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Editor's Note: *Archie Shaw is now Executive Vice President of Service ARGOS, and will become President of the US Processing Center later this summer. Archie is a leading advocate of wildlife tracking programs, and ARGOS is currently the only true satellite-based positioning system available for environmental programs. The system is unique in that it is capable of positioning transmitters directly. Other systems require the addition of an on-board receiver to establish position, which is then relayed through a satellite.*

ARGOS Data Collection and Location System

The ARGOS system was primarily designed to provide an operational environmental satellite data collection, location and dissemination service for the duration of the NOAA Polar Orbiting Environmental Satellite (POES) program. This system resulted from a 1974 bilateral agreement between NASA and NOAA of the United States, and CNES (Centre National d'Etudes Spatiales) of France.

The ARGOS instrument package is flown aboard NOAA's polar orbiting satellites. With a minimum two-year design lifetime, satellites are launched as required to maintain two fully operational units at all times. The 401.65 MHz uplink frequency is dedicated to environmental purposes, so programs using the ARGOS system must generally be related to environmental investigation acceptable to the joint NOAA-NASA-CNES/ARGOS Operations Committee.

The ARGOS system became operational in 1978 with the launch of the protoflight TIROS-N satellite, and proved highly successful during the 1978-79 First Global Atmospheric Research Program experiment. It was comprised of several hundred drifting buoys equipped with ARGOS Platform Transmitter Terminals (PTT's) deployed for meteorological and oceanographic data collection.

The ARGOS system is under the administration of Service ARGOS Inc., Landover, Maryland, USA, and CLS/Service ARGOS, Toulouse, France. Each of these companies houses a multi-machine computer processing center that provides internal redundancy. The two processing centers use the same operating system, thus providing further redundancy. This ensures that processing continues even in the event of a total facility outage. Data is networked via a connecting 64-kb per second digital link.

ARGOS is a random access, one-way system, employing two receivers and four Data Record Units (DRU's) on board each current satellite for the collection of uplinked messages from the PTT's operating within view of the satellite. The processing is performed by the on board Data Collection and Location System (DCLS) consisting of the identification of the PTT, the recording of the time of data reception, and the measurement of the Doppler shift on the received signal. Data are downlinked in realtime and stored on tape for later downlink.

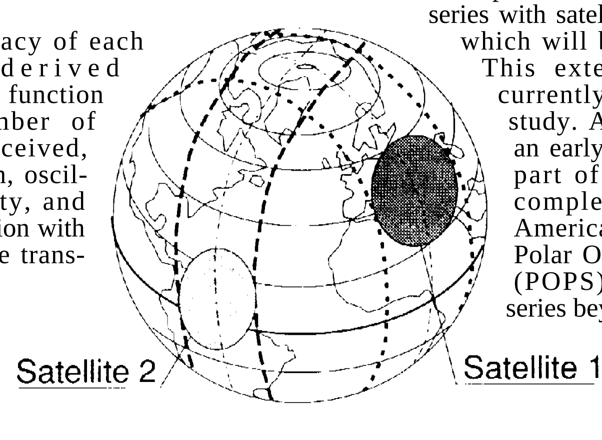
The recorded data are currently received by three telemetry receiving stations: Wallops Island, Virginia; Fairbanks, Alaska; and Lannion, France, when either of the satellites are in view. Realtime data are also received by these stations. ARGOS DCLS data and NOAA's other telemetry data are then rebroadcast from the receiving stations through telecommunication satellites to the NESDIS/NOAA computer facility at Suitland, Maryland. The data are then decommutated and forwarded to the two ARGOS Data Processing Centers where the following procedures are performed:

- decoding of received PTT messages and conversion of data into physical units;
- accurate computation of the orbit(s) of the satellite(s);
- computation of PTT positions from orbital data combined with Doppler shift data computed by the ARGOS instrument;
- storage of all these results on computer-accessible files for user access.

The two satellites can provide four to six locations per day from a PTT in equatorial regions, and up to 20 positions per day in polar areas (due to orbit overlap at the higher latitudes). In the mid latitudes, approximately eight positions per day are typically provided, assuming the PTT is transmitting 24 hours per day.

ARGOS offers three levels of location processing to users. These levels provide accuracies, with standard deviations, from 150 meters to 1 kilometer in latitude/longitude.

