method was to add /A to the PRV command (e.g. PRV/A,,DS,,). The /A command provides a subset of the available diagnostic information. The latest and preferred method of receiving the diagnostic information is with the DIAG command (e.g. DIAG,,,) and this article discusses the data generated in this manner.

For demonstration purposes, let's say your program number is 7016 and you are interested in displaying information concerning PTT ID#20785. At the ARGOS prompt, you would type "DIAG,,,20785" and press the Return key. This would produce the information shown on the sample screen.

SAMPLE SCREEN

```
PROG 7016
20785  Date: 03:09:92  15:08:12  LC: 0  Ll: -4
 Latl: 38.321N    Lonl: 72.651W    Lat2: 24.123N    Lon2: 128.453W
 Nb mes 006    Nb mes > -120 Db: 000   Best Level: -122 Db
 Pass duration: 540 s    Dist track: 18
 Calcul Freq: 401 650.419 Khz    Altitude: 1500 m
 225              137              200              05
```

1. The first line is self explanatory and simply identifies your program.

2. The second line begins with the PTT ID. Next, the date in day, month, year and time is presented in GMT. **L**ocation **C**lass is the third element on the line, which in this example is 0. (*Note: Good locations are classed 1 thru 3 and if this number is routinely other than 0, you don't need Location Class Zero Service.)* The **L**ocation **I**ndicator next defines the reason you did not receive a Location Class between 1 and 3 (see accompanying table). Under Class Zero Location Service, you should always get two sets of locations except when the **L**ocation **I**ndicator is a -6. **LC** will only be present when the **L**ocation **C**lass is 0.

3. The third line contains the two location sets. Either could be valid.

4. The fourth line contains the total **N**um**b**er of **mes**sages received for this satellite overpass. "Nb mes > -120" is part of the regular ARGOS processing and is really not applicable to animal tracking. A more realistic number would be **Nb mes** > **-126**. Animal trackers traditionally use low powered transmitters and it is not often that we receive signals greater than -120 db from animals. **Best level: -122** is the maximum signal strength received during this overpass.

5. The fifth line contains the **Pass Duration** in seconds. This is useful in that you can divide the PTT repetition period into the pass duration, add one, and this is the maximum number of messages you could receive. **Dist**ance **Track** is helpful in determining the relative distance to the satellite. The smaller the number, the shorter the distance.

6. The sixth line contains the **Calcul**ated **Freq**uency, which is the transmitter frequency calculated for this pass. If the location is considered valid, location class 1 to 3, the frequency is saved for future reference. For location class 0, the frequency is not considered valid and is not saved. The **Altitude** is the number that you supplied to the User Office for this PTT. It is the altitude that is used during the location process. The accuracy of the calculated location is related to the accuracy of this number.

7. The seventh and subsequent lines contain the actual data transmitted by the PTT.

After reviewing your data with the DIAG command, contact the applicable User Office if you still have problems. They have the tools to review the signal strength and frequency of each individual message received. Under some circumstances, they will provide this data to the user. As I said before, however, ARGOS archives only processed data. The raw data are dumped into the infamous bit bucket within 6 to 12 hours. We must know of your problems early in order to save these data.

PTT's within the footprint of the Wallops and Fairbanks Command and Data Acquisition Stations present a unique set of problems. I will try to identify a couple of the peculiarities and why they occur.

On The Edge of the Footprint

The number one complaint is that the number of messages in the Dispose file does not correspond to the number listed by the DIAG command. This usually occurs when the PTT is on the edge of the CDA footprint, but it could also occur at other times as well. When the PTT is on the edge of the footprint, the peculiarity occurs when the satellite realtime data are processed. Since the PTT is on the edge or the footprint, not all of the messages are received in realtime.

Let's say that only three messages are received. The ARGOS system processes these three messages and computes a location. The three messages are stored in the Dispose file and the location is saved in the Class Zero Location file.

The data set received from the satellite tape recorder is processed next. This data set may have five or six PTT messages (i.e. the three received in realtime plus the two or three that were transmitted before the satellite entered the CDA footprint). Again, a location is computed and the messages are stored in the Dispose file.

If the location computed has a Location Class greater than 0, the new location is stored. If the Location Class is 0, the system knows that it already has a Class Zero Location and the new location is ignored. By default, a Class Zero Location could be unreliable. The system does not try to determine which is the most reliable of the unreliables. Hence, you have five or six messages in the Dispose file but the location was computed on the basis of the first three received.

