Advances in Interference Detection, Characterization and Location

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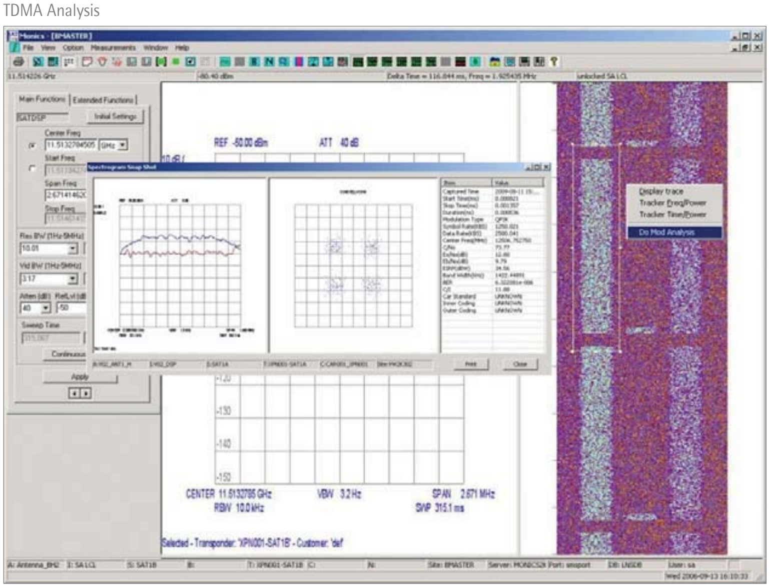
There is no doubt that the advent of the use of Digital Spectrum Analysis (DSA) which uses affordable frequency conversion and analog to digital converters along with sophisticated digital signal processing (DSP) algorithms based on a PC have provided significant improvements in the battle against interference. Satellite geolocation systems use a similar architecture for hardware and software, so it is a natural fit that the two technologies should come together to provide a single system that provides interference detection, analysis, characterization and location. This article discusses the latest advances in hardware and the DSP algorithms for these systems.

Signal interference can result in lost bandwidth and degraded quality of service leading to lost revenue. Today's economic environment simply does not allow any missed opportunities for revenue generation or efficiencies in operation. Satellite operators and service providers can now acquire an affordable CSM and geolocation system with the features they require to mitigate against interference on almost any service, whether that be Double Carrier (two similar carriers occupying the same frequency space) or time varying signals such as frequency hopping or MF-TDMA.

Today's interference detection systems can detect that what looks like a single carrier is in fact a double carrier and analyze each carrier as well as detect interference within the channel, this feature assists with closing the link and also ensure the quality of the link is maintained. Frequency hopping systems or MF-TDMA systems are difficult to detect interference using conventional spectrum analysis. The latest DSP algorithms can analyze the time varying signals, determine that the modulation format is correct, determine if interference exists and display that interference in the form of a spectrum.

Once interference has been detected and characterized, the CSM can search planning and known interference databases for similarly characterized carriers to quickly bring resolution to the interference occurrence. If this proves unsuccessful then the geolocation part of the system can be used to determine the location of the interference transmission.

TDMA Analysis

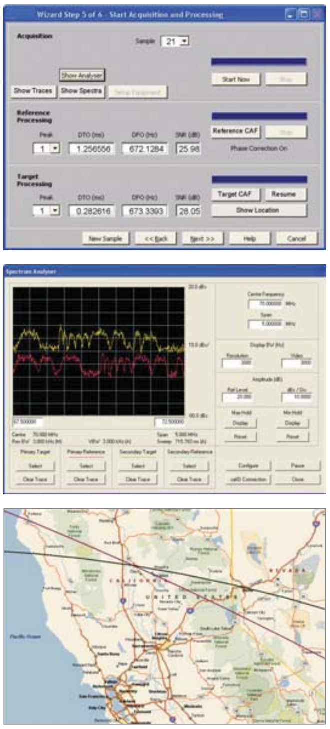


There are some features of geolocation that are important to understand to appreciate and understand what is required to be able to make fast and accurate geolocation of an interferer. In the past, there have been a number of statements that show a lack of understanding of the problems and serve only to confuse the market of which features are important in a repeatable, fast, accurate geolocation system. Below we clear up those misunderstandings and describe some essential features that should be present in any credible geolocation system.

Knowledge of satellite ephemeris data (gives satellite position in space) is a fundamental requirement for any geolocation system. It is usually the dominant source of error, as uncertainty of the position of the two satellites leads to greater uncertainty of the frequency and time measurements giving inaccurate geolocation estimates. Geolocation systems can use two-line element (TLE) ephemeris data – publicly available for most satellites – to generate a relatively coarse geolocation estimate. The problem with TLE data is that it is not very accurate and is typically updated every couple of days, so it can often be quite stale. To address this, a reputable geolocation system should have the ability to correct TLE data. This is termed Ephemeris Error Compensation (EEC™), which produces corrected TLE data several orders of magnitude more accurate than the original, thereby increasing the accuracy of the geolocation estimate often to the sub-kilometer range. EEC is a capability not found elsewhere in the marketplace but is essential for speed and accuracy of geolocation.

