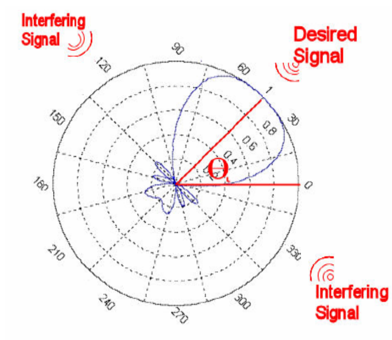
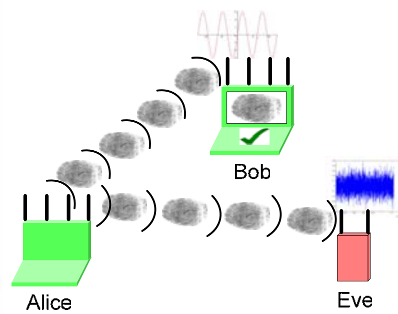
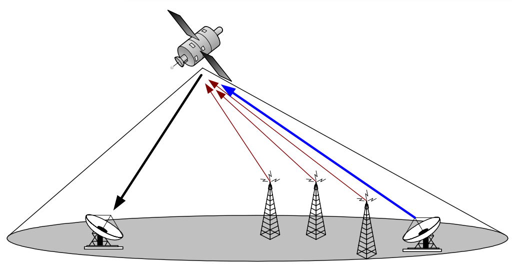
GIRD Systems, Inc.

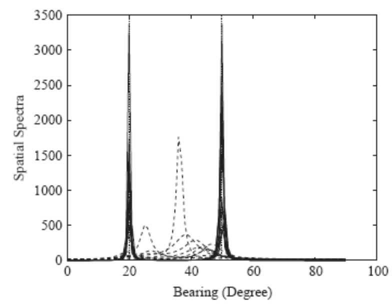
Engineering Research and Development

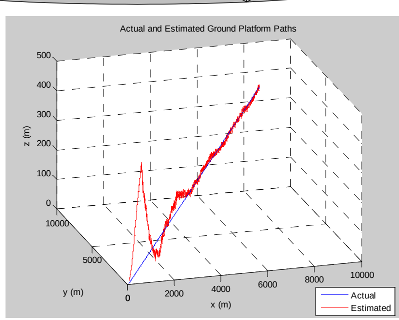
Programs and Capabilities

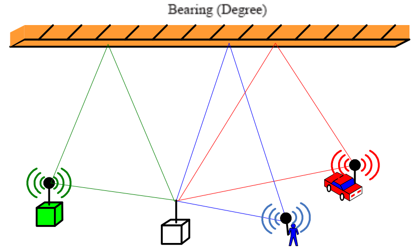












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GIRD Systems, Inc.
Engineering Research and Development

COMPANY BACKGROUND

GIRD Systems, Inc. is an Ohio based R&D company founded in 2000. Staffed with highly qualified engineers, the company specializes in research and development of communications and digital signal processing software/hardware systems and components.

GIRD Systems Headquarters in Cincinnati, OH

CLIENTS/PARTNERS

- US Navy SPAWAR
- US Navy NAVAIR
- US Army RDECOM
- US Air Force Wright-Patterson
- US Air Force Hanscom
- US Air Force Rome
- L-3 Communications Nova Engineering
- Northrop Grumman Xetron Corporation
- Pole/Zero Corporation
- Concurrent Technologies Corporation
- University of Cincinnati
- SUNY Binghamton

COMPANY INFORMATION

Corporate Structure:	Small Business
ORCA Registration:	Completed

NAICS CODES

541330	Engineering Services
541511	Custom Computer Programming Services
541690	Other Scientific and Technical Consulting Services
541712	Research and Development in the Physical, Engineering, and Life Sciences

AREAS OF EXPERTISE

GIRD Systems specializes in the development of innovative solutions in the areas of:

- Interference Mitigation
- Array Signal Processing
- Location and Navigation
- Wireless Network Security

CONTACT INFORMATION

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GIRD Systems, Inc.

Engineering Research and Development

Interference Mitigation

GIRD Systems, Inc.
Engineering Research and Development

NORTHROP GRUMMAN
Electronic Systems
XETRON

RF Solution to Narrow In-Band Interference in UHF SATCOM Channels

SPAWAR
Systems Center San Diego

Technology in Development:

- SPAWAR Phase I SBIR awarded June 2004
- SPAWAR Phase II SBIR awarded February 2006
- Hardware demonstration using captured signal data – Fall 2007
- Real-time over-the-air hardware demonstration – early 2008

General Description:

GIRD Systems, in collaboration with Northrop Grumman Xetron, is developing a novel Interference Mitigation System (IMS) for mitigation of narrowband interference from UHF SATCOM channels. Operating as a stand-alone processor, the IMS can be quickly integrated into virtually any SATCOM platform.

By exploiting *a priori* knowledge of the nominal Signal-Of-Interest (SOI) characteristics, GIRD's signal processing algorithms can better separate the interference and SOI, relative to conventional linear prediction and linear equalization approaches. Low algorithmic and hardware latencies ensure operation of the IMS is transparent to the receiver.

When the DAMA terminal's IF signal is not available, the IMS is augmented with a Radio Frequency Front End (RFFE) which performs downconversion to IF. Following digitization and processing, the signal is regenerated at the RF frequency specified by the terminal's tune word.

In some applications, the SATCOM receiver's 70 MHz IF signal is available for direct processing. In this case, the IF is digitized by the IMS, the mitigation performed, and the processed signal regenerated at IF. Operating in this manner, the IMS requires no side information about the SOI.

