CGMS-XXVII USA-WP-16
Prepared by USA
Agenda Item: I2

IDENTIFICATION OF POTENTIAL AREAS OF INTERFERENCE

Summary and Purpose of Document

The GOES DCS provides a valuable service critical to the mission of agencies and organization throughout the world. Since 1975, environmental data from remote platforms have been collected and relayed in real time through NOAA's geostationary (GOES) spacecraft to federal and international environmental managers and scientists. Known as the GOES Data Collection System (DCS), this satellite transmission technology consists of Data Collection Platforms (DCPs), dedicated satellite receive and transmit capability, and ground/satellite processing and distribution equipment. Data collected from DCPs measures or monitors such varied parameters as rainfall, river stage levels, soil, seismic or tsunami conditions, aircraft flight and fire events. These data are also used to verify and serve as "ground truth" for other types of remotely sensed data such as NEXRAD and satellite-derived precipitation estimates. DCS data provides fast, reliable information for flood, fire and other disaster forecasts and warnings amounting to incalculable savings of lives and property damage. The GOES DCS system is constantly monitored to protect it from unknown sources of interference that degrades the service it provides. These intruders have caused the loss of numerous transmissions and the forfeiture of an entire channel. This paper will describe NOAA’s effort to identify sources of interference to the GOES DCS system.

Action Requested: None

IDENTIFICATION OF POTENTIAL AREAS OF INTERFERENCE

INTRODUCTION

Over the past decade, the GOES DCS has suffered dramatically from interruptions in service due to unknown and unidentified interference. These disruptions in the DCS service have cost the users valuable time and resources. As the nation admires colorful images of major weather systems affecting areas of the world, little is known about the impact the remote surface observations have on the monitoring and forecasting of these events. The loss of data from a single platform, for a minimal amount of time, can have a cataclysmic effect on property and lives (Flooding on the Red River of the North, 1997 and Hurricane George in Guatemala). In addition, interference reduces the most valuable element of the DCS system, frequency spectrum.

THE OPERATION

Monitoring of the domestic and international channels is a continuous manual operation that determines the reliability and quality of the DCS service. NESDIS has defined interference in the system based on its severity or how quickly it can be resolved. Interference that affects the DCS system can be either short duration or long term as well as internal or external. The following is an overview of each type and its effect:

Type 1: Platform Clock Drift - Internal interference created when a platform clock drifts to allow transmission outside of the assigned time slot;

Type 2: Platform Frequency Drift - Internal interference created when a platform transmits with a drifting oscillator;

Type 3: Unknown Transmission (Short Duration) - External spurious interference created from illegal transmitters that last only minutes at a time;

Type 4: Unknown Transmission (Long Duration) - External interference created from illegal transmitters that last several days before disappearing; and

Type 5: Unknown Transmission (Continuous) - External interference created from illegal transmitters using a DCS assigned slot or entire channel.

THE PROBLEM

As the interference problem grew, NESDIS began to lose more and more time slots and eventually an entire channel to the pirate transmitters. The reassignment of time slots and the availability of manpower to update the platforms equates to an immense lost of data and a monumental budgetary expense. In 1994, NESDIS contracted for the development of a blocking transmitter to deny the illegal transmitter the use of the GOES transponder. Deliverable configuration of the new subsystem included:

o 2400 baud modem

o Sutron Model 800E antenna

o Cabling

o Power supply

o IBM 386 compatible computer

o Blocking antenna software

The system was delivered and deployed, but before it became operational, NESDIS determined the system would have serious consequences on the frequency bands it was designed to protect. After operational review, it was discovered that the system could not discriminate between authorized or unauthorized users. Blocking an illegal transmitter would render the assigned slot unusable. Therefore, the blocking transmitter would not allow anyone, legal or illegal, to use the disputed assignment slot.

With the ever-increasing presence of interference in the heavily used GOES DCS frequency band, NESDIS is faced with maintaining a quality service with reduced resources. To effectively manage its frequency resources, OSDPD has implemented new operations to monitor and identify unauthorized transmissions in the DCS system.

