

White Paper for Ground-Based C-sUAS Capability for Low Collateral Effects

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OVERVIEW

This white paper addresses the RFI issued by the Joint C-sUAS Office (JCO) seeking information regarding current capabilities of ground-based C-sUAS for low-collateral effects. Described herein are five IXI products – the DRONEKILLER®, HERMES, HYDRA, MINERVA, and I-DK. Each of these systems has “zero to low” collateral effect on personnel, buildings, property, and electronic systems in all environments. Each system is designed around a common core of 6-8 software-defined radios (SDRs). Each system affects all Class 1 and 2 sUAS, causing them to return to the operator, hover in place, or slowly descend to the ground. Table 1 is an overview of each system.

| IXI EW Product | Readiness | Configuration | Directivity | Weight | Power |
|----------------|-----------|---------------|-------------|---------------|--------------|
| DRONEKILLER® | TRL 8 | Handheld | 30° cone | 9 lbs | 90 min. batt |
| HERMES | TRL 7 | Mast/Veh. | 360° area | 70 lbs + mast | external |
| HYDRA | TRL 7 | Mast/Veh. | 120° sector | 70 lbs + mast | external |
| MINERVA | TRL 6 | Turret | 30° cone | 30 lbs | external |
| I-DK | TRL 5 | Handheld | 30° cone | 3 lbs | 30 min. batt |

Table: 1 Systems Overview

CAPABILITIES

Each of the systems described herein defeats small sUAS (Group 1/2 sUAS) operating in altitudes of less than 3,500 feet.

The IXI DRONEKILLER® is a hand-held, directional C-sUAS software defined radio (SDR) system that detects and interdicts Class 1 and 2 sUASs. The DRONEKILLER® interdiction range is up to 1,000 meters. DRONEKILLER® has been procured by the US military and international forces.

The IXI HERMES is a mast-mounted, omni-directional C-sUAS software defined radio (SDR) system that interdicts Class 1 and 2 sUASs at a distance of up to 5,000 meters. HERMES is currently designed into C-sUAS systems to be provided to US and international forces.

The IXI HYDRA is a mast-mounted, directional C-sUAS software defined radio (SDR) system that interdicts Class 1 and 2 sUASs at a distance of up to 5,000 meters. HYDRA is currently designed into C-sUAS systems to be provided to US and international forces.

Note: The IXI HERMES and HYDRA use the same electronics and software, each using different antenna arrays for the field of effect.

The IXI MINERVA is a turret-mounted C-sUAS software defined radio (SDR) system that interdicts Class 1 and 2 sUASs at a distance of up to 5,000 meters. MINERVA is currently designed into C-sUAS systems to be provided to the US military and international forces.

The IXI I-DK is an I-Rail® (Intelligent Rail) mounted, directional C-sUAS software defined radio (SDR) system that interdicts Class 1 and 2 sUASs at a distance of up to 1,000 meters. The I-rail will be fielded on the US Army Next Generation Squad Weapon. The I-DK has been selected for evaluation at the NATO C-sUAS event scheduled in Sept. 2021 in Sardinia, Italy.



Figure 1: DRONEKILLER® at Pendleton U5G, HERMES, HYDRA, MINERVA, and I-DK systems.

Engagement Capability

Each system defeats Class 1 and 2 commercial sUAS, including SWARMS, without destroying the sUAS, and causes no collateral damage to personnel, buildings, or property. Furthermore, these systems cause no damage to electronic systems and have minimal interference with military communication and navigation systems.

The effective range of each system is generally not affected by the operating environment relative to geography, density of buildings or people, or atmospheric conditions. Each system is only limited by LOS transmission coverage area.

Ease of Integration

Each IXI system is designed to integrate readily with other sensing and targeting systems, including radars, optics, acoustics, as well as kinetic effectors. IXI systems have simple hardware and software interfaces and remote triggering capability through USB (or I-Rail® for the I-DK).