Example Scenario:

Figure 2 illustrates one potential interference scenario. Two narrowband interferers are corrupting a 9600 bps BPSK transmission over a 25 kHz SATCOM channel. Without interference mitigation, the receiver BER is very nearly 50% because the interference energy causes complete failure of the receiver's carrier tracking and equalization loops.

Figure 3 illustrates the effectiveness of GIRD's interference mitigation algorithm. Following mitigation, the receiver BER is <1% at -10.3 dB SINR.

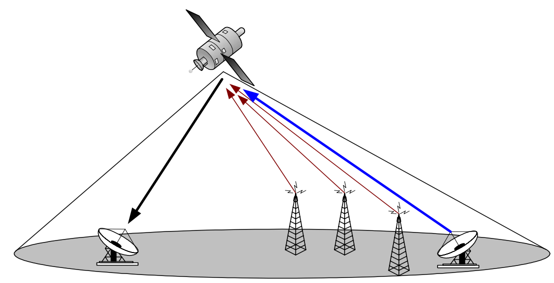

Figure 3 – Narrowband interference (incidental or intentional) often corrupts DAMA SATCOM signals because of the satellites' wide beams. Terrestrial emitters' signals couple into the satellite uplink and are downlinked along with the signals of interest.

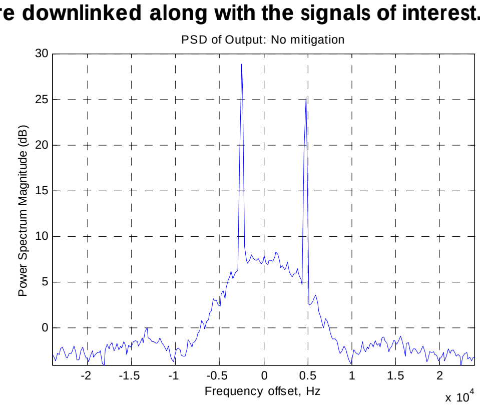

Figure 3 – 25 kHz DAMA SATCOM SOI corrupted by two CW interferers. The Signal to Interference power Ratio (SIR) is -10 dB, and the Signal to Noise power Ratio (SNR) is 2 dB. Pre-FEC BER = 5×10^{-1}.

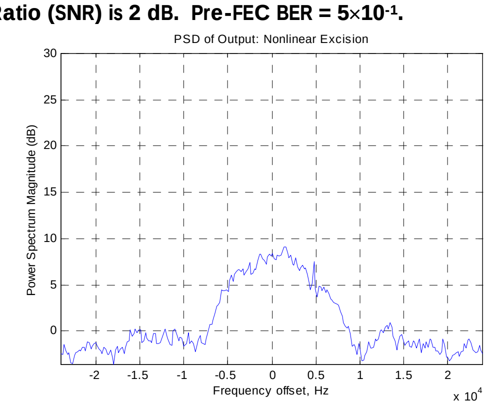

Figure 3 – Power spectrum of the burst following mitigation. The interference has been almost completely removed. Pre-FEC BER = 2×10^{-3}.

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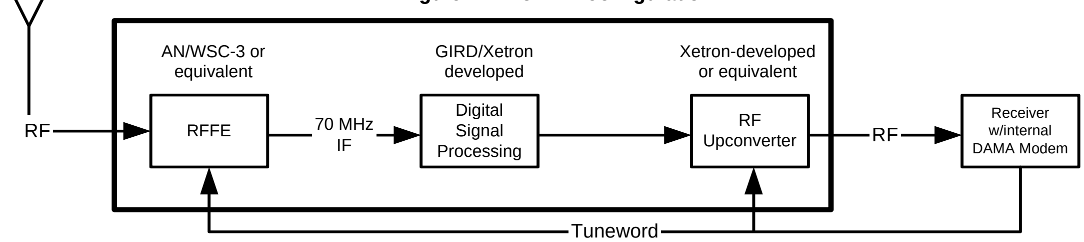
Hardware Mitigation Approach:

At the heart of the Interference Mitigation System lies the digital processor. GIRD's proprietary algorithms use signal processing to achieve improved rejection of the interferer prior to the signal reaching the receiver's carrier tracking and equalization algorithms. In this way, the IMS can offer improved performance relative to post-detection algorithms, which rely on successful carrier acquisition. By utilizing reconfigurable logic to perform the signal processing, the GIRD interference mitigation system will also allow rapid prototyping and evaluation of other interference mitigation algorithms.

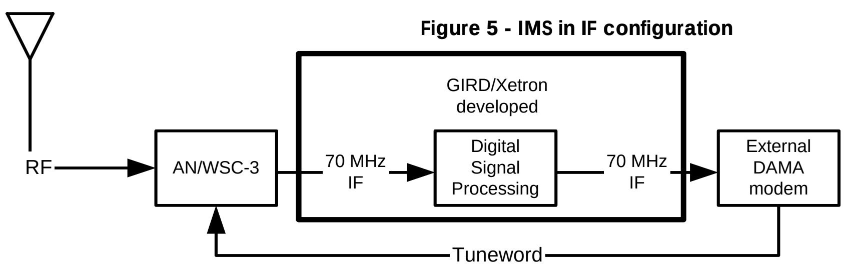
While the ultimate implementation depends upon the target SATCOM radio, normally an RF front end will be used to downconvert to IF. This downconversion can be accomplished with a conventional receiver (i.e. WSC-3), a COTS UHF Receiver, or a custom RFFE. In the prototype hardware platform, a COTS receiver is used in conjunction with custom RF low-noise amplifiers and filters. Following downconversion, the signal is filtered, digitized, and processed so that the sanitized signal (without interference) is regenerated at the output of the digital processor, upconverted to RF and fed into the receiver as shown in Figure 4.

