EpiSys Science

Developing Next Generation Cognitive Technologies and Systems for C4ISR Applications

EpiSci

About
Our Company

Founded in 2012, EpiSys Science, Inc. envisioned that future disruptive innovations would be derived from the paradigm of systems science. Through our deep technical expertise in multiple emerging areas, we develop the most innovative systems solutions for defense, intelligence, and commercial applications through an interaction among the following "sciences":

Tactical Artificial Intelligence (Tactical AI)
Wideband Digital Signal Processing (WDSP)
Collaborative Intelligent Radio Networking (CIRN)

We have a tremendous competitive advantage over companies that outsource product components from disparate entities in terms of development time, cost, and payoff. The breadth and depth of our experience is supported by the various R&D and system development projects we have received since our inception. Our *systems science* guiding principle is the key enabler for the successful advancement of our three interdisciplinary products at an accelerated speed with low development costs: **HiReS, SwarmSense, and HAMCOR.**

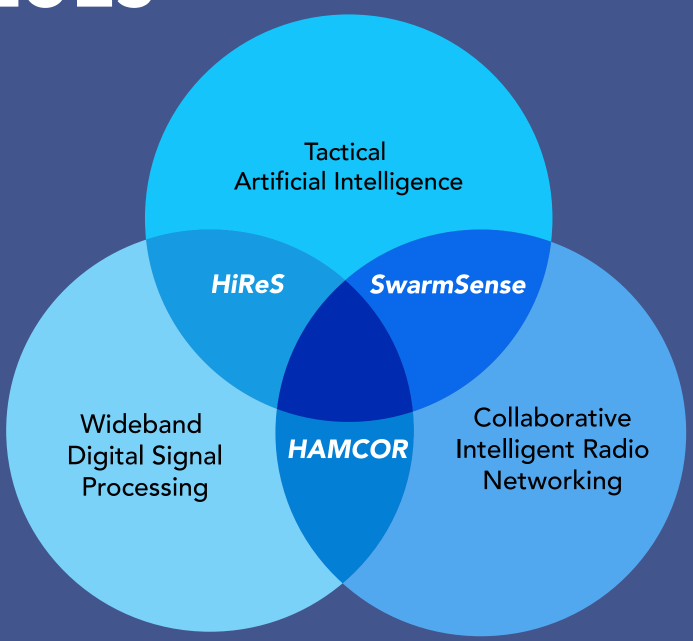
We are actively seeking military transition and commercialization partners for our products designed to address the most pressing problems and challenges of our customers.

VISION, MISSION, & VALUES

Our VISION at EpiSys Science, Inc. is to become a global leader in creating disruptive ***autonomous*** and ***intelligent systems*** founded on the principles of systems science for a wide range of defense and commercial applications.

Through a deep commitment to R&D and culture of innovation, our MISSION is to develop valuable and affordable solutions that exceed our customer expectations.

Our VALUES guide the way we do our work: **Integrity, Teamwork, Excellence, Innovation**.



Core Competencies & Technologies

TACTICAL ARTIFICIAL INTELLIGENCE (Tactical AI)

We anticipate that the use of AI for future tactical systems and applications will only increase over time. Our core AI technology, Surprise Based Learning (SBL), gives autonomous platforms the ability to learn and plan in an unknown environment without any prior knowledge of its actions or their impact on the environment. When combined with deep learning (DL) and reinforcement learning (RL), SBL profoundly improves their benefits for a broad range of tactical applications. SBL is capable of detecting unforeseen or anomalous trends that were not learned by DL or RL during its training phase, and adapting to these trends without un-learning / re-learning. On their own, both DL and RL require massive computing resources (e.g. supercomputer or large amount of cloud computing) whenever a new trend is observed or new data is obtained to update their original system parameters. Un-learning / re-learning requires both the old and new datasets, and thus the need for massive computing resources. Therefore, SBL minimizes or even eliminates the need for the resources originally required for un-learning / re-learning. This makes the combination of SBL, DL, and RL directly applicable to tactical missions when autonomous platforms cannot afford to un-learn / re-learn in real time.