The accuracy of each Doppler-derived position is a function of the number of messages received, pass duration, oscillator stability, and satellite location with respect to the transmitter.



A special location processing level ("Class O") was developed for biological applications. It derives locations from two PTT messages received from satellite passes of any duration. Class O service presents two possible position solutions to the user for their discrimination.

Data collected by the ARGOS system and the calculated location may be obtained by the user from computer files accessible by telephone, telex, or other communication networks. Most data are generally available within four hours after receipt of the data rebroadcast from the satellite. Processed data are also available on computer-compatible tapes (CCT's), floppy disks, or printouts. Certain designated and appropriately formatted data are also distributed over the Global Telecommunication System (GTS). It should be noted that ARGOS employs two levels of password security. However, users wishing to share data can do so by written notice to Service ARGOS.

Users requiring ARGOS realtime data can receive it directly from the satellite's realtime S-band or VHF frequencies. Since the satellite's instantaneous field of view ("footprint," a circle with a diameter of approximately 5000 km) is rebroadcast by the satellite as soon as it is received, anyone with an appropriate earth station within range can receive the data. However, location accuracies calculated from the information received by a Local User Terminal (LUT) are not as consistently accurate as those provided through the ARGOS system.

ARGOS instruments are scheduled to "fly" on board all future NOAA POES. The current POES launch manifest describes satellites to NOAA-N (operational satellite number 18), which will carry ARGOS into the next century. Notably, with the launch of NOAA-K in 1994, ARGOS will increase the on board DRU capacity from four to eight. This has the effect of quadrupling the number of PTT's capable of being received from within the satellite's instantaneous field of view. NOAA plans to continue the POES series with satellites 0, P, and Q, which will be a "new buy." This extended series is currently under Phase A study. ARGOS was also an early designation to a part of the instrument complement for the American and European Polar Orbiting Platforms (POPS), the satellite series beyond POES.

Archie Shaw

You Can't Tell The Satellites Without A Program

Satellite Predictor Software

With all the talk concerning satellites zinging around the sky these days, you would think that someone, somewhere, would be wondering where all those little "birds" were, are, or will be, at some point in time. Fact is, there is - it's us!

It all began many years ago when folks had the bright idea that we might be able to save our friends in the wildlife research field a lot of trouble if we could figure a way to track animals by hanging a little satellite transmitter on them. We knew we could instrument the animal, but the obvious question was, "what satellites could our little transmitters talk to?"

Enter Archie Shaw and our friends from Service ARGOS. The system was already well established as the only means of uplinking data and position-fixing utilizing Low Earth Orbiting satellites. With the specially designed ARGOS receiver/processors riding on the TIROS configuration, NOAA satellites created a marriage made in "heaven." We went to work on the transmitters, and the first satellite prediction software that we used was assembled by National Weather Service programmers on their own time as a public spirited gesture. This micro-sized version of SATTRAK convinced us of how much could be accomplished with further software advances.

After many evolutions and thousands of hours of software testing later, we have a program that really works — the Telonics TSD/TSP Satellite Display and Prediction Program — now considered one of the finest integrated satellite display and prediction packages available today for PC-based applications.

The Telonics Satellite Display (TSD) portion of the package offers realtime color display capability for multiple satellites (both orbiting and geo-stationary). Realtime satellite parameters such as azimuth, elevation angles, and range relative to any designated location on the earth's surface can be displayed. In addition, absolute doppler frequency and drift (in Hz/Minute), orbital revolution and phase of revolution, subsatellite latitude/longitude, altitude, and Sub Satellite Point are all calculated and displayed. Current twilight line position, as well as the designated satellite's relationship to as many as 15 other satellites on screen at any given time, can also be displayed. The software is capable of showing radio horizon circles in realtime, pseudo 3-D radio horizon views as seen from the satellite, and the cross-track scan line for AVHRR (Advanced Very High Resolution Radiometer), DMSP (Defense Meteorological Satellite Program), and other imaging systems. The future ground track of any satellite of interest can also be displayed by means of a ground track line which may be made to project ahead (lead), and trail behind (lag), the satellite by any amount of time the user wishes to invoke.