Systems Support Requirements

The DRONEKILLER® is a self-contained unit requiring no support requirements. The HERMES, HYDRA, and MINERVA require external power and the connection of cables between units and antennas. The I-DK is a self-contained unit requiring no support requirements.

Zero to Low Collateral Effects

Each system has the same effect on Class 1 and 2 sUASs within their radiation patterns. In most cases, the sUAS will hover in place, slowly descend, or return toward the operator. sUAS speed, angle, and altitude are not significant factors in defeating the sUAS. Because of how these systems affect a sUAS, there is no collateral damage caused to personnel, buildings, or property. The unique features of these systems are the primary reason several authorized law enforcement agencies have adopted the use of these system in urban environments.

A low collateral effect may occur when defeating unsophisticated, <\$100 remote-control toy sUASs. These sUASs may lose flight control and fall to the ground. These toys are very light; therefore, the collateral damage risk is low.

RECOMMENDATIONS

Unique Features

A unique feature of these systems are they are not barrage jammers that cause sUASs to crash. They transmit sophisticated signals, which are processed by the sUAS along with received C2 signals. The processing of both signals confuses the sUAS, causing it to go into failsafe mode. A sUAS in failsafe mode will slowly descend, return to the operator, or hover in place.

The second unique feature is that the sUAS flight log is unaffected. If the sUAS is captured, all flight log data can be reviewed, detailing all prior sUAS activity, and providing critical information to military and law enforcement. See Figure 2 Below.

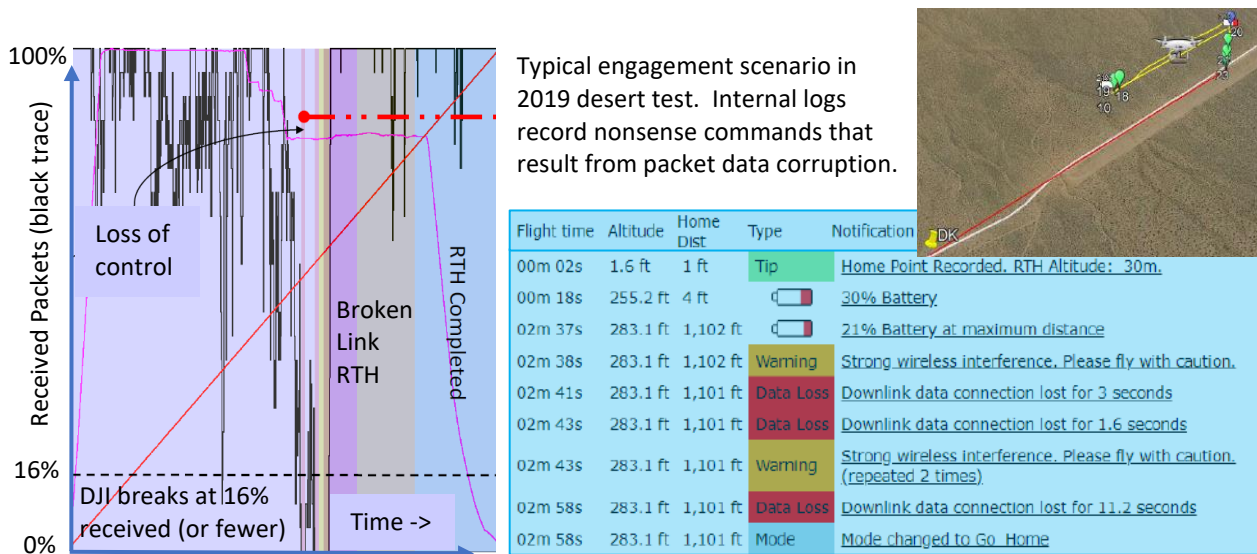


Figure 2: Recorded Flight Log Data with Google Earth flight map overlay.