Our breakthrough Tactical AI technology is currently being incorporated into all of our products: **SwarmSense, HiReS,** and **HAMCOR.**

WIDEBAND DIGITAL SIGNAL PROCESSING (WDSP)

The need for Wideband Digital Signal Processing (WDSP) technologies is rapidly growing for many C4ISR systems, along with the explosive advances in high-speed digital component technologies such as reconfigurable RF front-end devices, Analog-to-Digital-Converters (ADCs), Digital Signal Processors (DSPs), Field Programmable Gate Arrays (FPGAs), and Graphical Processor Units (GPUs). It is now common to be able to process several gigahertz (GHz) worth of RF spectrum data in real time over the entire duration of missions. Our innovative WDSP algorithms and systems, optimized for the latest digital components, enable real-time processing of massive amount of digital data for key aspects of Electronics Warfare (EW): RF signal sensing, detection, classification, beamforming, and communication. All of our WDSP innovations seamlessly support the paradigm of multi-function RF system interoperability such as VITA and OpenVPX.

Our WDSP technologies are currently being incorporated into **HiReS** and **HAMCOR**.

COLLABORATIVE INTELLIGENT RADIO NETWORKING (CIRN)

The goal of our Collaborative Intelligent Radio Networking (CIRN) research and development is to enable a rich spectral ecosystem to accommodate a wide variety of communicating devices while operating 100 to 1,000 times more efficiently than today's wireless networks through a new paradigm of collaborative, local, and real-time decision-making. In the military, there is growing reliance on unmanned platforms, from underwater sensors to satellites, and a push for broadband connectivity. However, there is also a growing shortage of RF spectrum. To maximize the RF spectrum, future radios will need to lose their isolation safety net and use greater intelligence to avoid interference. These radios will need to be able to collaborate directly with their peers to derive stable and satisfactory communications for all. Designing a complete CIRN system solution that has a credible path for widespread adoption requires an autonomous yet robust control and monitoring of the entire CIRN network. A practical and rapidly adaptive AI (e.g. Tactical AI) is needed to set several parameters for maximum spectrum sharing and optimal data transfer within a network, possibly in the presence of hostile entities. Each node must make decisions on its own as there is no guarantee of connectivity to a centralized node. Our CIRN solutions seek the maximum spectrum sharing achievable across heterogeneous CIR nodes by virtually eliminating the most common overheads associated with existing dynamic spectrum sharing approaches such as channel rendezvous, collision avoidance, quasi-static frequency division based sharing, separation of environment sensing and communication functions, and retransmission-based error correction.

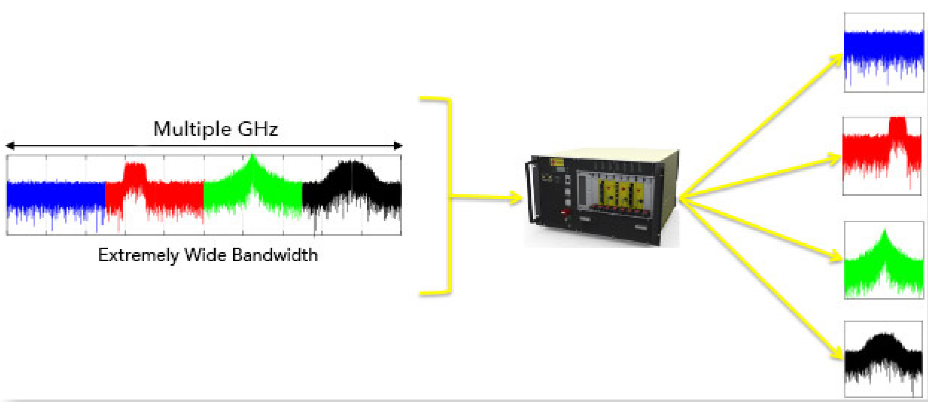
Our first product under development with our latest CIRN innovations is **HAMCOR.**

HiReS: High-Speed, Reconfigurable SIGINT System

Legacy SIGINT solutions are often scanning-based and lack the ability to detect low-power, wideband, and extremely short signals such as radar pulses and covert communication. Most are also built on proprietary hardware and software technologies, making it extremely difficult and costly to achieve timely upgrades.