The two main measurements made by a geolocation system are Time Difference of Arrival (TDOA) and Frequency Difference of Arrival (FDOA). These two measurements are used to generate lines of position which can be drawn on a computer generated map. The intersect of the lines of position are used to calculate and draw a probability ellipse that will contain the interference transmitter. The measurements can be made in any combination, meaning that TDOA/TDOA, FDOA/TDOA and FDOA/FDOA measurements can be made. Each combination has their uses in differing interference scenarios, but by far and away the quickest to yield a location of an emitter is FDOA/TDOA. This technique requires only two satellites to be monitored simultaneously, whereas TDOA/TDOA requires three satellites to be used and FDOA/FDOA requires the satellites to have changed position, so multiple measurements are normally made at 30 minutes or 1 hour intervals. This latter technique is normally used when locating a CW or CW like signal (a faulty modem can often produce a signal that appears to be a sweeping CW signal) which contains no timing information. TDOA/TDOA technique is less complicated to implement than FDOA so has some appeal, some vendors may state that FDOA is either not accurate or not needed for geolocation. Both statements are inaccurate and show a lack of understanding of interference occurrences and/or a lack of ability to measure frequency difference accurately. There are many interference occurrences caused by signals with no timing information, such as unmodulated Carrier Wave (CW) signals or periodic signals (sweepers), which are either impossible or impractical or slow to geolocate with TDOA only and there are occurrences where it is not possible to find three satellites near the same location to allow geolocation to be performed. Time taken to obtain a geolocation is always a problem when three satellites are needed to generate two lines of position, in addition accuracy can also be compromised as the satellites become closer together so the lines of position become more parallel and the uncertainty of insect increases thereby affecting accuracy.

Fast, accurate FDOA measurement capability is a must have to locate the complete set of interference scenarios that occur in geolocated satellites. With the ability to mix TDOA and FDOA measurements, the operator can obtain instantaneous geolocation estimates using only two satellites. This expands the number of scenarios where geolocation is possible to include those where TDOA alone is impossible or impractical. For example the fact that FDOA lines vary on the earth's surface over a relatively short time is a distinct advantage (and not a problem) as it allows signals with no time signature to be located accurately and quickly.



Wizard Based Geolocation GUI

For older satellites, the second-most dominant error source (after ephemeris error) is often phase noise on the transponder. A good geolocation system will have features and techniques to eliminate the effects of this noise, and produce corrected TDOA and FDOA measurements. This dramatically increases geolocation estimate accuracy. The accuracy of results without EEC and phase-noise correction is severely reduced, often to the point of uselessness.

Finally, a good geolocation system should be designed to be an operator-friendly system that can be used by technicians to quickly produce useful results. A simple to use Graphical User Interface (GUI) that leads the operator through the geolocation process increases speed to obtain a location of an interferer. Extensive use of a "Wizard" interface to automate processing and guide users through the geolocation process should be considered as essential in the operating environment.

Such a system that meets the requirements listed above is satID-SA which contains Integral Systems Inc. hardware and software technology. The system uses the latest hardware technology to provide 85MHz of instantaneous bandwidth to give fast detection of interference across a complete transponder. The system software is based upon the market leading Monics® Interference detection and characterization software, in use by the majority of the satellite operators around the globe. The system includes Carrier under Carrier™ technology which has the ability to detect interference anywhere in the bandwidth of a carrier, DoubleCar, which detects interference in dual carrier system and TDMA system analysis. The geolocation system is based upon satID® the fasted, most accurate and easiest to use system with advanced features to allow gelocation of almost any scenario. satID® includes patented technology for EEC™ and phase noise correction as well as de-sweeping and retransmit technology that allows location of sweeping signals as well as signals that are retransmitted from earth stations because of some system fault that has occurred.