A third unique feature is these systems dedicate two SDRs to low fast-hopping background channel data. The significance of this feature is a sUAS and controller will continuously attempt to reconnect when signals are disrupted by looking for open channels. For example, data links using Lightbridge, Occusync, and Wi-Fi detect momentarily empty channels and reconfigure to these channels. When the sUAS and ground station re-connect in the new channel, the IXI systems are already transmitting signals in that channel, so the sUAS radio must move again, wasting critical time and data opportunity.

A fourth unique feature is these systems increase background noise received by the sUAS. This causes wideband connections to be rejected by sUAS radios in exchange for higher-power narrowband links to maintain signal-to-noise ratio. This reduction in bandwidth improves the effectiveness of the IXI systems SDRs targeting the data link. This allows the IXI systems to have an extremely long range for their size and power output; correlating to improved SWaP and reduced collateral spectral impact. The low radiated EIRP has a zero to minimal effect on electronic systems in their areas of effect, and directional systems have negligible impact on spectrum users (e.g., Wi-Fi) off the angle of attack. See Table 2 below.

| IXI EW Product | UHF | | GNSS* | | | ISM/UNII | | |
|----------------|-------|-------|----------|----------|----------|----------|-------|-------|
| | 433 M | 915 M | L1/E1/G1 | L2/E6/G2 | L5/E5/G3 | 2.4 G | 5.2 G | 5.8 G |
| DRONEKILLER® | 31 | 32 | 23 | 19 | 19 | 36 | 28 | 34 |
| I-DK | No | No | 24 | 21 | 21 | 37 | 30 | 36 |
| MINERVA | No | No | 36 | 33 | 33 | 50 | 40 | 49 |
| HERMES | 42 | 42 | 45 | 43 | 43 | 49 | 42 | 47 |
| HYDRA | 46 | 46 | 48 | 46 | 46 | 52 | 45 | 51 |

*GNSS waveforms counter civilian GPS as well as global GLONASS, Galileo, and Beidou.

Table 2: Frequency Bands and Nominal Radiated EIRP (in dBm).

A fifth unique feature is these systems exploit sUAS radios recognize data packet loss and corrupt commands, and request new data repeatedly. The repeated loss of C2 and telemetry feedback triggers a “C2 lost” condition, and the sUAS enters failsafe mode.

A sixth unique feature is these systems use of 6-8 simultaneously operating field-programmable SDRs in each system. Besides efficacy improvements and swarm-defense afforded by multiple independent transmitters, the SDRs have different antennas in a compact array to resist fading and RF environment effects.

A seventh unique feature of IXI systems is they all have a common core of forward-compatible SDRs that are field-programmable for updating waveforms to counter new sUAS released to the market.

Understanding of the Operating Environment

IXI EW has a deep understanding of the operating environment; IXI has systems deployed world-wide. IXI systems are ground-based, underwater, on the water surface, and airborne. IXI’s C-sUAS systems are in use by authorized Department of Justice Agencies for counter-terrorism activities, public safety, and infrastructure protection. The DRONEKILLER® is publicly fielded by the U.S. Air Force, Los Angeles County Sheriff’s Department, Las Vegas Fire & Rescue Bomb Squad, multiple U.S. allies, and other LEO and Federal agencies with appropriate authority.

IXI is in constant contact with customers in military and defense, government agencies and law enforcement to stay informed on operational needs and requirements. IXI customers have expressed needs for:

1. The ability to operate within densely populated areas; competing “protocol-based” RF effectors typically struggle in the presence of non-threat RF signals.
2. The ability to accept field-upgrades as new threats emerge; early systems deployed in Iraq operations, for example, reportedly lost efficacy within a year of deployment.
3. Integration with co-located/remote sensing assets, e.g., “system of systems” to maximize available time for deployment of C-sUAS resources at increased standoff.
4. Defeat capabilities for autonomous or semi-autonomous sUAS traveling by waypoint, especially if using video terrain mapping and object tracking technologies.