Table of Location Indicator Values

LI	Meaning
0	Number of messages received is = to or > 4, but less than 240 seconds between first and last message. *(The minimum requirement for a Class 1 thru 3 location is 4 messages over a minimum of 240 seconds.)*
-1	Number of messages received is = to or > 4, but either the messages were grouped at start or end of pass, or excessive oscillator drift occurred during the pass. *(If messages are grouped, the calculated oscillator frequency is not reliable. The oscillator drift is considered excessive if the slope of the "least squares fit" of all of the solutions over a 15-minute period is 4 hz/mn or more.)*
-2	3 messages received. Last location is less than 12 hours old.
-3	3 messages received. Last location is more than 12 hours old.
-4	2 messages received. Last location is less than 12 hours old.
-5	2 messages received. Last location is more than 12 hours old.
-6	Location is impossible. Either just one message was received, or geometric initialization was aborted. *(Geometric initialization is aborted when there is no intersection between the two cones given by the doppler of the first and last message and the earth ellipsoid. This could be caused by either bad doppler data or wrong initial frequency.)*
-7	Location was rejected, unacceptable distance from ground track. *(A location is not considered reliable if the position is less than 1.5 degrees or greater than 24 degrees from the satellite sub-point.)*
-8	Location was rejected, unsatisfactory internal consistency. *(Internal consistency is the lowest sum of squares (hz) of location pair 1. Under normal circumstances, a sum greater than 1.5 is considered unacceptable.)*
-9	Located was rejected, excessive long term oscillator drift. (*The last location was calculated more than twelve hours ago and the current calculated frequency differs by more than 400 hz from the last calculated frequency.)*
-10	Location was rejected, location was impossible. *(We don't believe the computed location was valid. A good example would be if today you transmitted from New York and tomorrow from Los Angeles.)*

Within the Footprint

The same type of problem could arise when the PTT is located anywhere in the footprint, if realtime data are not processed. The satellite has multiple tape recorders. The first recorder contains data recorded during the previous orbit. A second recorder is programmed "ON" approximately 5 minutes prior to the playback of the first recorder. The data set received from the first recorder may contain only half of the data received during this acquisition period. The data set is processed and a location is computed.

The same scenario as above then takes place. One or more orbits later, the second recorder is played back. This recorder contains all of the messages received during the CDA acquisition period – duplicate data received from the first recorder plus new data. The data are then processed the same as above. It should be noted that if the second data set processed produces a location class better than the first, the second location will replace the first. If the location classes are the same, the first set will always be saved.

I have noticed a few times when the Dispose file contains three messages, but no DIAG information is available. This happens when one message is received from each of the two recorders and one message from realtime data. No attempt is made to compute a location with one message; therefore, no DIAG information is saved. This can only happen when the communication links are noisy.