Figure 4 - IMS in RF configuration



Where an IF input to the IMS is directly available, as in the case where an external modem is employed, or can be made available by tapping into the radio circuitry itself, an IF system configuration such as shown in Figure 5 would save the added size, weight, and expense of the RFFE and RF upconverter.

Figure 5 - IMS in IF configuration



A hardware platform for a prototype implementation is shown in Fig. 6 to the right.

Software Mitigation Approach:

Since the mitigation algorithm relies on digital signal processing techniques, the technology is also applicable to software-based radio platforms that can be upgraded to accommodate new processing techniques. The interference mitigation algorithm developed for this program can easily be integrated into most software-defined radio without requiring excessive memory or processor usage.

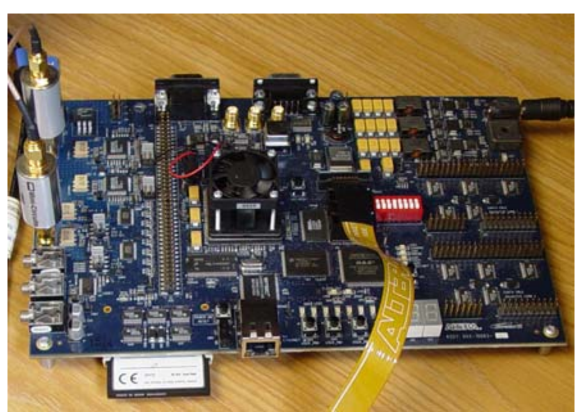


Figure 6 – Hardware platform

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POLE ZERO CORPORATION

ATMOSPHERIC NOISE CANCELLATION FOR LF AND VLF COMMUNICATIONS

Technology in Development:

- NAVAIR Phase I SBIR awarded Feb. 2007
- NAVAIR Phase II SBIR selection takes place Fall 2007

NAVAIR NAVAL AIR SYSTEMS COMMAND

General Description:

GIRD Systems, in collaboration with Pole/Zero Corporation, a subsidiary of Dover Corporation, is developing a novel Interference Mitigation System (IMS) for mitigation of atmospheric impulsive type interference for LF and VLF communications channels. Operating as a stand-alone processor, the IMS can be quickly integrated into virtually any LF/VLF platform.

By exploiting *a priori* knowledge of the nominal Signal-Of-Interest (SOI) as well as interference characteristics, GIRD's signal processing algorithms can better separate the interference and SOI.

The all-digital IMS directly samples the LF/VLF RF signal, and performs digital downconversion to baseband. Following digital signal processing, the sanitized signal is regenerated at the original RF frequency. Therefore the IMS system is completely stand-alone and can be easily plugged-into any existing LF/VLF receiver.

Example Scenario:

Figure 1 illustrates one potential interference scenario. Strong impulsive interference corrupts a BPSK transmission over an LF channel. With interference mitigation, the impulsive noise is largely reduced (Fig. 2).

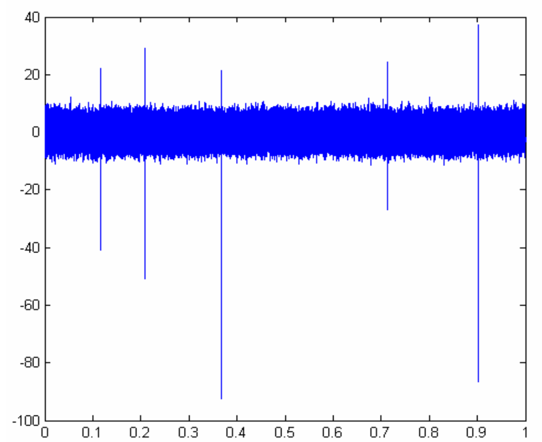

Figure 1 – Impulsive interference often corrupts LF/VLF signals due to lightning of the atmosphere. Shown here are a BPSK signal corrupted by strong impulsive noise.

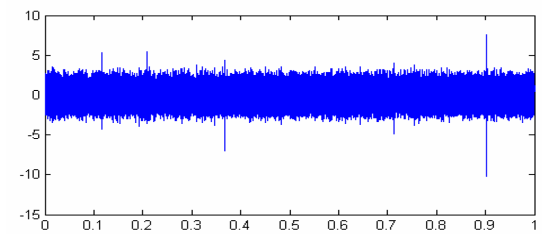

Figure 2 – After GIRD Systems' proprietary mitigation processing, the impulses are largely reduced.

All-Digital Hardware:

Figure 3 illustrates the all-digital approach of the IMS hardware structure for LF/VLF communications applications.

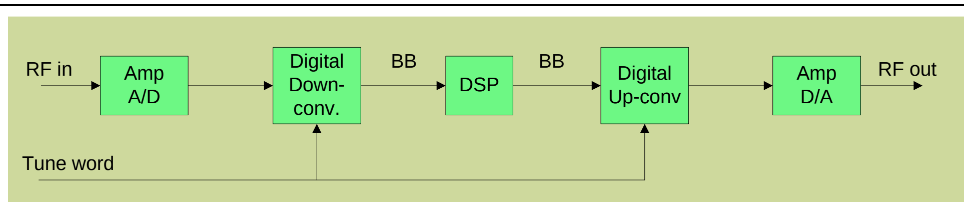

Figure 3 – An all-digital stand-alone system architecture. BB represents baseband frequency.

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GIRD Systems, Inc.