TSD incorporates satellite orbitography decay algorithms based on three different propagation models. A serial port interface is provided to output pointing angle information to other systems. As an example, NOAA uses it to turn off the megawatt wind profiler radar systems when the NOAA TIROS and Soviet COSPAS satellites come into view. The powerful radar signals would otherwise desensitize the ARGOS and SARSAT receivers as the satellites pass through their upward looking cones of radiation.

The Telonics Satellite Predictor (TSP) portion of the package provides disk files, screen tabulation, or hard copy print-outs of detailed overpass predictions for any satellites. They include simultaneous pointing angles (at specified time intervals during any satellite overpass) for any two locations on the earth. This unique "time of mutual view" capability is invaluable for predicting system performance when a satellite transmitter is monitored from a realtime local user terminal such as the Telonics D-Band TLUT-3 Earth Station.

This software was developed for our own internal use originally, but has now found widespread application. Users include NASA, NOAA, COSPAS/SARSAT, and many other scientific agencies and individuals interested in a satellite overpass prediction capability.

The TSD/TSP package has been interfaced to highly accurate time sources for more accurate realtime satellite tracking, and can be employed with our precision time base PC cards in areas where highly accurate time is either too difficult or too costly to obtain.

I can say (with a clear conscience) that this is the only package I am aware of that is both friendly and "bulletproof." We have not seen a documented problem in the last three years — a unique situation.

The TSD/TSP package requires an MSDOS-based computer system with a minimum of 640K of RAM and a math coprocessor. It supports all popular display types. I like it because I don't need to read a manual or learn another language to use it. Of course, you can get really fancy if you learn all the capabilities, but you also can do anything you really need to do using the menu-driven hot-key help screens.

And if you think you are in over your head, you can simply hit [Esc], then [=], to get out of anything you can possibly do from the keyboard. The TSD/TSP software package saves me an untold amount of time and is unfailingly accurate. I like that in a program!

Dave Beaty

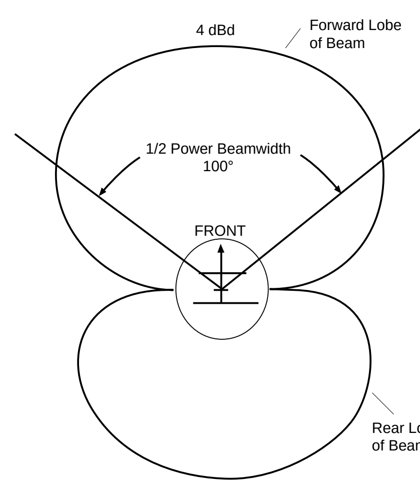
Receiving Antenna "Accuracy"

Antenna Patterns

We are frequently asked questions such as "what is the accuracy of a particular antenna?", or "how do accuracies of several types of antennas compare." Although these questions may appear simple, there are not necessarily simple answers. A number of factors need to be considered in attempting to answer such questions., if indeed, "accuracy" of an antenna can be defined at all.

This article will introduce the concept of antenna patterns, and look specifically at what is termed the half power beamwidth of an antenna. These concept;s are important building blocks in understanding the potential accuracy with which you can locate a transmitter, but they do not, by themselves, define accuracy. The antennas discussed here are termed directional antennas and, for our purposes, are used to receive a signal and determine the direction from which signal strength is greatest. This, theoretically at least, indicates the direction to the transmitter. Examples of such antennas include "yagi" antennas with various numbers of elements and Telonics' 2-element "H" antennas.

Pattern for RA-2A (2-Element Antenna) In Horizontal Plane

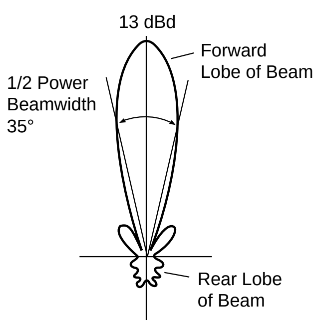


Each type of antenna exhibits a characteristic pattern. In understanding these patterns, it is useful to know that although certain types are typically used for specific applications, a given antenna can function as either a transmitting or receiving device. Thus, from the transmitting view, the "radiation" pattern of an antenna defines the way in which the radio frequency (RF) energy fed to the antenna from a transmitter is distributed into space. When attached to a receiver, the "reception" pattern defines the area in space from which RF energy is captured.