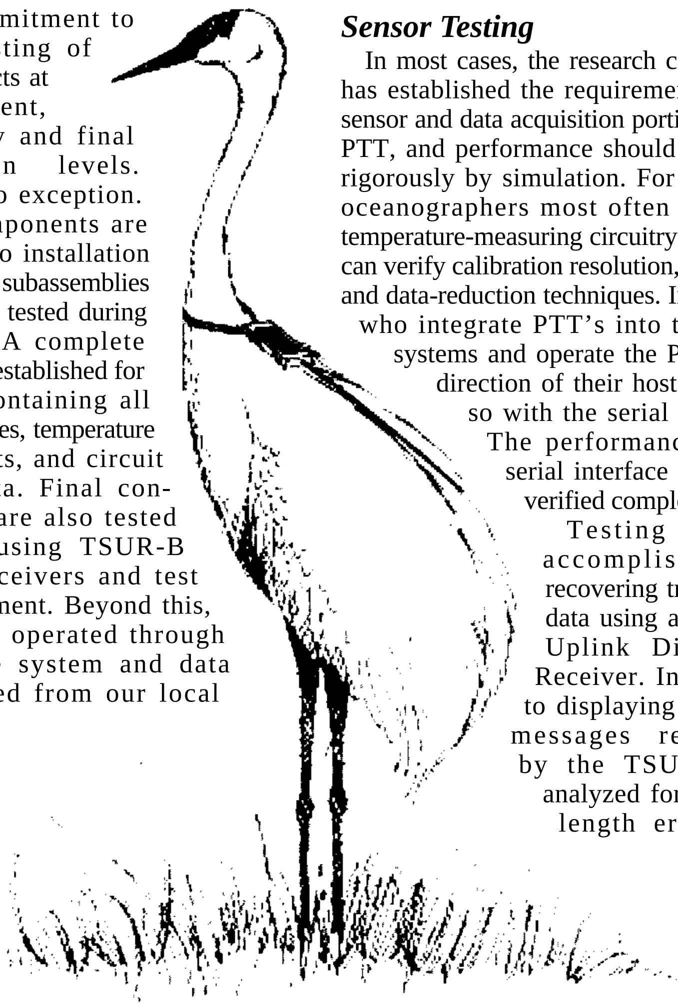
In Summary

To sum up the last few paragraphs – when working with satellites, communication links and computers, some unusual circumstances can and do occur. In fact, we have come to expect the unusual. We invite you to call us with any problems or questions. Service ARGOS maintains User Offices in Landover, Maryland and Seattle. Washington (USA), Toulouse, France and Melbourne, Australia.

Howard Sparks, Service ARGOS

Testing Satellite Transmitters (ARGOS PTT's)

The ARGOS system is composed of PTT's (Platform Transmitter Terminals); a space segment deployed on the NOAA earth-orbiting satellites; and the ground segment responsible for recovering the downlink data, data transfer, processing, storage, and dissemination. The space segment has exhibited consistent and reliable performance levels for many years and, in point of fact, none of us has a great deal of impact or control over that segment of the system. As researchers, you do directly influence the design and manufacture of PTT's within the constraints and specifications of the ARGOS system. And, as consumers of ARGOS products, you influence the design, operation, and performance of the ARGOS system. In another article in this newsletter, Howard Sparks describes some of the value-added diagnostic products provided by ARGOS which can be utilized to analyze performance of PTT's. At Telonics we have made a commitment to rigorous testing of all our products at the component, subassembly and final configuration levels. PTT's are no exception. Critical components are tested prior to installation and electronic subassemblies are repeatedly tested during production. A complete history file is established for each PTT containing all measured values, temperature testing results, and circuit analysis data. Final configurations are also tested repeatedly using TSUR-B uplink C receivers and test bench equipment. Beyond this, each PTT is operated through the satellite system and data are recovered from our local user terminal.



A history of the number of successful uplinks for each pass and a profile of signal strength received at the satellite is acquired and retained for future reference. This serialized data base is critical to answering questions about field performance. Further, it is used to make comparisons of data recovered from units undergoing refurbishment to original data sets when the units were first produced. Even with all this testing in place at Telonics, we encourage users to test PTT's themselves. In this article, we address testing which can be conducted by users to verify performance of PTT's.

Mechanical Inspection

We welcome and strongly recommend direct involvement of the investigator into the mechanical design of the PTT's, their packaging and attachments. The researcher must ultimately determine the mechanical suitability of the instrument for his application. All PTT users should visually inspect the PTT's upon receipt of their units and, if questions arise, the user should feel free to contact us, or any other manufacturer, to resolve these questions prior to deployment.

Sensor Testing

In most cases, the research community has established the requirements of the sensor and data acquisition portions of the PTT, and performance should be tested rigorously by simulation. For example, oceanographers most often calibrate temperature-measuring circuitry and, thus, can verify calibration resolution, accuracy, and data-reduction techniques. Individuals who integrate PTT's into their own systems and operate the PTT at the direction of their host, often do so with the serial interface. The performance of the serial interface should be verified completely.

Testing can be accomplished by recovering transmitted data using a TSUR-B Uplink Diagnostic Receiver. In addition to displaying the data, messages recovered by the TSUR-B are analyzed for message length errors, bit format synchronization errors, initialization error and ID code errors. There are also a simple, inexpensive shirt-pocket test receiver (TSTR-4) which can be utilized to determine whether a PTT is transmitting at the appropriate times. Data can also be recovered from ARGOS to assure overall system performance and ensure that data processing is correct and that position fixing is occurring. To this stage, the testing can be quite rigorous and very direct and most researchers have the tools in hand to do such testing.

From here on it gets a little more difficult because the testing involves the radio frequency (RF) portion of the PTT. There are usually two areas ol special interest with regard to the RF testing, and each is critical to the performance of the PTT. The first involves frequency stability and the second received signal strength at the satellite.

Oscillator Stability

There are actually three components to the ARGOS frequency stability specification: "long-term" stability, which is what happens to your PTT's frequency over the weeks, months, and years that the unit is deployed; "medium-term" stability, which is what happens to frequency over the course of a satellite pass; and "short-term" stability, which is what happens to the frequency during a single transmission.