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Array Signal Processing

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POLE ZERO CORPORATION

WIDEBAND INTERFERENCE REJECTING ANTENNA SUBSUSTEM (WIRAS)

Technology in Development:

- Army Phase I SBIR awarded November 2006
- Army Phase II SBIR award selected June 2007
- Real-time demo 18 months into Phase II

General Description:

GIRD Systems, in collaboration with Pole/Zero Corporation, a subsidiary of Dover Corporation, is developing a novel antenna array subsystem for mitigation of strong interference while allowing a sensitive receiver to receive very weak signals.

By using an antenna array and GIRD Systems' proprietary signal processing methods, the subsystem is capable of rejecting strong multiple interference while allowing very weak signals to pass though to a subsequent sensitive receiver simultaneously, provided that the directions of the interferers are different from that of the weak signal source.

Figure 1 – A possible application scenario of WIRAS for an Army convoy. However, WIRAS is also equally applicable to other application scenarios in an interference rich environment or in electronic warfare.

Example Application:

Figure 1 illustrates one potential application – an Army convoy. Strong intentional or unintentional interference, which could be wideband, hampers a sensitive receiver to receive very weak signals of interest. Application of WIRAS mitigates such strong interference and allows the sensitive receiver to receive the very weak signals of interest. Other applications include communications in interference-rich environments, and air, land, or sea based electronic warfare.

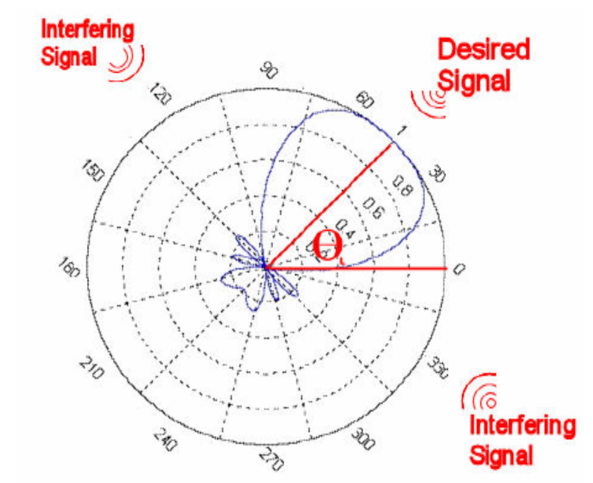

Figure 2 – An antenna array subsystem can maintain receiver gain in a desired direction while rejecting multiple strong interference from other directions.

Principle of Operation:

Figure 2 illustrates the antenna array subsystem's general principle of operation. The multiple antennas and their subsequent signal processing place multiple notches towards the strong interferers, whereas maintains a desired gain in a "look" direction, allowing very weak signals of interest to pass though.

Simulation Example:

Figures 3 to 5 illustrate an example of Phase I simulation results. Shown in Figure 3 is a very weak signal of interest (SOI) that is

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completely submerged in very strong wideband interference without processing. A sensitive receiver is unable to receive the weak SOI. After processing by WIRAS, the weak signal of interest is recovered (Figure 4) so a subsequent receiver can now receive the weak SOI.

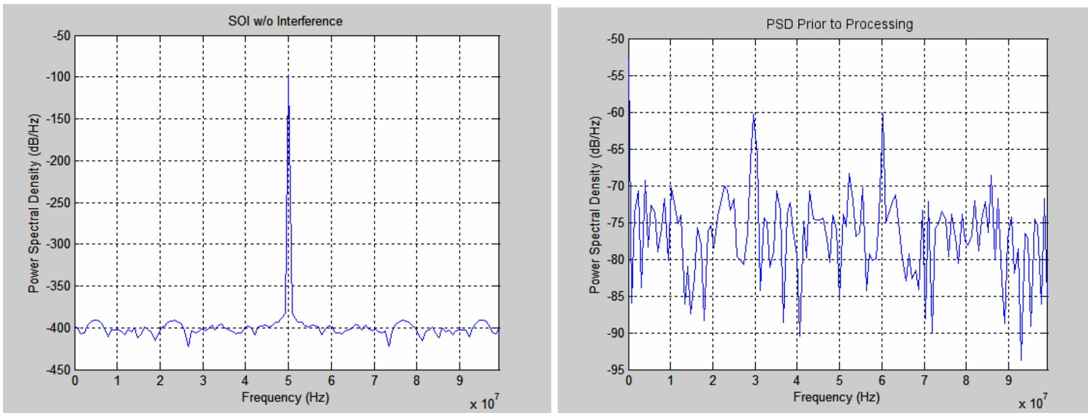

Figure 3 – A simulation example: SOI alone (left) and SOI plus interference (right) before processing. Note the different scales of the two plots – the SOI is completely submerged in the strong interference.

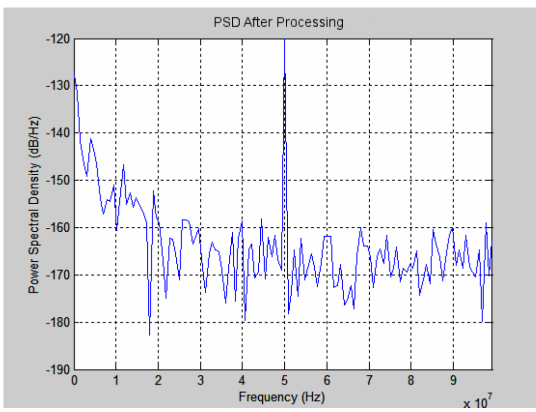

Figure 4 – Simulation example continued: After WIRAS processing, the SOI is recovered from the wideband strong interference of Figure 3 (right).