NEW APPROACHES

NESDIS is reviewing the system reports to determine proper platform transmission times. The DCS Automatic Processing System (DAPS) monitors the operation of the system and provides vital statistics about the operation of the platforms. The new DAPS system will allow NESDIS to display platform activities, a history of operation, geographical location and telemetry. In addition, the IDCS will provide real-time reports of interference on domestic and international channels.

Interference reduces the reliability of the GOES communications system and denies the NESDIS the full use of their frequency assets, and thus produces loss of resources and diminishes customer confidence. The only solution is to locate the source of the interference when it occurs and turn it off. NESDIS is working with a commercial vendor to determine the hardware and software needed to locate and identify interfering transmitters.

The Transmitter Locator System (TLS) reviewed by NESDIS uses interferometric techniques to determine the location of a signal that is being carried over a satellite transponder. This method is totally passive and requires only that the TLS site be in the transponder "footprint" of both the interfered satellite and an adjacent satellite that has a transponder closely matching the characteristics of the interfered transponder. The TLS determines the transmitter's location by observing the difference in arrival times and the difference in frequency caused by transmission of the interfering signal through two satellites. Using this technique, and accurate satellite orbit information, the TLS is able to report position accuracy within a few kilometers. In most cases, this accuracy was more than sufficient to allow identification of the transmitter, and thus, elimination of the interfering signal.

Interference on a given satellite may occur from many sources. As an example, interference may be caused by system malfunctions, poor polarization control, improper antenna pointing, untrained operator mistakes, insufficient knowledge of new equipment, deliberate interference, and even intentional terrorism.