As part of the ARGOS certification process, there is a set methodology requiring sophisticated measurement equipment for the analysis of each requirement. Most researchers do not have the instrumentation to duplicate frequency stability measurements for the PTT's. It is important to make a few notes concerning this subject. It is difficult to achieve the "long-term" and "medium-term" stability requirements over the full environmental temperature range by utilizing a simple crystal oscillator (see figure 1). Temperature influences the output frequency determined by the crystal. Originally, an oven was used to heat and hold the crystal at a specified temperature. Such an oscillator is called an Ovenized Crystal Oscillator (OCXO). The limitation of the OCXO's was that they required substantial current to hold temperature constant and thus maintain a near-constant output frequency.

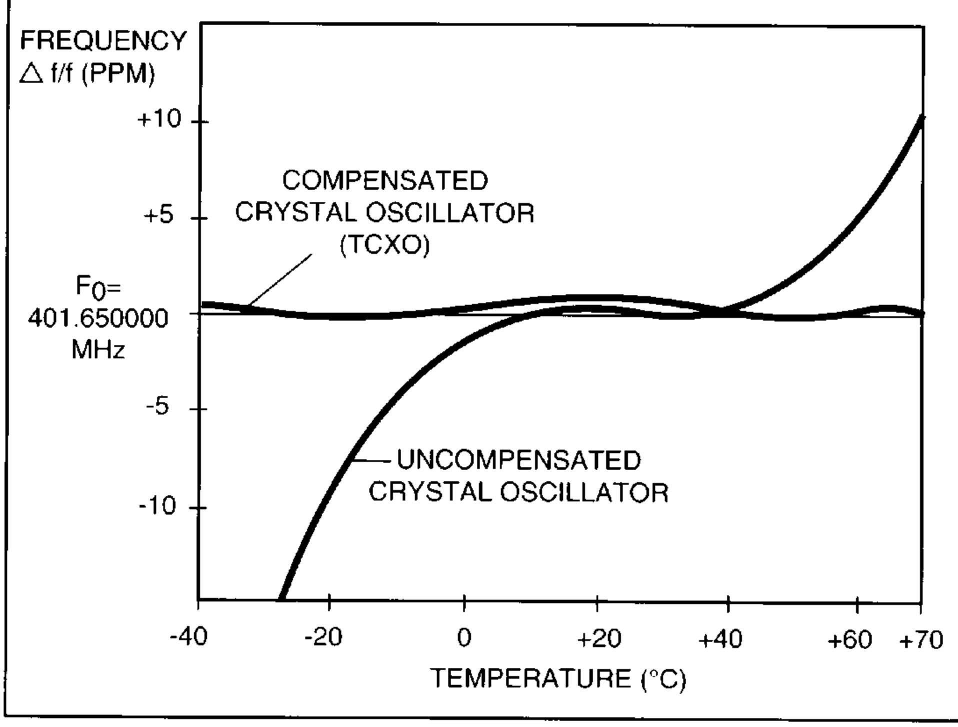
In the early 1980's, an alternative process of temperature compensation using an analog network of components to offset the effects of temperature called a "Temperature-Compensated Crystal Oscillator (TCXO)" was pursued. Our low-voltage TCXO's can be operated at much lower currents than an OCXO and do not require the extensive warmup/stabilization times exhibited by OCXO. TCXO's provided a solution to the long-term stability issue. The short-term stability was also adequate, as was phase noise. Current TCXO technology provides only a partial solution to the maintenance of medium-term stability.

Figure 1 shows the frequency of the PTT versus temperature and illustrates that if the transmitter was subjected to temperature change, the frequency changed slightly.

In the near-ideal case of oceanographic buoys, the PTT's have a relatively large thermal mass and a stable thermal environment is achieved in the ocean – thus, a TCXO can be nearly as stable as an OCXO. In high-altitude balloons or animal applications, PTT's generally have a small thermal mass and, if a significant thermal gradient develops, the PTT can experience more rapid changes in temperature than is experienced by the oceanographer's PTT.

Such dramatic temperature fluctuations create very small changes in the frequency of the transmitter and can, in some instances, create medium-term stability problems. By looking at data recovered from the satellite, ARGOS can (under certain circumstances) determine that the frequencies measured at the satellite are shifting at a level above that which is acceptable to fit the Doppler curve. Under these instances, the position of the PTT cannot be determined. Indirect measurement of oscillator stability must be considered with some caution. Medium-term oscillator instability, determined by measurements made at the satellite, is often related to a very specific set of circumstances wherein the PTT is subjected to a large temperature excursion or a specific temperature excursion where the frequency versus temperature curve is very steep. The diagnostics associated with oscillator frequency stability provided by ARGOS are useful, but must be applied carefully.