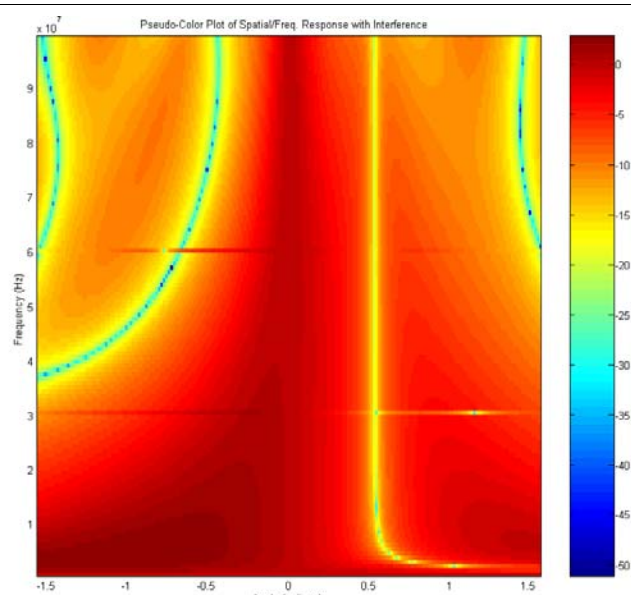

Figure 5 – Pseudo-color plot of spatial-frequency response of the WIRAS mitigation. The gain in the look direction (0 radian) is kept at unity from 0 to 100 MHz, while a wideband interferer at about 0.5 radians with frequency span of 10 – 100 MHz is notched out, also two strong narrowband interferers at - 0.8 radian with center frequency of 60 MHz and 1.15 radian with center frequency of 30 MHz are notched out.

DIRECTIONAL FINDING FOR SOURCES WITH UNKNOWN BW & CENTER FREQ

Technology in Development:

- AFRL Phase I SBIR awarded June 2007

General Description:

GIRD Systems, in collaboration with L-3 Communications Nova Engineering, is developing a novel direction finding technology for direction finding with sources of unknown bandwidths and unknown center frequencies.

The target processing bandwidth that the technology will cover is 400 MHz, which will scan in the frequency range of 500 MHz to 2 GHz. The target sources may fall anywhere within this wide frequency range, and with unknown bandwidths of up to 400 MHz. The challenge is to accurately find directions of such sources.

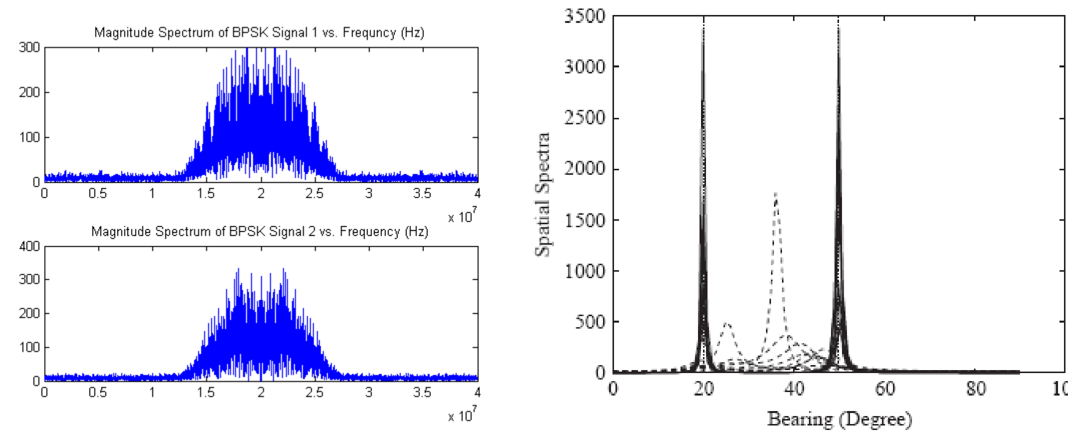

Figure 1 – Left: Overlapping spectra of two wideband BPSK signals, both 10 MHz BW on 20 MHz carriers, coming from 20^0 and 50^0, respectively; Right: Estimated DOA: Solid lines – The proprietary algorithm identifies both signals correctly; Dashed lines – A competing algorithm fails to identify either one.

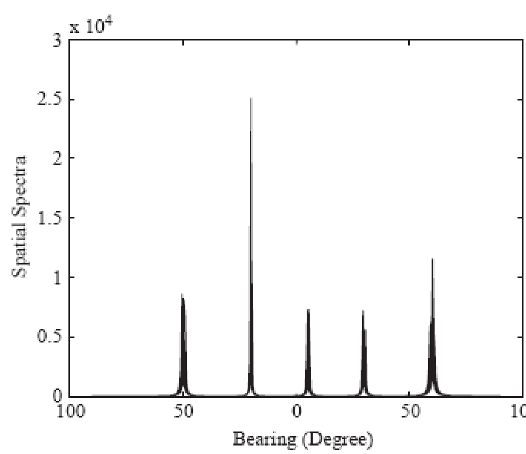

Figure 2 – Five wideband BPSK signals at the same bit rate of 10 MHz, and on carriers of the same frequency 20 MHz, impinge on an array of four elements, from angles -50^0, -20^0, 5^0, 30^0, and 60^0, respectively. SNR is 15 dB. All five signals are correctly estimated as shown.

GIRD Systems has developed a proprietary direction finding algorithm to perform this difficult task. Figure 1 illustrates computer simulations of two wideband sources in the same frequency range but coming from two different directions, and being identified properly by the algorithm. Figure 2 further illustrates that five wideband sources can be properly identified by GIRD Systems' proprietary algorithm with an array of four antennas.