MANPOWER

DRONEKILLER® and I-DK units are hand carried, require no installation, and are fully operational within seconds. The entire sequence of action is to press the “power on” button, aim at a target, and pull the trigger. No maintenance is required. HERMES, HYDRA and MINERVA require less than one hour for two persons to install on a tripod, mast, or turret. Sentry View UMDBs are deployed to USAF Minuteman sites and can automatically aim and trigger MINERVAs without user intervention. Maintenance is minimal.

PRODUCTION CAPACITY

IXI is AS9100D & ISO 9000:2015 certified with a 40,000 ft² design and production facility in Yorba Linda, CA. IXI supports 50+ products with audited MRP and quality systems including compliance with RFP Section C.9 (NISPOM and NSWCDD Command Security Manual) and DSS requirements. The DRONEKILLER® is in production, and HERMES, HYDRA, and MINERVA are in production readiness review. I-DK is scheduled for production 15 MAR 2022.

| Product | Production Start | Qty 10 | | Qty 50 | | Qty 100 | | Qty 250 | |
|--------------|------------------|--------|---------|--------|---------|---------|---------|---------|--------|
| | | Deliv. | \$ROM | Deliv. | \$ROM | Deliv. | \$ROM | Deliv. | \$ROM |
| Dronekiller® | In Production | 8 wk | \$32.5k | 12 wk | \$32.5k | 14 wk | \$32.5k | 16 wk | \$30k |
| Hermes | 17 May 2021 | 12 wk | \$125k | 14 wk | \$125k | 16 wk | \$120k | 16 wk | \$115k |
| Hydra | 17 May 2021 | 12 wk | \$135k | 14 wk | \$130k | 16 wk | \$125k | 16 wk | \$120k |
| Minerva | 30 Jun 2021 | 10 wk | \$68.5k | 12 wk | \$68.5k | 16 wk | \$68.5k | 16 wk | \$65k |
| I-DK | 15 Mar 2022 | 8 wk | \$29.5k | 12 wk | \$29k | 14 wk | \$28k | 16 wk | \$27k |

Table 3: Lead Times and Pricing for IXI products (Lead after PO/Production Start).

COMPANY HISTORY

IXI provides military forces worldwide with reliable COTS C5ISR tactical data products for 37 years with more than 90% of its revenues from the Defense sector. IXI deployments include U.S. Navy destroyers, cruisers, carriers, and ground stations as well as U.S. Coast Guard and allied navies. IXI products are even found in Army AN/TPQ-36 Firefinders still in service after 35 years. Reviewers are encouraged to contact IXI references regarding reliability and cost-effectiveness:

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| Customer | Contract Number | Award/Ceiling | Program |
|---------------------|------------------|---------------|------------------------------|
| US Air Force | FA5422-20-Q-7111 | \$70,528 | Drone Jamming Guns |
| NSWC Dahlgren | N00178-15-D-2017 | \$11,500,000 | Aegis Weapons System |
| NSWC Port Hueneme | N63394-16-P-0216 | \$2,616,268 | MK-92 Fire Control System |
| NSWC Port Hueneme | N63394-09-P-1193 | \$2,454,183 | USCG MK-92 Fire Control |
| NAWC Patuxent River | N00421-08-D-0033 | \$2,268,770 | AN/UPX-24 (IFF) & AN/UPX-29 |
| NSWC Crane | N00164-15-D-WM59 | \$1,998,500 | AN/SLQ-32(V)6 Shipboard EW |
| NSWC Port Hueneme | N63394-19-P-0120 | \$1,631,000 | MK-41 Vertical Launch System |
| NSWC Port Hueneme | N63394-14-P-0230 | \$1,119,720 | Aegis ORTS |

Table 4: DOD Contracts

COMPANY INFORMATION

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IXI is a Service-Disabled Veteran-Owned Small Business (SDVOSB) but not a Traditional Defense Contractor, as it has not submitted proposals subject to full coverage under the cost accounting standards prescribed pursuant to section 1502 of title 41 and the regulations implementing such section. The described approaches have not been funded by any Federal agency.