CRFS

# RFeye DroneDefense

Adaptive 3-dimensional counter UAS &
operator detection, geolocation and alert

RFeye DroneDefense

RF Multi-Target, Multi-Mission drone & operator detection solutions

# THE UAS UAV DRONE THREAT VECTOR

## The technical challenge:

**Small** – Low visual and radar cross section
**Manoeuvrable** – Flight path can be erratic
**Low flying**– Can easily disappear into clutter
**Inexpensive and widely available** – Easy to buy and within the means of many people
**Easy to operate** - Quick to launch; requires minimal training
**Increasingly capable** - Ever greater capacity and endurance for battery and propulsion technologies
**Swarms** – Can overwhelm defense systems

## Public Security

Threat targets:

**Disruption and fear**
**Panic, unrest and violence**
**Distraction attack**

## Military Security

Threat targets:

**Ground & flight traffic disruption**
**Target designation**
**Signal spoofing**
**Operational interference/jamming**
**Intelligence gathering**
**Wardriving/penetration testing**

## Critical National Infrastructure

Threat targets:

**National & state-level disruption**
**Economic & diplomatic instability**
**Operational disruption**
**Intelligence gathering**
**Wardriving/penetration testing**

## Battlespace

Threat targets:

**C4ISR disruption**
**C5ISTAR provision/ground support**
**Kinetic targeting**
**Signal spoofing**
**Operational interference/jamming**
**Intelligence gathering**

# The RFeye DroneDefense threat response

RFeye DroneDefense is a passive RF sensing system that geolocates drone & operator emissions in 3 dimensions: latitude, longitude and altitude. The system can track multiple drones simultaneously and alert operational/security staff to their confirmed presence and location, all in real time.

The RFeye®DroneDefense system was developed from a wide area 'air defense' technology that employs a geolocation technique called 3DTDOA. This technique draws upon a military-tested and field-proven methodology called TDOA.

The system uses four or more ground sensors or 'RFeye Nodes' to cover a wide swath of RF spectrum. This means the system not only covers conventional drone threats, but also more advanced custom systems.

RFeye Drone draws upon the power of an autonomous software platform to monitor airspace, identify threats and alert users.

## What does it do?

RFeye DroneDefense uses ultra-sensitive RF receivers to collect and process the signals created by both a drone operator and the drone itself. These receivers cover a very wide section of the RF spectrum, and scan from 9 kHz up to 18 GHz, sweeping many times per second. This does not just allow you to detect common drone systems, but enables you to also detect threats that use custom transceivers.

Signal detection takes place in real-time to deliver pinpoint accuracy. Once a signal has been detected, all four receivers compare the time reception with nanosecond accuracy to determine the point in space from which the signal originated.

| Countermeasure/Exploits | RF | Radar | Electro-Optical |
|---|---|---|---|
| Blind Flight - 100% Autonomy | ✗ | ✓ | ✓ |
| Small size/low cross section | ✓ | ✗ | ✗ |
| Take off & landing location | ✓ | ✗ | ✗ |
| Camouflage/coating | ✓ | ✗ | ✗ |
| Poor line of sight - Buildings/trees | ✓ | ✗ | ✗ |
| Low altitude | ✓ | ✗ | ⊗ |
| Jamming | ✓ | ✗ | ✓ |
| Multi target/swarms | ✓ | ✓ | ✗ |
| Stealth design | ✓ | ✗ | ✓ |
| Awaiting take-off/Pre-flight | ✓ | ✗ | ✗ |
| **Special Features:** | | | |
| Operator location | ✓ | ✗ | ⊗ |
| Technical type determination | ✓ | ✗ | ✗ |
| Jammer targeting | ✓ | ✗ | ✗ |
| Bird differentiation - native | ✓ | ✗ | ✗ |
| Native 360 deg coverage | ✓ | ✗ | ✗ |

## The RFeye DroneDefense advantage

While media coverage around the drone issue has resulted in many new vendors and systems to counter the drone threat, RFeye DroneDefense consistently outperforms other drone detection systems in the field including radar, electro-optical and passive RF systems from other vendors.

## RF detection

Radio signals are agile. They naturally spread to find routes around objects, which is why drones use RF for their command protocols. RFeye Drone excels at geolocating these emissions, whether on the ground or in the air, regardless of drone design. Unlike radar systems, it naturally distinguishes between electrical and organic objects, and is the only system designed to geolocate an operator.

