TELONICS QUARTERLY™

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Interpretation of Satellite Overpass Predictions

Telonics Satellite Display and Predictor Program Use in Establishing PTT Duty Cycles

Telonics Real-Time Satellite Display (TSD) and Satellite Predictor (TSP) program provides a variety of satellite overpass prediction and color display features for use on IBM compatible personal computers. Many of the program features were discussed in an earlier article by Dave Beaty (*Telonics Quarterly* 4:2). The current article focuses on interpretation of satellite overpass predictions as can be provided by the program, and emphasizes use of the program to aid in establishing optimal duty cycles and hours of operation for ARGOS PTTs.

One of the important decisions that must be made when ordering and using PTTs is the duty cycle to be used. The duty cycle of a PTT defines periods within which the PTT transmits (according to its repetition period), versus periods of temporary shut-down. Examples of simple duty cycles are 8 hours on/16 hours off, and 12 hours on/84 hours off. Considerably more complex duty cycles are possible with many PTTs, including definition of cycles which change over time. Duty cycles are referenced either to the time since power-up (standard for many PTTs); or, with some PTTs, to a real-time clock and calendar. PTTs using Telonics new ST-14 electronics offer the user a selection of these two potential time references.

An obvious advantage of duty cycling is the extension in life provided; a PTT operating 8 hours/day will operate longer than a similar PTT operating 24 hours/day (assuming the same battery pack). Defining limited periods of operation may also reduce data collection costs through ARGOS. Definition of a duty cycle is thus very important in customizing PTTs to your research objectives.

The satellites used in the ARGOS system orbit the earth, and are thus only “in view” for limited periods each day. The number of overpasses and the cumulative visibility is greatest in polar regions and least near the equator. The Telonics Satellite Display and Predictor Program can be used to predict satellite overpasses for your deployment area. This allows you to select an appropriate duty cycle, and synchronize “on” portions of the cycle with periods when overpasses most frequently occur.

Telonics will, upon request, provide researchers purchasing PTTs with a limited amount of overpass data to help determine the optimal duty cycles and “on” periods. Alternatively, researchers can procure a copy of the TSD/TSP program and run complete overpass predicts for analysis on their own computers.

Figure 1 shows a portion of the overpass predictions generated using Mode 6 of the Satellite Predictor Program. This particular mode provides overpass information for multiple satellites relative to one observer, and is the portion of the program normally used to aid in establishing PTT duty cycles. Each line of information provides the day and date of the overpass, satellite (object) designation, frequency of the beacon transmission from the satellite to earth, the time the satellite rises above the horizon relative to the specified location, time of closest satellite approach (tca), satellite set time, maximum elevation the satellite reaches above the horizon, whether the pass is south to north (a) or north to south (d) and to the east or west (geo), and finally the satellite orbit number. Of this data, the most relevant to decisions regarding PTT duty cycling include the date, object, time of closest approach, and elevation. All times are given in Universal Time Coordinated (UTC).

At the time of writing, ARGOS is primarily utilizing data from NOAA-12 and NOAA-14. Thus, if you will be relying primarily or exclusively on data provided by ARGOS, predictions of optimal PTT “on-times” should be based on those satellites. Periodically, new satellites are launched and older ones decommissioned, thus you may wish to check with ARGOS to determine which satellites they are using during your study period. If you will be using a Local User Terminal (e.g. Telonics **t-ris**™ LUT) to collect data, additional satellites may be relevant.

Satellite overpasses which are very low on the horizon relative to the PTT offer little chance of data collection or location determination. Overpasses very

Continued on page 5.