The characteristic patterns of a two-element "H" antenna and 14-element yagi antenna are illustrated in their horizontal planes. Yagi antennas with fewer elements (i.e. 3,5 or 8 elements) would essentially be intermediate to these examples.

One of the primary characteristics of a directional antenna's pattern is its "half-power beamwidth." This parameter has been defined as "the angular separation of the points (with the antenna itself being the apex of the angle) where the main beam of the power pattern equals one-half." Put another way, given a line-of-sight situation which is not complicated by bounce signals, the received signal is strongest if you point the front of a directional antenna directly towards the transmitter. Signal strength decreases as you rotate the antenna clockwise and counter-clockwise from this position. The half-power, or 3-dB, beamwidth is the angular distance between the directions at which the received power is one-half the maximum power. Half power beamwidth for the two antennas is also illustrated.

Pattern for 14-Element Yagi Antenna In Horizontal Plane



In general, increasing the number of elements in a directional antenna results in a decrease in the beamwidth. Based on this knowledge, users sometimes conclude that an antenna with more elements is thus more "accurate." Unfortunately, it is not so simple. Even a 14-element yagi has a half power beamwidth of 35 degrees. Few users would consider this acceptable accuracy. In addition, a 150 MHz, 14-element antenna is about 15.5 feet long and unusable for most applications.

Three-element yagis have a beamwidth of 60 degrees in the horizontal orientation, and 2-element "H" antennas have a beamwidth of 100 degrees in the horizontal position. (Note: Beamwidths for yagis and the "H" are greater in the vertical orientation.) These angles are determined for a particular type of antenna under optimal conditions; that is, the antenna is in "free-space" with no conductive surfaces (e.g. ground, vegetation, or the person holding the antenna) within a 2-wavelength radius (about 12 feet at 150 MHz).

In the field, most users determine some angle over which the signal sounds loudest, and then determine a bearing by mentally bisecting that angle. This typically works very well when the tracker monitors the signal more or less continuously, and moves towards the transmitter (animal) until they see it or are convinced of its location (e.g. in this tree, stand of trees, drainage, etc.). It is, however, more difficult to determine very specific bearings because of the relatively wide angles which must be bisected.

In future articles, we will discuss combining two antennas into an array through use of a precision null combiner (e.g. Telonics RA-NS system) as one method of providing a much more precise bearing than is possible with a single antenna. The critical importance of proper antenna tuning and antenna usage will also be discussed as they relate to achieving accurate bearings. *Bill Burger*

Introducing Some Of Our Staff

Telonics works with professional wildlife and environmental research organizations all over the world, and most of our contact with customers is via the phone. Since the calls we get range anywhere from inquiries about conventional VHF and UHF (satellite) equipment for wildlife (e.g. squirrels, sea turtles, elephants) to oceanographic or meteorological applications (e.g. ocean buoys, balloons, parachutes), just answering the phone can be quite an adventure.

Our primary concern when you call is to get you in touch with the right person as quickly as possible. That's a little more complicated at Telonics than it might sound because we don't have a sales staff in conventional terms. The people that you deal with most frequently on the phone are all specialists in their particular department and we thought it might be helpful if we introduced them to you.

New Equipment Orders

Most new equipment orders for environmental telemetry are handled by three program coordinators — Bill Burger, Susie Crow, or myself. Bill has his Master's in Natural Resources and Wildlife Management, and deals with researchers working on biological programs worldwide. Susie has been with Telonics since 1985. She consults with customers using conventional VHF telemetry and lends support to some of the satellite programs. I have been with the company since the early days (nearly 13 years now). I have seen the product lines expand to include everything from VHF to satellite products, and watched the staff increase from just a handful to nearly eighty. I have consulted on programs involving conventional VHF equipment, satellite products (mainly oceanographic/climatology applications), and I also manage the Administrative Department.

As program coordinators, we think our system offers real advantages to you in terms of service. In most cases, the person you speak to on the telephone to define the instrumentation for your study objectives is going to follow your equipment through every phase of production, test, and delivery. That's particularly important at Telonics because most of our work is highly customized and requires a great deal of hands-on management.

Even after delivery, we're here to work with you whenever any question arises. We want to understand the research you're doing and support you both technically and administratively.