HiReS overcomes these drawbacks by offering a novel capability to detect, isolate, and classify hard-to-find signals over wideband instantaneous bandwidth without a priori knowledge such as center frequency, signal bandwidth, signal duration, and modulation features. HiReS is being developed under the initiative of OpenVPX-based Multi-Function RF systems where electronic attack, communication, and SIGINT functions can be instantiated using common, interchangeable hardware platforms. HiReS allows warfighters to achieve and maintain a significantly higher level of RF situational awareness thanks to its "constant-stare", low-power signal and radar detection. HiReS has been verified for its functionality, open architecture interoperability, and innovation of the technology.

HiReS enables warfighters to maintain significantly improved RF situational awareness because it: (i) eliminates "scanning"; (ii) estimates signal types and parameters with much higher accuracy; (iii) detects hard-to-find signals such as radar pulses and weak signals; (iv) visualizes both instantaneous and temporal signal behaviors; (v) significantly reduces costs by utilizing COTS products; and (vi) complies with OpenVPX standard for seamless interoperability with emerging multi-function RF systems.



HiReS in a Nutshell

Core Capabilities
- "Constant Stare" over extremely wide bandwidth
- Blind signal detection, isolation, and classification
- Robust estimation of key signal features
- OpenVPX for interoperable and scalable multi-function RF systems

HiReS Fits in OpenVPX 3U/6U Platform

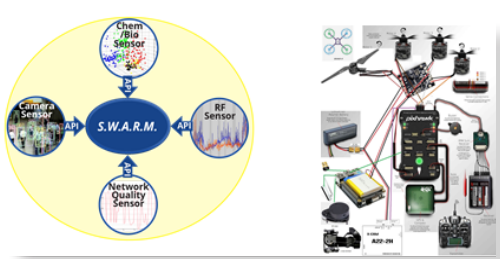
- Drastically reduces size, weight, power, and cost requirements
- Scalable, Modular, and Open standard design for complex missions requiring additional processing capacity

SwarmSense

The term "drone swarm" is increasingly attracting public attention thanks to some eye-popping demonstrations being reported by media outlets such as CBS "60 Minutes". A typical drone swarm system may consist of as few as two drones to as large as over 100 drones. As the number of drones in a swarm system increases, so does the required level of autonomy since no one operator can manually pilot all of the drones. However, this level of autonomy is difficult to achieve and the effective and robust management of the autonomous swarm is significantly hindered in Anti-Access (A2), Area-Denied (AD) and Bandwidth Limited Environments (BLEs).

SwarmSense is a group of autonomous drones that can collectively solve complex missions without manual piloting, while achieving significantly more efficient and scalable solutions for managing multiple heterogeneous airborne nodes in A2, AD, and BLEs. In particular, **SwarmSense** achieves "bounded autonomy" such that a **SwarmSense** operator has precise understanding of how much autonomy is being exerted by individual drones, while providing effective command and control capabilities as needed based on mission dynamics. For example, our bounded autonomy drastically improves the available bandwidth among UAVs and the command and control center, and intelligently enhances collaborative engagement based on feedback from all assets participating in the mission. Our Tactical AI equips **SwarmSense** with its adaptive decision-making abilities while maintaining continuous communication among UAVs during a mission. It enables multiple autonomous air platforms to "self-fly" according to mission objective and real-time on-board sensor data. This approach is novel because our drones can continuously and rapidly adapt to new and unfamiliar situations in real time. Unlike drones that rely on Deep Learning, SwarmSense uses our Tactical AI so that it does not have to re-learn an entire new data set when a new "trend" is manifested.