Figure 1. Partial printout from Telonics Satellite Predictor Program

TEST

date	object	beacon	rise	tca	set	el	geo	orbit
Mon 01Apr95	NOAA-11	1698.0000	00:01:09	00:07:16	00:13	13	a-e	33592
Mon 01Apr95	NOAA-12	1707.0000	01:30:20	01:37:48	01:45	51	a-e	20156
Mon 01Apr95	NOAA-11	1698.0000	01:39:23	01:47:12	01:55	71	a-w	33593
Mon 01Apr95	NOAA-12	1707.0000	03:11:36	03:18:02	03:24	16	a-w	20157
Mon 01Apr95	NOAA-11	1698.0000	03:24:01	03:28:31	03:33	5	a-w	33594
Mon 01Apr95	NOAA-9	1707.0000	03:34:28	03:40:57	03:47	16	a-e	53107

Products — Space Systems Group

Many of our customers know Telonics as a company that produces equipment for the wildlife research field—we have been producing high quality VHF tracking equipment since the late 1960s. In the early 1980s, however, the commerciali-zation of space had evolved to the point where satellite systems could be used for a wider variety of scientific purposes. Shortly after the ARGOS system became operational, we began a developmental effort to produce equipment that could track animals in remote locations using this new technology. The effort required that we develop both satellite transmitters and systems to determine that the data was being transferred through the satellite system for processing and eventual positioning of the animals.

Interestingly enough, this develop-mental effort led to a new product line for Telonics. With the first Telonics/ ARGOS Local User Terminals (LUTs) in 1984, Telonics became involved in the business of earth stations. An earth station may be defined as the ground receiving segment of the space system—the antenna, mounting pedestal and motorized positioner, receiver, work-station and associated software.

By early 1989, Telonics began receiving requests from the oceano-graphic, meteorological, and climato-logical fields of research to provide information on sea surface temperatures and other environmental parameters which could be obtained from satellites via remote sensing. The first equipment that we developed was designed to recover HRPT data from the NOAA polar-orbiting satellites. It is interesting that this downlink data stream was initially linked to the ARGOS data that we were already recovering with the Telonics LUT. We were discarding the HRPT data, but other scientists required this kind of imaging information and sophisticated image processing systems based on high-end workstations had been developed to make it available.

By 1990, Telonics was providing the front end of these systems—the antenna, positioner, pedestal, prediction and tracking software, receiver, and bit-synchronization portion of the system. Image processing companies began buying our equipment to integrate with their image processors. The combination produced a complete earth station for $100,000 to $250,000. These stations took the place of systems which cost $2,000,000 prior to this time.

With the ever increasing power of small personal computer systems, it soon became clear that limited image data processing could be accomplished using a 486-based machine. For some users, this was all the image processing needed and the demand led to the development of the Telonics Remote Imaging System (**t-ris**™) in 1992. The **t-ris**™ combines a complete tracking antenna and image processing system in a functional earth station for about $26,000 (or the price of a slightly used Dodge pick-up).

As you can see from the chart accompanying this text, a proliferation of products has occurred in the last few years to meet various requirements. In some instances, researchers have their own image processing equipment. For those users, we provide the antenna portion and either bit-synchronized data or frame-synchronized data as an output product that can be directly ingested into the customer's image processing system. In other situations—for example, research and teaching institutions—a complete image processing system has been developed in a price range that is affordable to support instruction as well as graduate research. The smaller **t-ris**™ is also being used in professional applications, and enhancements continue on the capabilities of this system.

Today privatization of space is resulting in a proliferation of satellite technologies and companies responsible for launching and maintaining systems. Low-cost satellites and launch systems are opening the door to a wide array of applications. STARSYS, ORBCOM, and IRIDIUM are destined to change the way global communications occur. EYE-GLASS, SEAWIFS, and other systems promise to make high resolution imaging systems available from space to study the environment, and open the door to additional data sets and remote sensing systems to be deployed on various new satellites in the future.

The Global Positioning System (GPS), originally designed for military appli-cations, is giving people the ability to position themselves with a high degree of accuracy anywhere in the world. This system is being integrated into a wide array of other systems (i.e. ARGOS) that allow commercial users to recover information about the movements of railcars, truck stock, and other commercial vehicles. The **t-ris**™ LUT will be available in 4Q95 to recover ARGOS-linked GPS positions in near real-time.