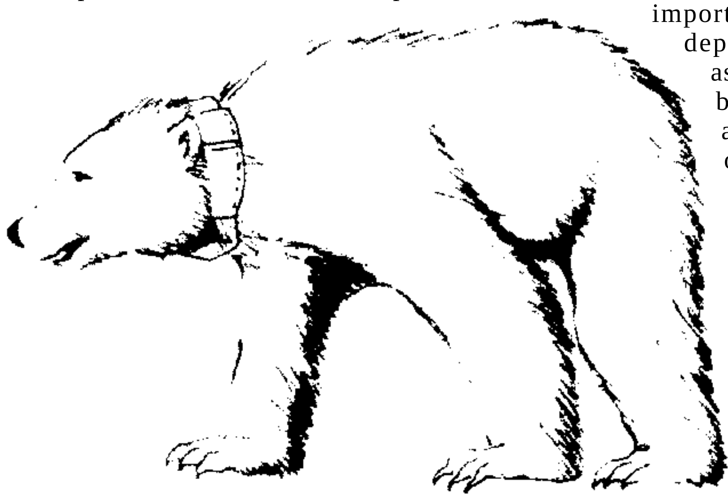
Figure 1



This graph shows the relationship between a compensated crystal oscillator (TCXO) versus temperature, and an uncompensated crystal oscillator versus temperature. From this analysis, it is clear that the uncompensated crystal oscillator is unable to meet the frequency stability requirements of the ARGOS system (+/- 3 parts per million) over the full environmental temperature range. Although the compensated oscillator meets the long term frequency requirements for the ARGOS system, rapid changes in temperature can cause minor shifts in frequency which affect the medium term stability.

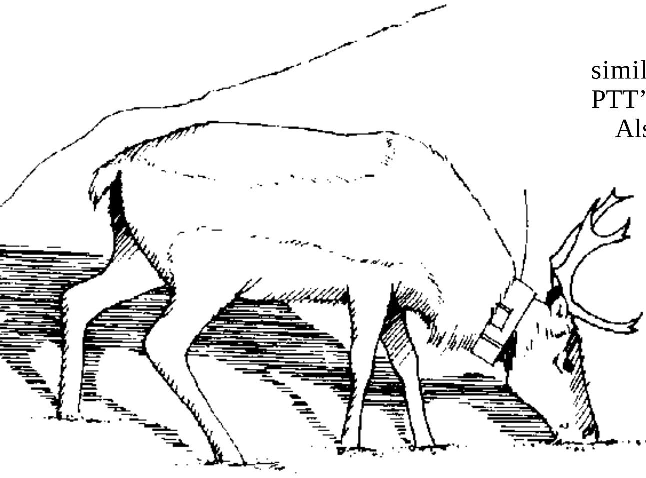
Link Margin

Perhaps the issue of greatest importance to researchers deploying PTT's is to ascertain that the link between the transmitter and the receiver onboard the satellite is adequate. This testing problem is complex, but unlike the frequency problem, the researcher often has a better opportunity to test this parameter than does the manufacturer.



When a transmitter is packaged in an oceanographic buoy, the antenna can usually be deployed effectively and its performance should be good. The ocean presents a large ground plane. The antenna radiation pattern is, therefore, about as omni-directional as we can hope to achieve in a real-world application. To test these PTT's, buoys can be put in the ocean and tethered to provide a good simulation of real-world conditions.

With animals, the situation is vastly different. Animal PTT's are typically deployed on the neck or back of the animal, and the antenna is influenced by the close proximity of the animal's body. This can result in an antenna that does not radiate equally in all directions. The body can also detune the antenna to reduce its performance at the desired frequency. This reduces the radiated power, in some cases dramatically. The animal's behavior can also affect performance. Animals that hibernate may virtually "disappear" during the



hibernation period simply because they are underground and the signal is blocked. Other effects are more subtle.

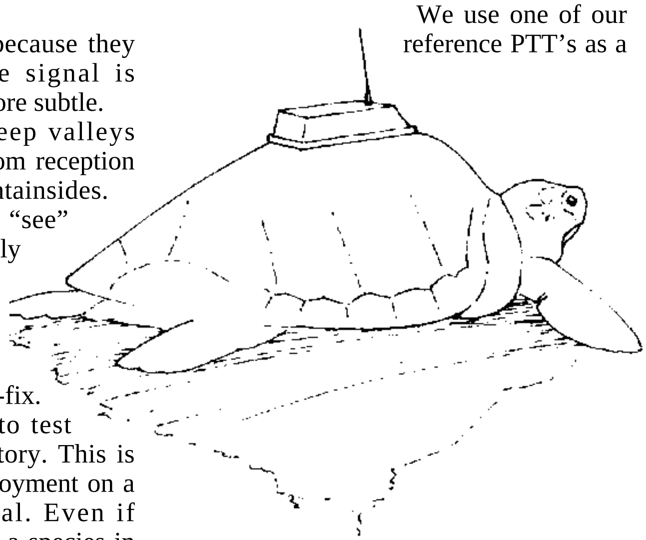
PTT's on animals in deep valleys can have signals blocked from reception at the satellite by the mountainsides. The only overpasses which "see" these PTT's are passes directly overhead. Since they do not provide data usable for position-fixing algorithms, the PTT's provide data, but no position-fix.