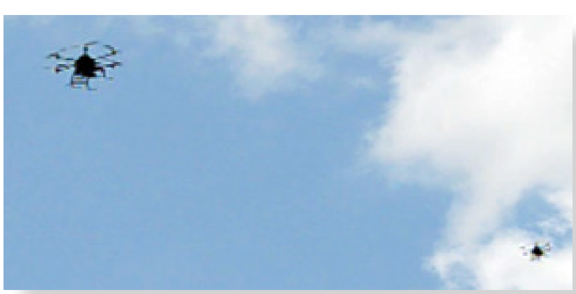
With their strength in numbers, **SwarmSense** can be programmed for any type of mission including tracking enemy fighters, surveillance, jamming enemy communications, and forming wide area communication networks.



Our SBL algorithms are uploaded into our SwarmSense payload.

One of our 2016 SwarmSense prototype designs.

Final SwarmSense design as of March 2017.

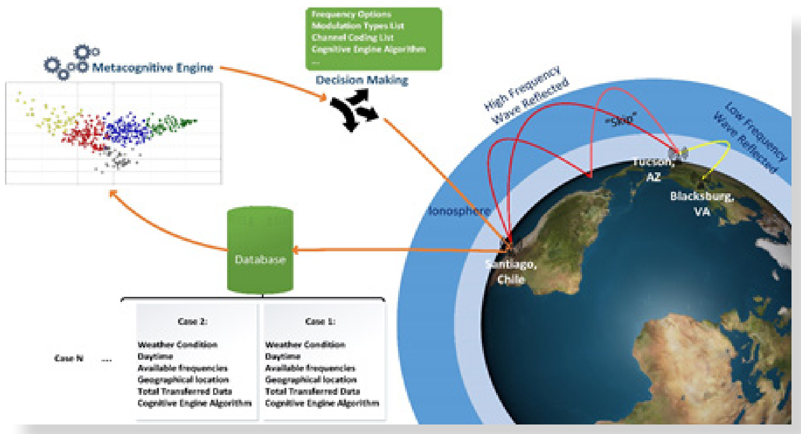


Three node SwarmSense system during early flight tests in summer 2015 at the Air Force Research Lab in Rome, New York.

(Two out of the three drones pictured.)

HAMCOR: High Frequency Meta Cognitive Radios

High Frequency (HF) tactical radios offer tremendous benefits to warfighters due to their long-range communication capability when aided by favorable ionospheric conditions. However, this benefit is significantly hampered by lack of "dependability", i.e. whether the link can be established or not, and how long the link will remain alive even if established. Consequently, the instability drastically outweighs the benefits of HF, because there is no assurance that warfighters can establish critical communication on demand, thus limiting the use of HF radios for critical battlefield situations. Another significant challenge for existing HF tactical radios is that they cannot establish a communication link without pre-planned frequency planning, even if they all support multi-band modes.



HAMCOR is an adaptive multi-band HF tactical radio adopting the Software Defined Radio (SDR) paradigm. Scheduled to be available during the 1Q of 2019, HAMCOR will have "dependability", "sustainability", and "predictability" required for most pressing missions across the globe with the following features that are not available in the existing HF tactical radio products:

- Automatically finds the frequency band that is reliable for communication with its counterpart located thousands of kilometers away across the entire 3 – 30 MHz HF frequency range.
- Automatically switches to the new frequency band without disrupting the ongoing communication product. Again, no existing HF tactical radio provides such capability.
- Automatically adjusts its communication parameters to sustain the communication while maximizing the link capacity through its cognitive engine under widely varying channel conditions.
- Automatically tunes its advanced low-profile antenna matching circuit to the selected HF band.
- Automatically finds the "relay" node(s) if the direct communication becomes not possible due to the challenging ionospheric channel condition.

No existing HF tactical radio is capable of offering dependability (on demand communication without a priori frequency planning), sustainability (via frequency agility and adaptive communication link), and predictability (which HF channel is likely to be available when and where for how long with what channel properties). Consequently, warfighters are no longer at the mercy of the capricious ionospheric channel conditions. Rather than using their radios opportunistically, more and more warfighters will be able to use them when and where they want it, in order to transmit and receive mission-critical information anywhere in the world without relying on expensive relay assets such as satellites or unmanned airborne assets. Our HAMCOR radios will be able to offer a complete tetherless low-data-rate links anywhere in the world thanks to their dependability, sustainability, and predictability.