Refurbishments

Those of you who purchased our transmitters in the past realize that most are completely refurbishable. That means you can use them again and again for different studies without having to buy new equipment. Receivers can also be refurbished, retrofitted, and/or updated. In fact, many of the units have been around since the mid-70's. Dan Decker and Kathy Hansen are responsible for overseeing this area. They locate and research the original data from the files and make certain that the unit can be refurbished/retrofitted as requested. They also oversee the scheduling of disassembly, testing, reassembly and shipment back to you.

Accounting

Tricia Frank manages our Accounting Department and, considering how the government works, this is no easy task. When you need help with questions pertaining to accounts payable (we owe you), Diana Brandt can help. When the shoe is on the other foot and you owe us, Tricia and/or Diana will help you with accounts receivable. Annette Nordgren and Jean Hall are our accounts receivable coordinators, and they prepare all the packing lists and invoices when an order is ready for shipment.

Communications

Together with Sheila Allred, Jean and Annette also answer our telephones. That's right! We have real people you can talk to as opposed to a machine. This means someone is actually going to say "Hello" or "Good Morning," and maybe ask you a few questions to get things started. You'll be directed to the right person just as soon as is humanly possible. In addition to phone communications, Sheila also handles much of the telex, fax, and written correspondence supporting users in the field.

A Different System

Telonics is organized a little differently because our customers in the field tend to have rather unique needs. Both technically and administratively, our job is to support your work in the field. So the next time you call, ask for any one of us by name. *Brenda Milam*

Helicopter Update

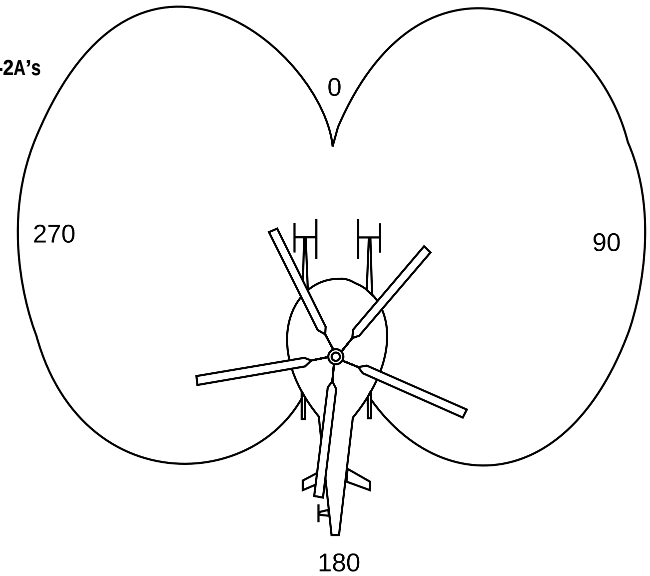
Weather conditions in the northern Oregon Cascades often create difficulties in aerial monitoring of radio-collared big game. Annual average rainfall is 70 inches with wind gusts of 40-50 mph. The terrain ranges between 1,000 and 7,000 feet, requiring flight altitudes of 2,500' to 7,500' Mean Sea Level.

Since several critical winter months of monitoring in a fixed-wing aircraft were being lost due to weather, efforts were directed to using helicopters. We soon discovered, however, that the single antenna concept for helicopters was not adequate. It was difficult to locate a transmitter with any accuracy and speed and, since helicopter rental costs four times that of a fixed wing, we began looking for alternatives.

The antenna system designed for our helicopter by Telonics employs the dual side-looking antenna concept used on fixed-wing aircraft. We are extremely pleased with the results and are now able to fly in unfavorable weather conditions with the accuracy and precision we had in the fixed wing.

Meg Eden, Wildlife Biologist, Oregon Department of Fish and Wildlife, Columbia Region

Antenna Pattern, Dual RA-2A's for Helicopter



The antenna bracket system developed specifically for Meg's study in Oregon may have application in other telemetry programs where terrain and weather conditions dictate the use of a helicopter for aerial tracking.

This system requires no permanent modification to the aircraft and is simple to install. In this particular case, the system was designed for use on a Hughes 500 D, but the brackets can be custom manufactured to fit many other helicopters. Regulations for attachment of equipment to aircraft vary depending on ownership, use, and location. Users should check with appropriate authorities regarding specific requirements.

Gary Jones

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