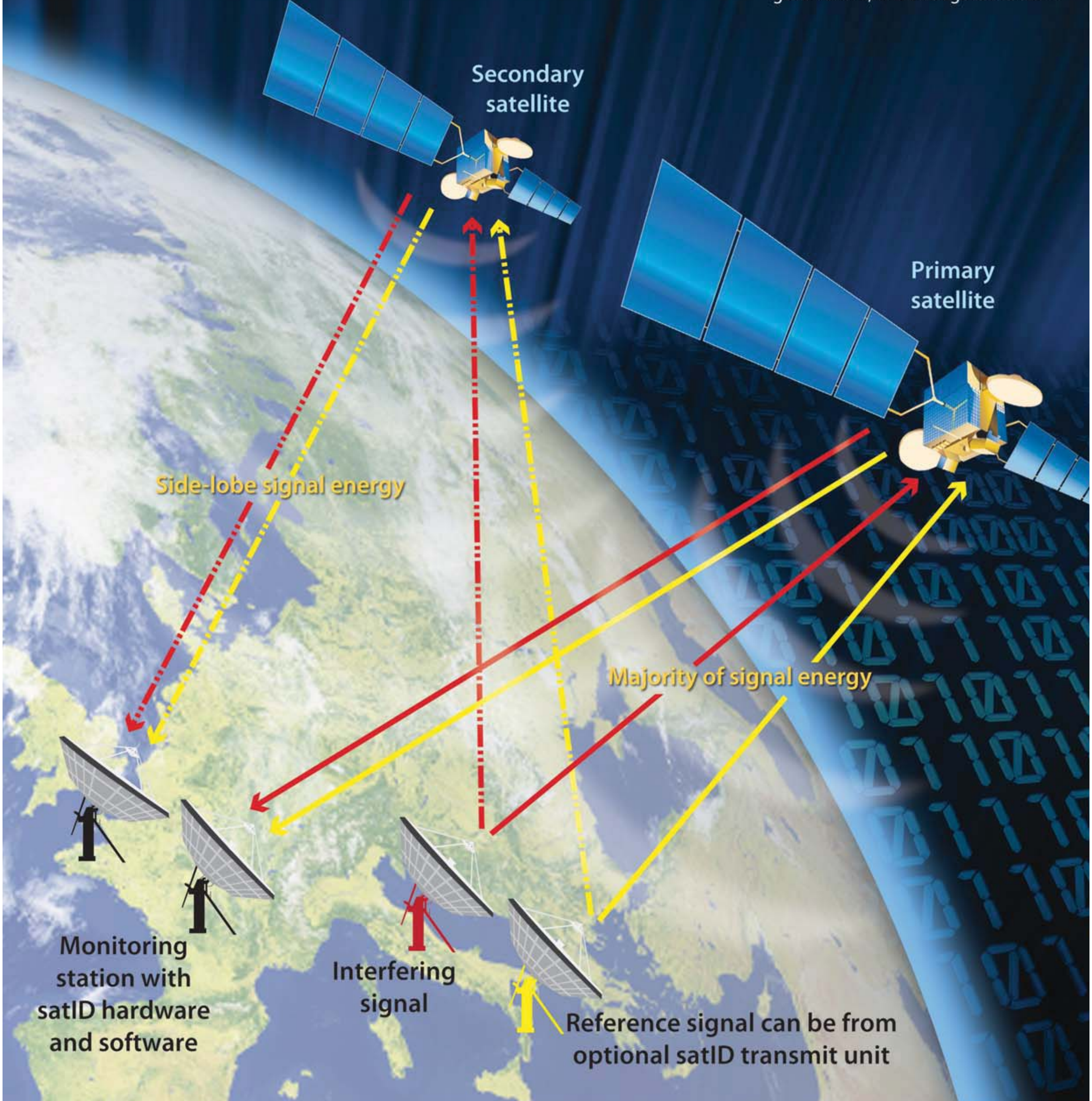
Integral Systems and its subsidiaries – Integral Systems Europe, SAT Corporation, Newpoint Technologies, Lumistar, and RT Logic – will continue to focus on bringing to market a distinctive set of Commercial-Off-the-Shelf (COTS) products, solutions, and world-class systems engineering services that will uniquely position us to continue supporting our customers around the globe. We see the increasing demand for bandwidth driving satellite operators to squeeze more efficiency from their current fleets. Integral Systems' products and services help operators achieve significant operational efficiencies. We are also well positioned to continue expanding our international footprint. In particular, we see an opportunity to build on our record of success in the Asia-Pacific region.<

Robert Potter is the President of SAT Corporation, a wholly-owned subsidiary of Integral Systems, and a world leader in developing innovative and complete sets of products and algorithms for RF communication link interference detection, analysis and geolocation. His experience in RF systems design and measurement techniques extends back more than 20 years. Before joining SAT, Mr. Potter served as the R&D Manager for Maxon Europe Ltd. He chairs the working group for unique carrier identifier within SUIRG. Mr. Potter holds a B.Sc. with Honors degree in Electronic Engineering from Southampton University, UK.

satID
technology that protects

Integral Systems' satID Signal Geolocation System

The satID suite comprises comprehensive, integrated software and hardware solutions enabling satellite operators to locate equipment failures, erroneous transmissions, interferers, jammers, and unauthorized users of their satellites. Used by global satellite operators and governments, satID affords advanced situational awareness for the commercial, military, government, and intelligence sectors.



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