It is almost impossible to test such conditions in a laboratory. This is the reason that the first deployment on a species is so experimental. Even if deployment has occurred on a species in one environment, the results may not hold true for the same species in another environment.

When it comes right down to it, there are two ways in which link margins can be examined. The first way is to simply deploy PTT's in an open area. Usually this is done on a rooftop so that the PTT's have a clear view of the horizon. This test usually provides the optimum level of performance that will be achieved from the PTT's. When you test in this fashion, we recommend taking a lot of data and testing over several days. Because of the effects of antenna-radiation pattern lobing, good signal strength will be seen from some passes while poor signal strength will be observed during other passes. Look at the results and do a lot of mental averaging. The more data you take, the more likely you have defined the PTT's performance and the more realistic your comparisons among PTT's will be.

It is also important to make sure that the PTT's are spaced well apart from one another so that their antennas do not interact or cause lobing. Space the PTT's several feet apart. If you can, it would be preferable to move the PTT's around during the course of an overpass, as well as between passes, to provide an effect similar to what will be seen when the PTT's are deployed on animals.

Also, during testing it is best to keep the PTT's off metal or conductive surfaces which may provide reflective ground plane and, thus, unrealistically good results. In each case, it is best if you can examine the number of uplink messages and the signal strength of each message during the course of the overpass, as compared to a standard PTT of known performance.



We use one of our reference PTT's as a standard at Telonics. Unfortunately, ARGOS does not provide the signal strength for each satellite uplink message as part of the diagnostics. This can only be obtained by utilizing data from a local user terminal, such as the TLUT-4.

If you are really interested in intensive testing for units which are to be deployed on large animals, a model can be used. For deployment on large ungulates, it might be possible to use a horse. For medium-sized animals, it might be possible to get the family dog to volunteer to wear the collar. This approach takes testing a step further than simply testing a unit placed on the roof. This test becomes much more meaningful and usually results are more variable; therefore, large data sets and averaging are even more critical.

In general, the effect of the animal on the radiation pattern is greatest when the antenna is actually up against the animal's body. Often, PTT's on birds perform well simply because the feathers that surround the bird's body are filled with air and, essentially, buffer the antenna from the effects of close proximity to the body.

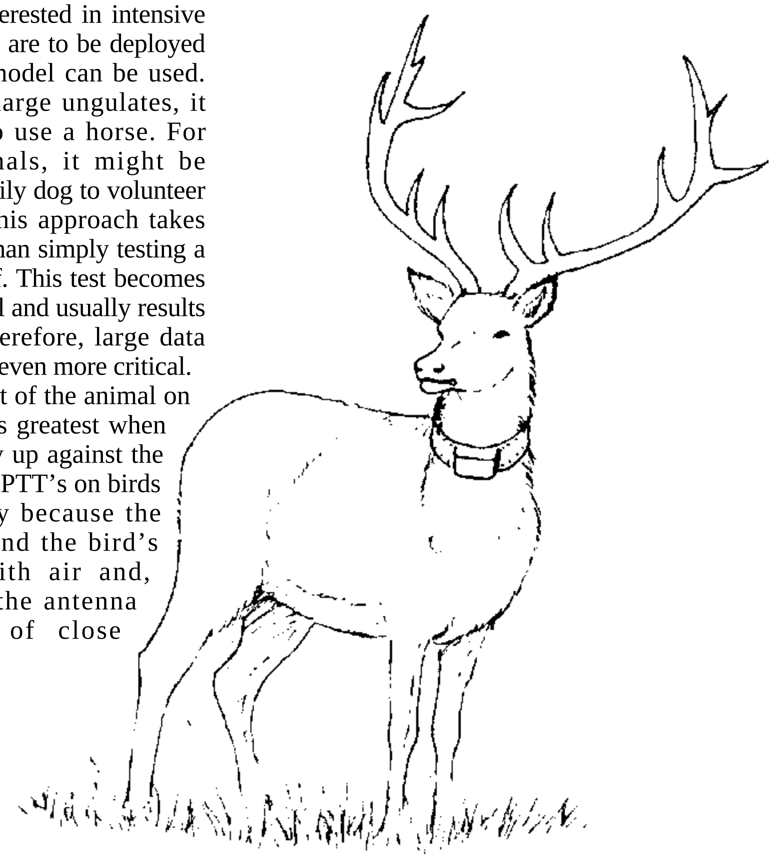
Worst-case conditions include deployment on an animal where the antenna is pressed against wet fur and a large body mass. It helps a lot to get even a portion of the antenna away from the body by exiting an inch or two of the tip from the collar. The problem is that this exposed portion of the antenna is then subject to breakage, often leaving the unit with very poor performance.