In general, the old adage that "everything that goes up must come down" is also true in a satellite system. For every application that uses satellites, downlinks are required. Earth stations for those downlinks have become an important research and development area at Telonics. *Dave Beaty*

Geostationary and Polar-Orbiting Satellites

Geostationary satellites are located approximately 23,000 miles out in space. Their orbitography is such that they remain at a constant position relative to a subspace point, which essentially means that they overlook the same point on the earth all the time. The geostationary systems are often used for various types of communications. Some that you may be familiar with include satellite television, various communication transponders, and the GOES and GMS weather monitoring systems which produce the animated cloud images seen on the evening news. Actually, the earth stations associated with geo-stationary satellites are not as complex as those for polar-orbiting satellites because these stations are in a fixed position and the antenna is simply pointed at the satellite. Additional tracking equipment is not required.

Polar-orbiting satellites are typically deployed 300 to 1200 miles above the earth. Because these satellites are in a relatively low orbit, they move at approximately 18,000 miles per hour relative to the earth's surface. Depending upon the exact altitude of the satellites, they complete one revolution about every two hours. Thus it is necessary to continuously track satellites with antennas in order to maintain the communications link.

There are several advantages to low orbiting satellites—including the fact that it takes less power to uplink information to the satellite and, in the case of imaging systems, it is often possible to get a higher degree of resolution. In addition, many of these satellites are designed to "paint" the entire surface of the earth over time.

The most familiar polar-orbiting satellites are those used by ARGOS and those used to recover high-resolution picture transmission. The NOAA series of polar-orbiting satellites are located about 600 miles from the surface of the earth.

THRPT-2 Professional System

- **Local User Terminal (LUT) Earth Station**
  Developed to recover data and provide positions for ARGOS transmitters. Retrieves NOAA/TIP data in real time.
  First deployment in Alaska to process downlink.
- **THRPT-1 NOAA/HRPT Earth Station**
  Developed at request of satellite imaging companies.
  THRPT-1 receiver systems are incorporated into commercial imaging systems to retrieve NOAA HRPT/AVHRR data in real time.

t-ris™ THRPT-6

TRAD-8 Radome

Military Products

- **Receive Only Systems**
  - **Orbiting**
    - **THRPT-2** - *Desert Storm*
      Developed for real time DMSP downlink; designed for maximum portability.
    - **Lightweight Tactical Receiving Systems**
      Designed for Small Tactical Terminal (STT) use by Harris Corporation
      - TD-2, 5' tracking antenna system for HRPT/DMSP.
      - TD-5, 2' tracking antenna system for DMSP only.
      - TWELGO-8, 4' antenna system for WEFAX data from geostationary satellites.
- **Command & Control**
  - **THRPT-2 CDAM**
    Tracking receiving transmitting antenna systems designed to control customer-owned satellites.

Commercial Products

Professional Systems

All outside equipment fabricated with aircraft quality aluminum and stainless steel using high quality two-part urethane paints.

Designed for deployment in most rugged environments with minimum maintenance.

Advanced noise filtering techniques for improved performance in high noise environments.

Withstands close proximity to high level radars.

Rack mountable.

- **Receive Only Systems**
  - **Orbiting**
    - **THRPT-2**
      Designed for HRPT or DMSP downlinks when convergence applications become available.
      Heavy duty model produced to specific OEM requirements.
      Tracking software available.
    - **THRPT-6 DHLW**
      Miniaturized dual band HRPT/DMSP system for incorporation into highly portable OEM workstations.
  - **Geostationary**
    - **TGEO-2**
      High quality receiving systems designed to support the following downlinks:
      - NOAA VISSR
      - Europe METEOSAT
      - Japan GMS
      - NOAA GVAR/AAA
      10' to 16' antenna sizes available.
- **Command & Control**
  - **THRPT-2 CDA**
    Tracking receiving/ transmitting antenna systems designed to control customer-owned satellites

Economy Systems

Features aluminum/steel construction with proprietary coating system.

Designed for deployment in less rugged environments (i.e. less extreme wind, temperature, salt and pollution levels.)
Note: t-ris™ can be upgraded with professional quality antenna and positioner.