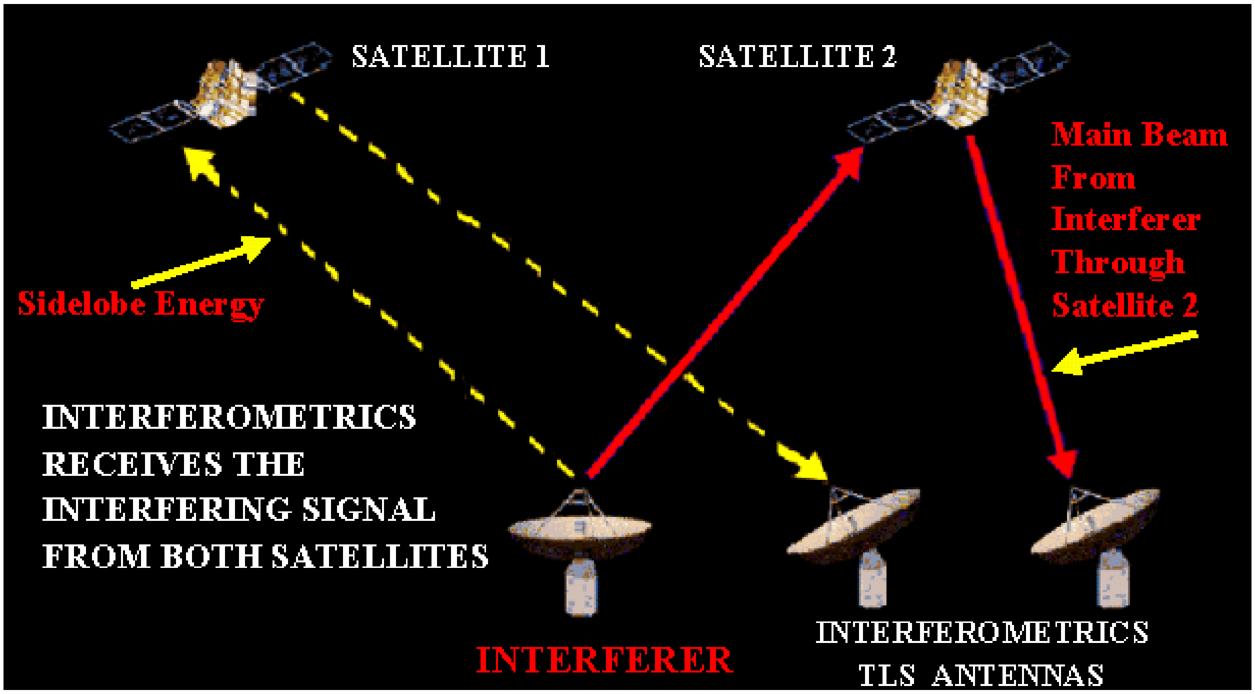

Figure 1 : Interfering Platform and Sidelobe Energy

Every transmitter has energy in its sidelobes. The level of these signals is too weak for communications and too weak even to be seen on a spectrum analyzer. The locator system investigated by NESDIS uses techniques developed for radio astronomy applications. This unique system is not only capable of detecting the signals, but in fact is able to pinpoint the location of an interfering uplink transmitter. Interfering signals are processed in a series of steps. Initially they are converted to baseband. Following that, the system's unique digital hardware correlator extracts time and frequency information from the incoming data stream. After processing the data, the system produces a position ellipse showing the location of the interfering ground-based transmitter.

THE TIMELINESS AND ACCURACY OF THE LOCATION ELLIPSE IS DIRECTLY RELATED TO THE ACCURACY OF THE SATELLITE EPHEMERIS.

The very small location ellipse shown in Figure 2 was generated from a customer's activation. The location shown, near Atlanta, GA, is only 2.5 miles by 20 miles, and was generated less than one hour after activation. Using the results of the TLS, NESDIS can concentrate its efforts into a small geographic region, isolate the source of the interference, and contact the appropriate authority to shut it down. Without TLS, the interference can often last for days, weeks, or longer.