Meet

Our Founding Team

DR. BO RYU, President: Over the last two decades, Dr. Ryu has accumulated a wealth of successful experiences on high-risk, high-payoff R&D programs sponsored by DARPA, ONR, AFRL, and various Department of Defense agencies. Prior to founding EpiSys Science, Inc., he served various technical positions responsible for spearheading advanced research projects, pursuing new government programs, and performing various government and industry-sponsored projects in the area of self-organizing wireless networking systems. He has authored and coauthored more than 40 publications, and holds thirteen U.S. patents. He received two performance awards for his technical achievements on DARPA's Adaptive C4ISR Node program, and is a recipient of a Meritorious Award from Raytheon in 2001 for technical performance recognition. He received his Ph.D. from Columbia University.

DR. TAMAL BOSE, Vice President: Dr. Bose is the department head and professor of the Electrical and Computer Engineering Department at the University of Arizona, Tucson. He is also the national director of the NSF sponsored multi-university multi-industry wireless research center called Broadband Wireless and Applications Center. Dr. Bose is well known for his research in signal classification for cognitive radios, channel equalization, adaptive filtering algorithms, and nonlinear effects in digital filters. He has authored or co-authored over 60 journal papers and 100 conference papers. He is an IEEE EAC ABET program evaluator and a member of the DSP Technical Committee for the IEEE Circuits and Systems society. He received his Ph.D. from Southern Illinois University.

DR. WEI-MIN SHEN, Vice President: Dr. Shen is the Director of Polymorphic Robotics Laboratory, the Associate Director of the Center for Robotics and Embedded Systems, and a Research Associate Professor in Computer Science at University of Southern California and Information Sciences Institute. His current research interests include self-reconfigurable and metamorphic systems, autonomous robots, machine learning, artificial intelligence, and life science. He is the PI for the SuperBot project, a project for developing a self-reconfigurable and self-healing robotic system for space applications. He is the primary inventor of hormone-inspired distributed and decentralized control for self-reconfigurable systems such as SwarmSense. His research activities have been reported by leading scientific journals and CNN, PBS, BBC, Fox, and Discovery. He received his Ph.D. under Nobel Laureate Professor Herbert A. Simon from Carnegie Mellon University.

DR. NADEESHA RANASINGHE, Director: Dr. Ranasinghe is the primary inventor of SwarmSense, a fully autonomous drone swarm system that solves complex C4ISR missions without manual piloting. He specializes in autonomous robots and AI systems. He and Dr. Shen are the inventors of the Surprise-Based Learning algorithm, which is capable of autonomously detecting and adapting to unpredicted changes in robots, drones, and agents. He received his Ph.D. in computer science from the University of Southern California, Los Angeles in 2012.

EpiSys Science, Inc.

EpiSys Science, Inc. is a Department of Defense and NASA SBIR company. Since 2012, we have been successfully carrying out high-risk, high-payoff research and development (R&D) efforts to unlock technology breakthroughs for a wide range of C4ISR systems and applications. Through our deep technical expertise in multiple emerging areas, we develop the most innovative solutions for defense, intelligence, and commercial applications through an interaction between the following "sciences": Tactical Artificial Intelligence (Tactical AI), Wideband Digital Signal Processing (WDSP), and Collaborative Intelligent Radio Networking (CIRN).

Existing Relationships

Customers:
- Office of Naval Research (ONR)
- Defense Advanced Research Projects Agency (DARPA)
- Missile Defense Agency (MDA)
- Air Force Research Lab (AFRL)
- US Space and Naval Warfare Systems Command (SPAWAR)
- The Boeing Company
- Raytheon

Partners:
- University of Arizona
- University of Southern California
- Drogen (Korean drone manufacturer)

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