- **Receive Only Systems**
  - **Orbiting**
    - **t-ris™ THRPT-6R**
      Antenna/receiving system for incorporation into customer's OEM image processing system. Includes tracking software.
      Image processing software not included.
    - **t-ris™ THRPT-6L**
      Antenna/receiving system with Local User Terminal (LUT) processing.
      Image processing software not included.
  - **Geostationary**
    - **t-ris™ TGEO-6R**
      Low cost receiving system for OEM applications.
      Permits customer ISA PC compatible image processing workstations to retrieve geostationary downlinks.
      Currently available for NOAA GVAR.
      Image processing software not included.
- **Receive & Image Processing Systems**
  - **Orbiting**
    - **t-ris™ THRPT-6**
      Complete pc-based earth station designed to provide low cost access to NOAA HRPT satellite data. Includes advanced image processing software. Professional quality antenna and positioner available as upgrade.
  - **Geostationary**
    - **t-ris™ TGEO-6**
      Complete pc-based earth station designed for geostationary downlinks. Includes advanced image processing software.
      Available 1996 for NOAA GVAR.
- **Workstations**
  - **Orbiting**
    - **t-ris™ THRPT-6W**
      Workstation includes computer, bit/frame synchronization hardware and image processing software. Designed to provide customer-owned receiving systems with ability to process NOAA HRPT satellite data.
  - **Geostationary**
    - **t-ris™ TGEO-6W**
      Workstation includes computer, bit/frame synchronization hardware and image processing software. Designed to provide customer-owned receiving systems with ability to process geostationary downlinks.
      Available 1996 for NOAA GVAR.

Related Products

- **TMSB-2 ASMU**
  Advanced Multi-Satellite Bit/Frame Synchronization Unit allows users to ingest data in real time.
  PC ISA bus compatible.
- **TRAD-8 Radome**
  Low cost radome for up to 1.73 meter antenna.

Continued from page 1.

high overhead the PTT provide good probability of data collection; however, they often do not result in a position determination. In general, overpasses between approximately 12-75 degrees elevation have a good chance of being able to provide data and a location. If PTTs are used in areas with tall mountains nearby, some lower elevation overpasses may be blocked or partially blocked by the mountains, thus it may be wise to predict duty cycles and data availability based on a higher minimum elevation in such applications. In contrast, passes with elevations down to about 5 degrees above the horizon may work in recovering data and obtaining locations for PTTs deployed in flat open environments such as tundra or the ocean. *Note: For practical purposes, transmissions do not propagate through saltwater, thus they can only be received when a PTT is on the surface.*

To determine overpass distributions the following steps are suggested:

1) Determine the latitude, longitude, and approximate elevation of the area where the PTTs will be used. Run the predictor program or, if you are purchasing PTTs, request predicts from Telonics, using this information. Consideration of predicts covering one or two periods, of 7-10 days each, during your study period usually gives a good representation of overpass patterns. It is usually best to limit predictions to within 12 months due to changes in satellite orbitography.

2) Develop a histogram or other summary of the number of "good" overpasses of relevant satellites in 1 hour increments throughout the 24 hour UTC clock. Figure 2 provides an example of such a summary showing overpasses of NOAA-12 and NOAA-14, with elevations of 12-75 degrees relative to Telonics. Two periods are plotted, 1-7 April and 16-21 July 1995. These periods were selected at random. They illustrate a clumping of overpasses which is typical of many areas, and also little variation in the overall pattern of overpasses during the two disjunct periods. Note that within the overall pattern, the exact timing and number of overpasses does vary day-to-day. For example, Figure 2 shows that between 3 to 8 "good" passes of NOAA-12 and NOAA-14 occur on a daily basis at Telonics.

3) Decide the optimal duty cycle for your PTTs based on desired longevity, intensity of data collection desired, overpass distribution, and any scheduling that may be pertinent to your data collection (e.g. day versus night, etc.). Other factors might also be relevant; for example, there is little value in having intensive "on" portions of a duty cycle during periods when an animal might be predicted to be in a den where transmissions would likely be blocked. It is generally best to define minimum "on" periods of about 4 hours (often longer in low latitude areas) to account for daily and possible long-term variation in overpass timing. Trying to critically select 1-2 hour "on" periods can result in more substantial short and long-term variation in the number of overpasses which occur during the "on" period.