Hardware Implementation:

The challenging task of performing digital processing for a 400 MHz bandwidth with a frequency range of 500 – 2000 MHz is accomplished by the GIRD/Nova team's extensive experience in every aspect of R&D in hardware prototyping, ranging from RF to DSP.

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GIRD Systems, Inc.
Engineering Research and Development

REMOTE CONTROLLED IMPROVISED EXPLOSIVE DEVICE DETECTION IDENTIFICATION & CLASSIFICATION ALGORITHMS (RADICAL)

Technology in Development:

- AFRL Phase I SBIR awarded June 2007

General Description:

Improvised explosive devices (IEDs) are often enabled by consumer-grade electronic devices. Commodity wireless devices have made possible completely decentralized communications among adversaries. At the same time, areas of interest to operators have shifted from jungles and deserts to primarily urban settings, where elevated electronic noise and dense multipath are more the rule than the exception.

GIRD Systems, in collaboration with L-3 Communications Nova Engineering, is developing a SIGINT system solution designed to pinpoint the very weak RF signals that are typical of the unintentional radiated emissions from electronic devices and receivers. Building on Nova and GIRD's successes with the Army's Digital Direction Finding (DDF) and Handheld Emitter Detector (HED) programs, the proposed concept will provide emitter mapping, even in dense urban areas, with a single sensor platform, using a bearings-only target tracking algorithm. The system applies recent developments in array signal processing to overcome the limitations imposed by operating in multipath-rich urban environments. The system design will include hardware and software development aimed at demonstrating a full system prototype in Phase II.

Multipath Mitigation and Source Association:

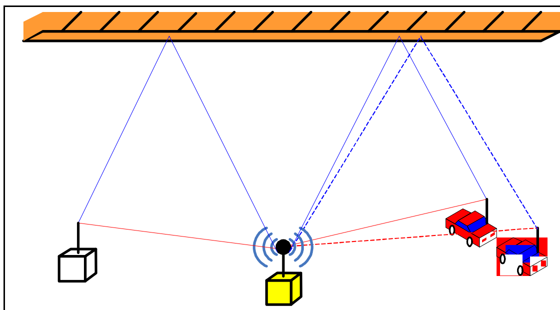

Figure 1: Multipath Mitigation: The LOS and reflected paths of stationary emitter-receiver have fixed lengths. Those of a moving receiver have time-varying lengths that are different for the LOS and reflected paths.

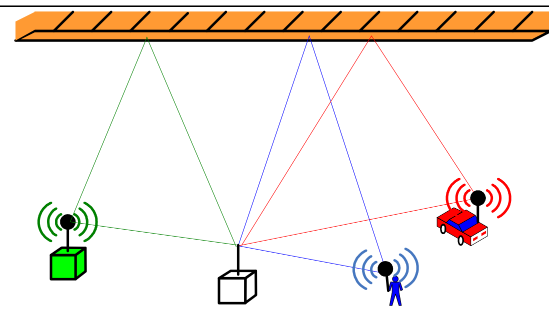

Figure 2: Source Association: All paths of each source need to be associated together, thus identifying the number of sources and the number of paths in each source.

Example Hardware Performance Objectives:

- Emitter localization using a single, vehicular mounted platform
- Operation in urban areas, including rich multipath
- Emitter position fix in three dimensions: Spherical error probable (SEP) < 10 m
- Platform operating velocity: < 60 mph (27 m/s)
- Probability of detection: > 0.9
- Operating frequency range: 20-3,000 MHz
- Minimum signal strength for position fix: -140 dBm
- Position fix improves with increased time on target, degrades gracefully with increased distance to target, reduced signal level, and reduced time on target
- 3 or more simultaneous emitters tracked
- Instantaneous BW_{min} = 20 Hz; BW_{max} = 10 MHz
- Time to first fix < 10 s;
- Low profile antenna sizes: < 3 cm high; Receiver size < 20 cubic inches
- HMI resides on a notebook PC inside vehicle

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Engineering Research and Development

Location & Navigation

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NETWORKED OFDM RANGING SYSTEM (NORS) FOR GPS DENIED NAVIGATION

Technology in Development:

- SPAWAR Phase I SBIR awarded to Nova Eng. July 2005
- SPAWAR Phase II SBIR proposal pending
- Hardware real-time flight demonstration – 2 years into Phase II

SPAWAR Systems Center San Diego

General Description:

GIRD Systems, in collaboration with L-3 Communications Nova Engineering, is developing a novel GPS-denied navigation system called networked OFDM ranging system (NORS).

The weak GPS signals are easily denied, due to shadowing, foliage, or intentional jamming. The NORS allows a ground user to compute its locations when GSP is denied in such situations.

The basic concept of NORS is illustrated in Figure 1, where the aid of a position server (PS) such as a UAV is required. The position server can fly-by or loiter overhead, with access to GPS. It communicates with the ground user through a radio link using an anti-jam OFDM waveform. The ground user derives its own location based on the received signal from the position server. The ground user is completely passive in this process, thus it is LPD/LPI.