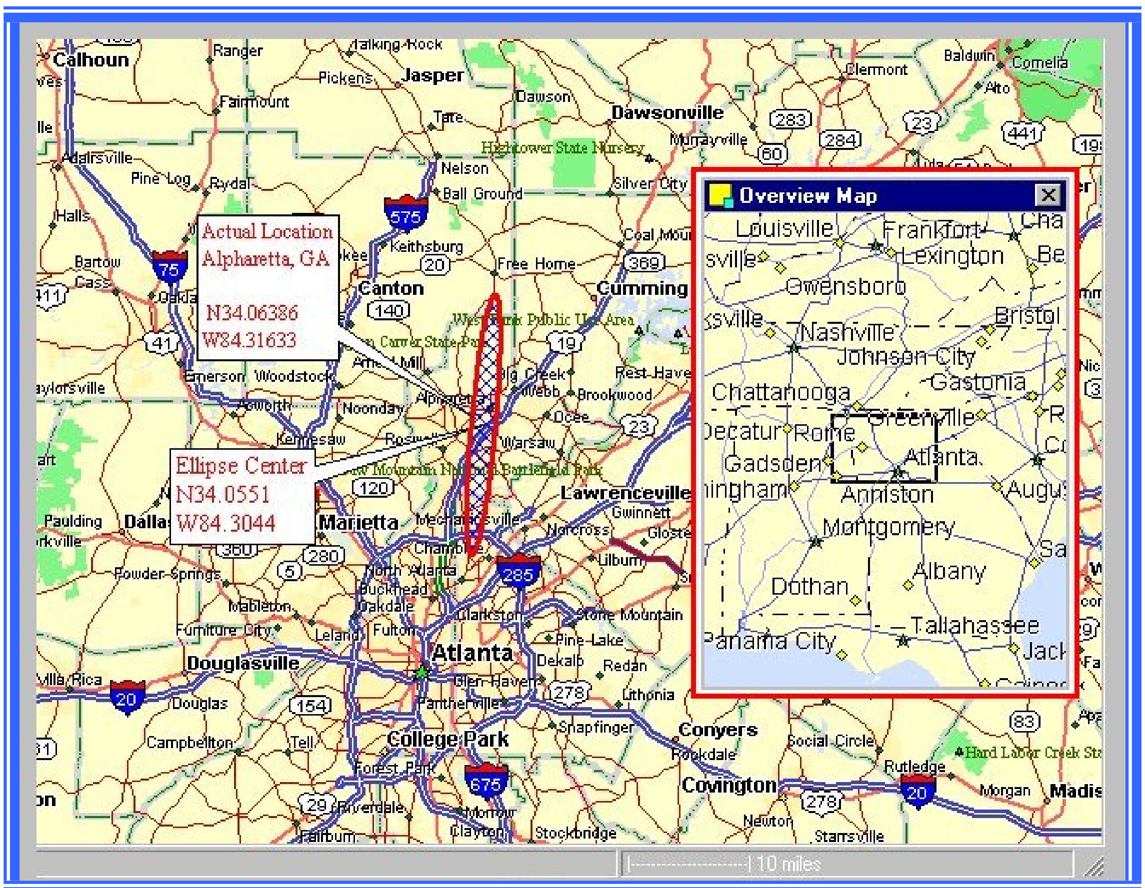

Figure 2: Sample Location Ellipse map

The locations of unknown transmitters on the Earth's surface are determined from measurements of the difference in travel time from the transmitter, traversing paths through two satellites close together in the orbital arc, to two receivers. Owing to complex transponder plans it may be that the downlinks from the two satellites are sent to different geographical areas of the Earth. In this case, which we refer to as distributed TLS, the receivers and associated electronics must provide time-stamped, sampled data representing the downlink signals, and transmit these samples to a central location for further processing.