We have seen researchers take the PTT's and strap them on their own waists and move about during the course of the pass to simulate deployment on large animals. This may be difficult to explain to colleagues, but it may provide a useful insight into the performance of the PTT under more real-world conditions.

Under all these circumstances, the main theme that must be reiterated is to take a number of overpasses and to look at lots of data, preferably signal strength from each uplink message. Tests can be further refined by placing the PTT on captive animals, but metal enclosures and flight cages can affect performance. Vegetation and seasonal changes in moisture levels between "wet" and "dry" seasons can also influence performance.

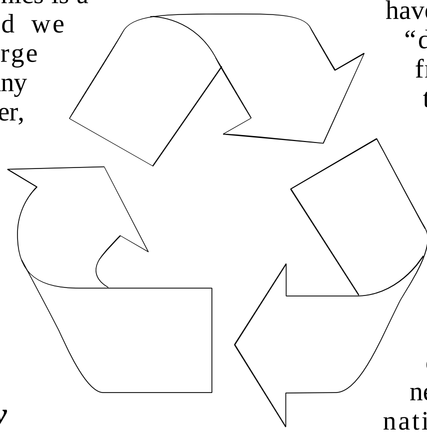
It is useful during testing to have satellite predictor programs (such as TSP/TSD) to predict satellite overpasses. This limits the time when you have to pretend to be a caribou or polar bear in front of the student body or staff. In any event, the more realistic the testing protocol, the more likely you will have an insight into what will happen after deployment.

Stan Tomkiewicz



Briefly

While electronics is a comparatively clean industry, we believe that every responsible manufacturer assumes an active role in minimizing the consumption of natural resources and the protection of the environment. We have to make intelligent choices about the materials we use in production, and we have to responsibly dispose of waste materials hazardous to the environment. Telonics is a small company and we don't consume large quantities of water or any other resource. However, we are very proud of our efforts to be a responsible manufacturer and we are constantly trying to make good choices in all our business activities.



We're using a new paper!

You may have noticed that the newsletter looks a little different this issue. That's because we've moved to a recycled paper, Evergreen Gloss, and we're very excited about the change. For a number of years, recycled papers tended to be grainy with lots of fleck and expensive. That's not true anymore; recycled paper has improved tremendously in quality. A combination of consumer demand and new processing technology is also making it more economic. We hope you like our choice.

More about recycling.

Reclaiming material is also important and Telonics has been recycling solvents for a number of years. The used base is sent to a certified facility for cleaning and recycling in a closed loop system. We also save the brass used in our transmitter packaging. When transmitters arc returned for refurbishment or repair, the brass housing is removed and saved for reprocessing. Our company-wide paper recycling program is now six months old. All computer paper, white office paper and newspaper is sorted and periodically delivered to a local recycling center. While we're not a large volume manufacturer, we are proud of the programs now in place and will continue looking for opportunities to improve processes.

Finding good alternatives.

Recent international agreements to stop the depletion of the ozone are translating rapidly into new legislation. By mid-1993, all products manufactured with the use of any ozone-depleting substance will have to be labeled accordingly. The major generator of chlorofluorocarbons (CFC's) in the electronics industry is the solvents used to clean circuit boards after soldering. Telonics is currently testing a variety of solutions (alcohols, semi-aqueous and aqueous cleaners). While we have not yet found a simple "drop in" substitute for freon, we are committed to testing all options and will keep you informed as we determine our best course of action!

Telonics is also looking at batteries. Nickel-cadmium batteries have always presented a serious disposal problem and we need to find a viable alternative. We are currently testing nickel-hydride (green) batteries as a potential substitute and we are also looking at a mercury-free alkaline battery. Our R&D group is conducting tests that will help us determine the feasibility of incorporating the new batteries into the full Telonics product line. If they prove successful, we will let you know and begin making changes as rapidly as possible.