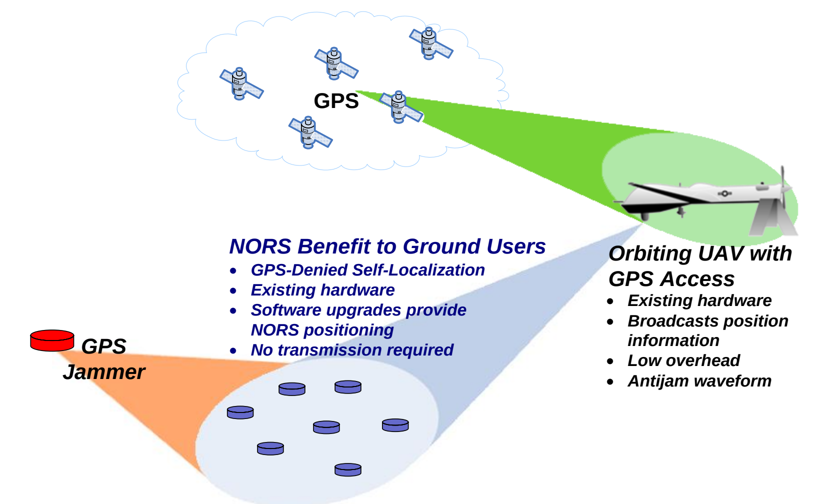

Figure 1 – The NORS concept: While the ground users are denied GPS, a flying UAV still has access to GPS. With an anti-jam communications link from the UAV to the ground users, ground user locations can be computed.

Figure 2 illustrates computer simulations of tracking a single moving ground user. A UAV PS loiters

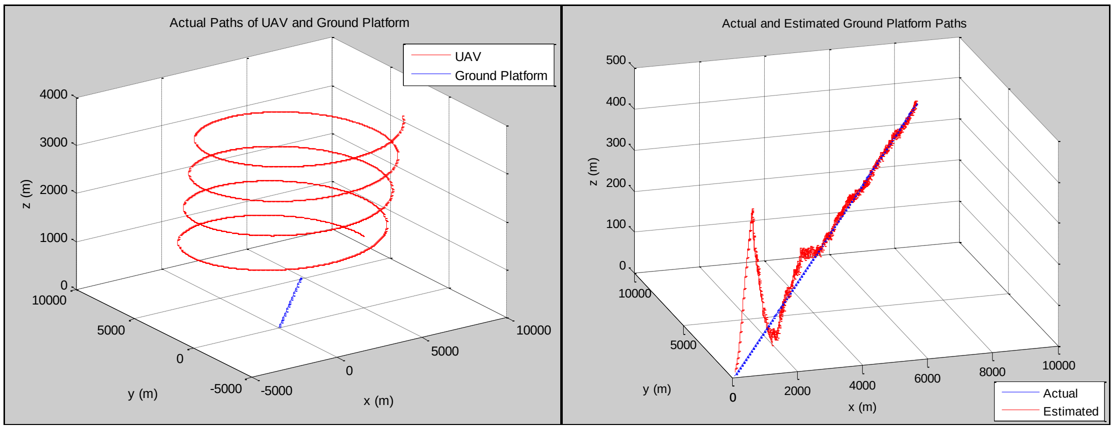

Figure 2 – Simulation results: Actual trajectories of loitering UAV (left, red) and ground user (left, blue). Tracking results on the right: Actual ground user trajectory (right, blue) and tracked trajectory (right, red).

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overhead the ground user, and broadcasts pertinent information. The ground user receives such information, then uses it to track its own locations as shown.

Figure 3 shows a fast moving airplane that flies-by, instead of a loitering UAV. A number of stationary ground users use the broadcast information from the airplane to compute their own locations. It is seen that the location accuracy are mostly within 10 meters.

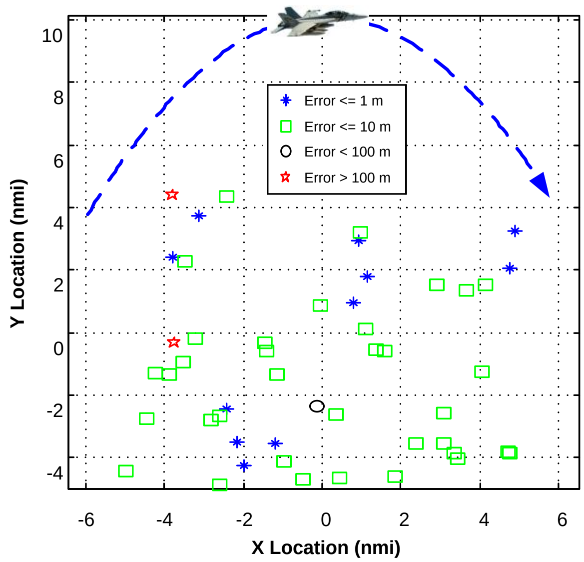

Figure 3 – Even when fast moving positioning servers are only available for a few seconds, most users in this scenario experience localization accuracy to within 10 m.

Hardware Implementation:

The NORS will be implemented in Nova Engineering's multi-band radio. Figure 4 shows the digital board for the radio, a compact board providing the digital processing of the waveform and networking processing. The radio was developed for the UAV environment, its SWAP (size, weight, and power) characteristics meet the requirements and the resources available on a UAV. Of course, the location capability can also be implemented as software upgrade to any existing radio that has extra computational capabilities.

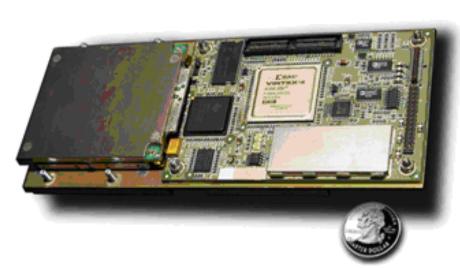

Figure 4 – During Phase II real-time flight demonstration, Nova Engineering's multi-band radio will be used as a radio platform.

Accommodating Other Functions of Position Server:

Since to fly a UAV just for the positioning purpose alone could be expensive, the NORS is designed to fit into an existing airborne PS that is carrying out other missions. The positioning capability becomes an addition to existing airborne platform's multiple missions, and is an enhancement for the ground users. Figure 5 illustrates how the positioning functionality and capability can be tied into the airborne server's other missions.