Bill Burger

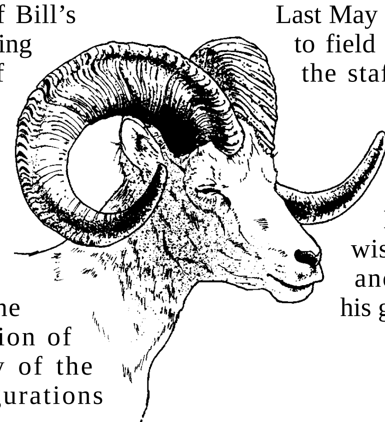
	7		X		X						0	0				X		X							
	6															X	X				0				
Day	5		X	X							0										0		0		
(1-7	4		X	X						0	0				X		X				0		0		
April 95)	3		X		X					0		0				X	X				0		0		
	2				X					0		0				X		X			0		0		
	1	X		X						0		0				X		X				0	0		
UTC Time		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	16	X		X						0	0										0		0		
Day	17															X		X			0	0			
(16-21	18		X		X								0			X	X								
July 95)	19		X		X						0	0			X		X								
	20		X	X							0	0										0		0	
	21	X		X						0		0				X		X				0	0		

Figure 2: Distribution of NOAA-12 (X) and NOAA-14 (0) overpasses (12-75° peak elevation) relative to Telonics' location (N 33.384°, W 111.811°, 410 m Alt.).

Bill Burger Joins Staff of Arizona Game & Fish

Bill Burger has been the Staff Biologist at Telonics for the past nine years. During that time he has been involved with every aspect of our business. Many of you have undoubtedly talked with Bill personally and read his articles over the years in this newsletter.

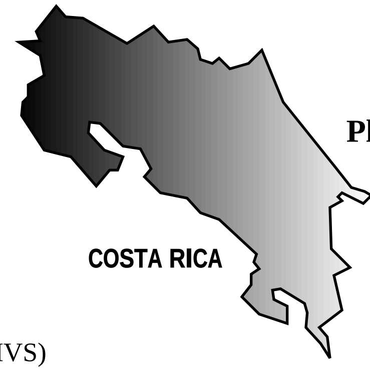
As a former field researcher with U.S. Fish and Wildlife Service and other agencies. Bill's knowledge and understanding of field work made him invaluable to both Telonics and the customers we serve. One of Bill's responsibilities involved working to further the development of conventional VHF telemetry. As part of his efforts in this area, Bill spent several months working in the field with researchers studying lions in Yellowstone National Park. Bill was also very actively involved in the development and application of satellite telemetry. Many of the smaller satellite configurations employing the ST-10 and the ST-6 PTTs were deployed as a joint effort between Bill and researchers in the field.



Last May Bill decided to return to field work. He has joined the staff of Arizona Game & Fish, and is currently working on a variety of projects involving Bighorn sheep. We wish Bill the very best and thank him for all his good work.

Stan Tomkiewicz

International Workshop on Radio Telemetry Systems



Dates: October 16 to 18, 1995*

Sponsors:

Telonics, Inc.
Regional Wildlife Management Program
for MesoAmerica and the Caribbean (PRMVS)
Universidad Nacional Costa Rica,
Fundacion Neotropical Costa Rica

Topics Include:

Radio Telemetry • Conventional Telemetry • Antenna Concepts
Receiver Technology • Data Acquisition Systems
Satellite Telemetry • Local User Terminals • Uplink Receivers
AVHRR Imaging • GPS ARGOS • GPS FM • GPS Stored Data
FM Transmitters

Special Note:

Several talks will be given on studies made in MesoAmerica using radio telemetry.

Optional Special Events:

The practice session on October 18 will be held in the Punta Leone Hotel. For participants who choose to stay in the hotel, the cost is U.S. $50 per day plus food.

Place:

PRMVS UNA, Heredia, Costa Rica (2 days)
Carara Biological Reserve and Punta Leona
Private Wildlife Refuge (1 day)

Travel:

Regular airline service to Costa Rica is available from throughout MesoAmerica.

Registration:

U.S. $50 Students
U.S. $100 Professionals

For more information, contact:

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*We apologize for the lack of advance notice on this workshop.

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