Conscientious handling and shipping.

In order to obtain the operational field life essential in many studies, we continue to be forced to utilize battery technologies with lithium content. These technologies require special handling during assembly. In addition, the U.S. Department of Transportation regulates shipments of products with lithium, increasing consumer costs due to the special paperwork required and the use of "cargo only" aircraft. Any responsible manufacturer who ships lithium batteries must be in compliance with U.S. DOT and IATA standards. We will continue to meet all such public safety regulations.

A low cost PC-based earth station!

Telonics will introduce our new TIRIS (Telonics Interactive Remote Imaging System) in January. It is a very low cost, completely self-contained satellite tracking acquisition and processing earth station system designed for both educational and professional users.

A PC-based system, TIRIS provides full coverage of primary and backup downlinks for all HRPT-like polar orbiting/LEO satellites. The system includes everything from the tracking antenna and receiver/demodulator/sectorizing subsystems to image processing hardware and software. TIRIS will be supplied in two configurations: one for stand-alone usage with advanced image processing capabilities and one for OEM integration with large workstations. The Spring newsletter will fully describe the new system and its capabilities.

We're expanding - again!

Telonics is committed to providing you with the finest products and service in the industry. In order to keep pace, we have periodically added to our facilities and we're about to do it again. We've purchased another parcel of land and expect to build an additional 18,000 sq ft facility within the next few years. In the meantime, our need for direct production space is critical and we're leasing an additional 4500 sq ft this December. We hope the expansion will make it easier for us to meet your requirements.

Happy holidays!

It's that time of year and, as always, Telonics will be closed over the holidays. We want to spend more time with our families and friends. Our last day of the year is December 23 and we will resume our normal business hours on January 4. Our thanks to all of you for your business and support throughout this past year and we look forward to working with you in the future. We send each of you our best wishes and hopes for a safe, prosperous and happy New Year. Have a wonderful holiday !

COAXIAL CABLES

The coaxial cable connecting the receiving antenna to the receiver is a frequently ignored, but critical, component in telemetry systems. Use of the wrong type of cable, or a damaged cable, can degrade system performance. For example, an open center conductor will severely reduce system range, and an open ground connection may result in loss of antenna directionality.

So, what can be done to avoid such problems?

1. Make sure the cable is long enough so that connectors are not continually yanked during usage.

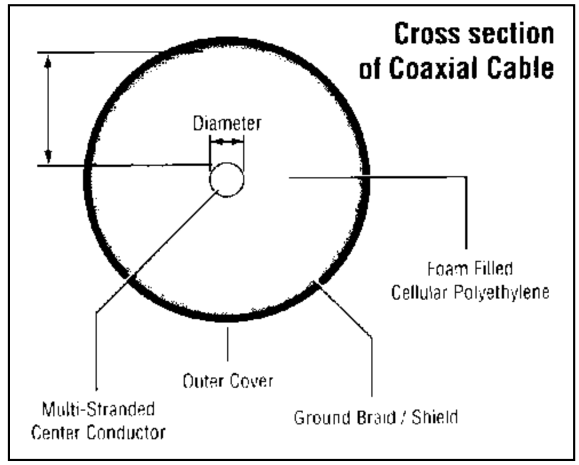
2. Check the connectors and cable for damage, corrosion or looseness. Move the cable and connectors while listening to a signal – static or intermittent signals may indicate a problem.

3. Make sure your cable is 50 ohm impedance. Coaxial cables of various impedances can look the same, and impedance mismatches will reduce reception range.

4. An ohm meter can be used to verify that neither the cable ground nor the center conductor are open, and the two are not shorted together.

If any of these checks indicate a problem, the cable needs to be fixed or replaced. These are not complete tests because they do not identify impedance mismatches along the length of the cable which may have resulted from the cable being crushed, stepped on, etc. Impedance problems can sometimes be identified through use of appropriate RF test equipment, but expensive equipment and procedures are required to determine the location of a mismatch, as would be required to fix such a damaged cable. Such testing is usually not practical .

For most telemetry users, a simple test involves swapping a questionable cable with one that is known to be good. If performance improves, the old one may be the source of your problem.



The characteristic impedance of a coaxial cable is determined by the ratio of the diameter of the center conductor to the distance between the center conductor and the ground braid.

Coaxial cables are critical, commonly abused, yet inexpensive components in telemetry systems. Having a spare cable is usually a good idea because it allows comparative testing and quick replacement if necessary. Without a functional coaxial cable, tracking operations can be completely shut down.

Bill Burger

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