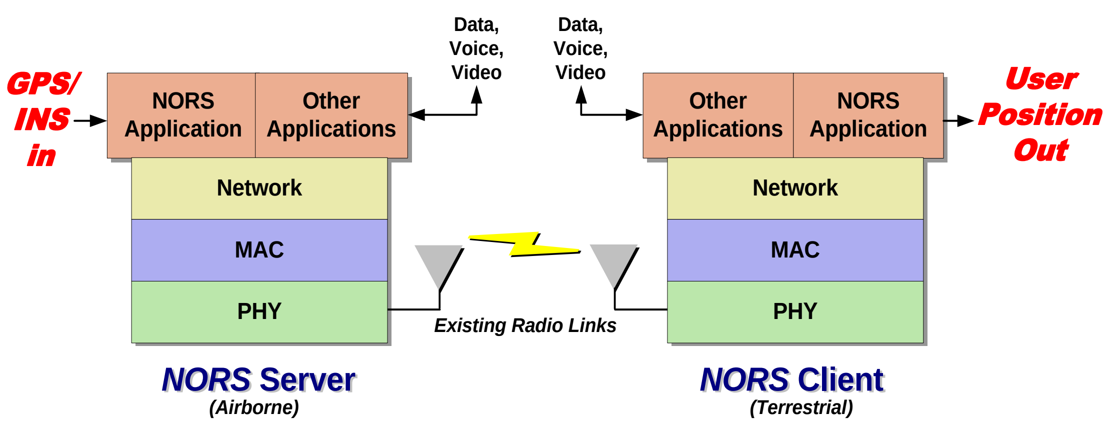

Figure 5 – Positioning as an additional functionality/capability of an existing Server's multiple missions

GIRD Systems, Inc.

Engineering Research and Development

Wireless Network Security

GIRD Systems, Inc.
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ADVANCED RADIO FREQUENCY TECHNOLOGY FOR WIRELESS NETWORK SECURITY

SUNY
THE STATE UNIVERSITY of NEW YORK

Technology in Development:

- AFRL Phase I SBIR awarded April 2007

General Description:

Various forms of wireless information assurance measures have been proposed and implemented, mostly in the data link and network layers, e.g., user names and passwords, MAC addresses, SSL certificates, WEP/WPA keys, etc. The security of these measures comes ultimately from the encryption keys shared *a priori* among the communication parties, which may not be sufficiently secure – encryptions can be cracked, it is only a matter of time and resources.

GIRD Systems, teaming with L-3 Communications Nova Engineering and the State University of New York (SUNY) Binghamton, is developing an innovative physical layer wireless security technology and associated algorithms. This new method is based on the promising near future OFDM-MIMO communications with multiple transmit and receive antennas, and combines two of the latest proposed physical layer security methods that are able to restrict physical access of an intruder into a wireless network. Figure 1 illustrates the basic concept of this new technology. Combined with existing upper layer security measures, this new technology is capable of making a wireless network very secure.

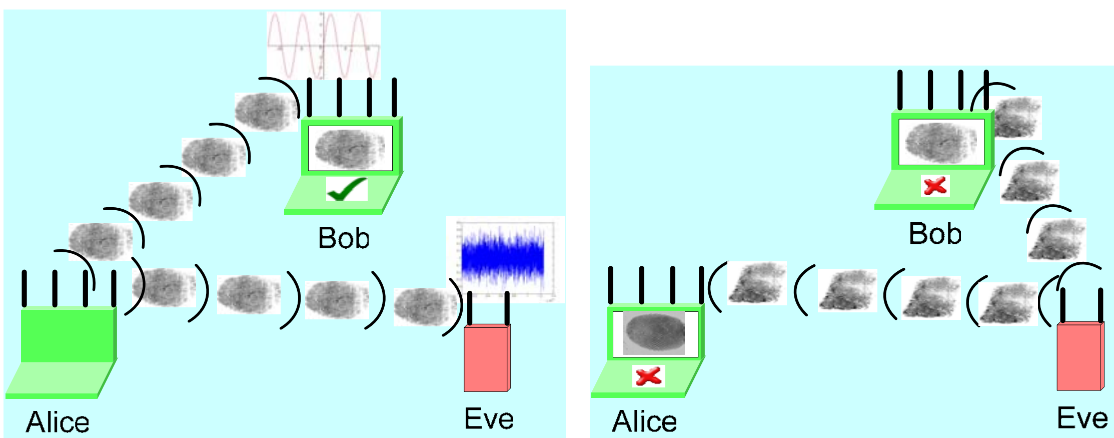

Fig. 1 **– Concept of the physical layer wireless network security. An adversary needs: (a) successful reception, and (b) successful transmission, to intrude into a wireless network by radio links.
The technology under development aims to deny both of these two means, by: (a) Physically denying adversary's passive reception (left) – while intended receiver Bob receives a signal from Alice, which matches Alice's RF fingerprint in Bob's database, eavesdropper Eve will only receive noise; and
(b) Physically denying adversary's active transmission (right) – Eve's transmission does not match any friendly RF fingerprints and is therefore discarded by both Alice and Bob.**

Hardware Implementation:

The hardware implementation of this technology will leverage Nova's commercial product NovaRoam software defined radio (SDR). Nova's OFDM NovaRoam is an existing, proven commercial mobile IP router that provides an OFDM physical layer, MANET routing and full IP protocol stack. The OFDM physical layer used in NovaRoam is based upon Nova's military JTRS WNW OFDM implementation, which is completely in software and is easily modified to include the physical layer network security algorithm implementation.

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