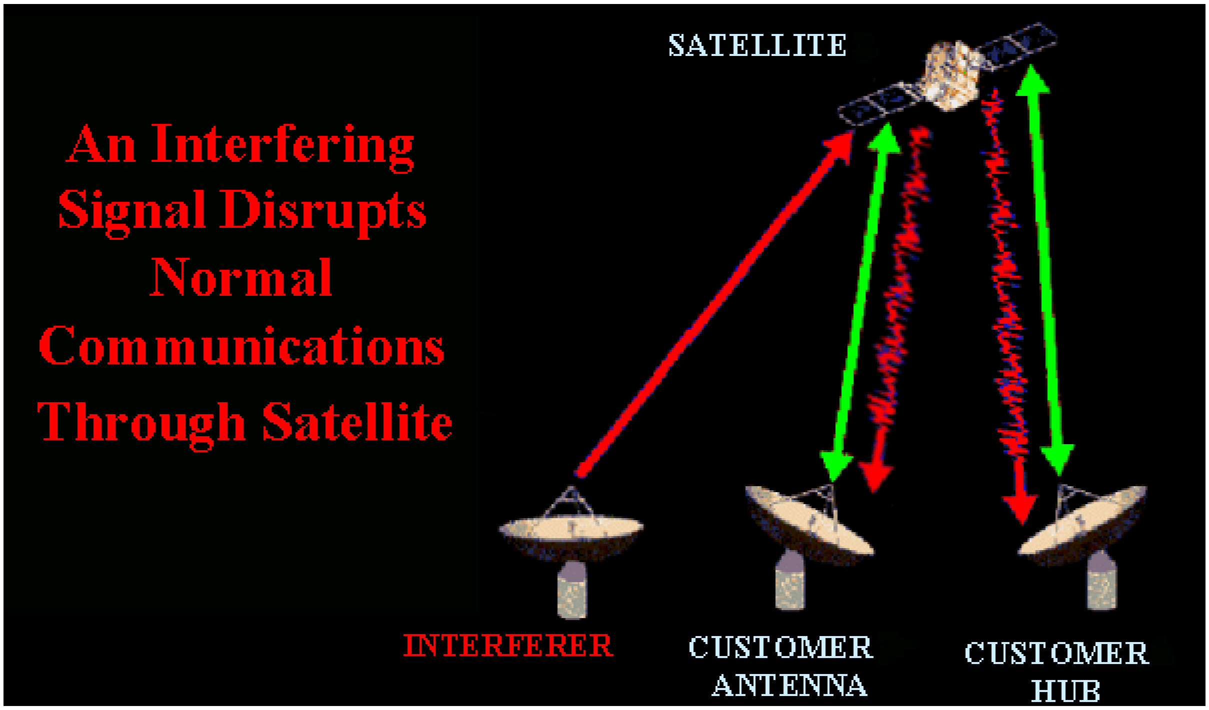

Figure 3: Interfering Transmitter Detected via Single Satellite

For either collocated receive facilities or distributed systems, the inherent speed of the hardware correlator saves time compared to what is possible from a software correlator. Once collected, a single set of measured data may be processed repeatedly through the hardware correlator at a rate faster than the rate at which the data were collected. Recycling the data through the hardware correlator while sequentially stepping the midpoint in Time Difference of Arrival (TDOA) allows the system to rapidly search extremely wide geographic ranges without having to wait to collect more data on each attempt. Because the clock speed of the correlator is so great, the results appear in a matter of seconds instead of tens of minutes. The benefit is a location ellipse that is useful to the NESDIS much sooner than can be obtained with software correlation.

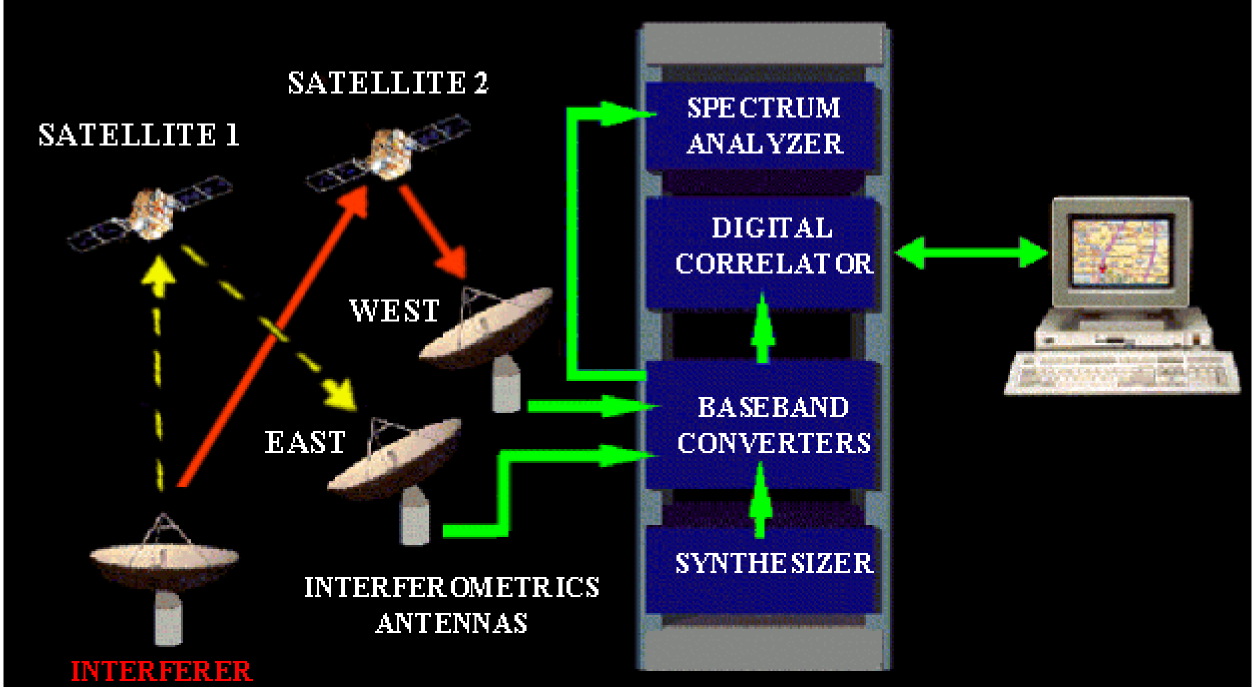

Figure 4: Transmitter Location System

CONCLUSION

NESDIS will continue to investigate the transmitter location system and evaluate the benefits this system has on the operation of the DCS system and possibly the GOES system.. Satellite parameters and operational procedures of the DCS as well as the GOES will be provided to the contractor for an on-site demonstration of locating violators of the system. NESDIS plans to use the TLS as integral part of quality control of the DCS operation. Verifying platform locations and monitoring transmission from platform that have recently expired MOAs will increase the quality of the DCS service.