## Radar

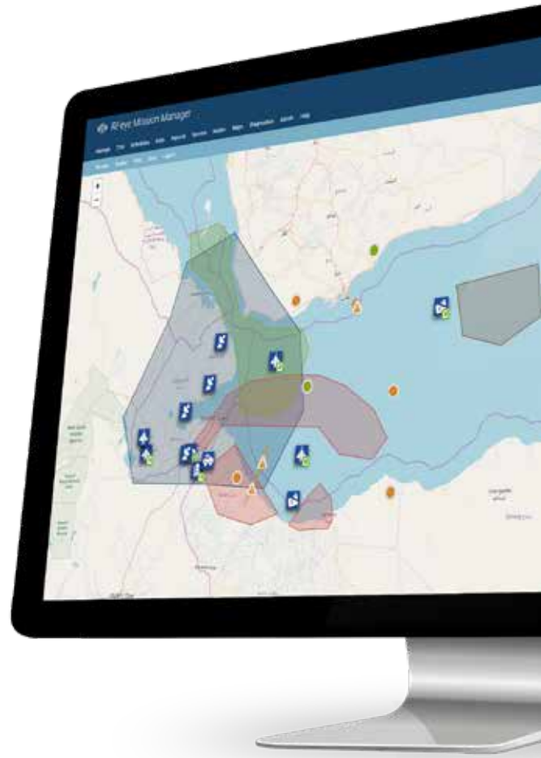
Radar has a long, illustrious history in identifying aircraft. Modern holographic systems cope well with smaller devices such as drones. Radar has drawbacks in terms of cost, "false alarms" for birds and line-of-sight requirements, we recommend it as a secondary layer working alongside RF drone detection systems where feasible.

## Electro-Optical

Optical systems extend our own senses using superior optics and image enhancement. They still need additional hardware to perform geolocation, and these systems have difficulty coping with multiple threats. Optical systems do, however, give an unrivaled understanding of context during an active mission.

# RFeye DroneDefense in use

The RFeye® DroneDefense system delivers actionable intelligence to operational staff, including detection latitude, longitude and altitude and the control/telemetry frequencies used in flight. By confirming target presence and location, you can then precisely prosecute/take-down using 3rd-party countermeasures.




The software suite that accompanies RFeye DroneDefense is designed for use by two user types: operational and expert. The operational suite automates all aspects of the detection schedule to deliver precise data on approaching threats, while the expert platform allows a user to look in detail at the signal emissions for live prosecution and post-analysis as needed.

## No library needed: Wideband, live threat discovery

RFeye DroneDefense is different to other RF detection systems. It is not reliant upon an existing threat library, but instead looks at all energy emissions across a very wide band of RF spectrum. By auditing and understanding its environment, the system can differentiate between typical and atypical energy sources. That's not to say that RFeye Drone does not support signal classification. It can still characterize and identify newly detected threats to help build a historical picture of adversary attack vectors. Additionally, the system allows you to white-list known signals, e.g., friendly aircraft.

## Geofences and exclusion zones

Geofences and exclusion zones can be easily assigned within both operational and expert interfaces. These zones can be assigned in 3 dimensions, allowing you to manage specific airspace in and around your area of interest. There are no physical limits to the number of such zones you can create.

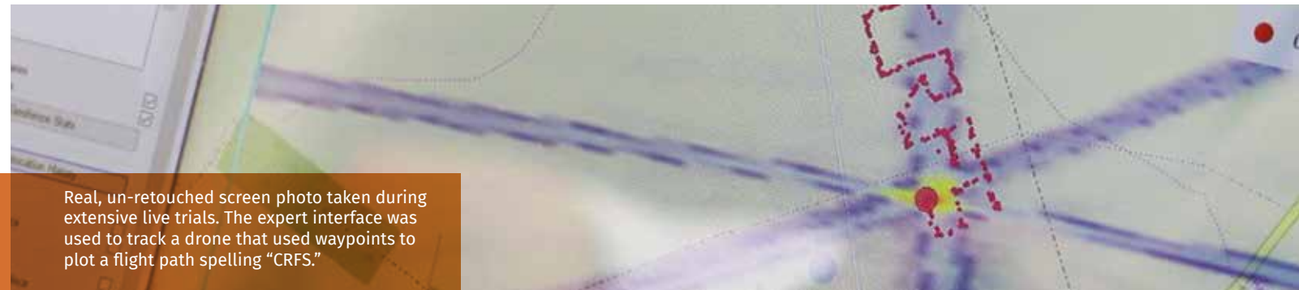
## Multi-mission

RFeye DroneDefense can track and detect nearly any type of RF emission, not just drones. Experiencing interference across 2-way radio networks? This system can help identify the cause. Need to know if electronic devices are being used in a restricted area? Track mobile, bluetooth, wifi and GPS emissions with ease.

## Deployed & Ready

RFeye DroneDefense uses the same high-performing RF sensors and software we supply to military and intelligence agencies and national regulators around the world. The RFeye system is a TRL9 product, used in field environments both day and night, often for years on end.

CRFS's RFeye hardware is not another generic, low-quality COTS SDR. Our extremely wideband, low-noise, high-resolution receiver uses a super-heterodyne architecture to deliver unrivalled probability of intercept (POI) to capture even the most rapid transient signals.



Real, un-retouched screen photo taken during extensive live trials. The expert interface was used to track a drone that used waypoints to plot a flight path spelling "CRFS."

# RFeye DroneDefense

## CUSTOM BUILDS

Live-track even unknown or homemade transceivers and log to threat database for analysis

## TELEMETRY

A drones telemetery and system data may be sent to the ground even in autonomous flight mode

## WIDEBAND RF DETECTION

Detection from 9 kHz to 18 GHz ensures high probability of intercept (POI) of custom drones

## LIVE VIDEO STREAM

Live video transmissions can be used to determine target positioning

## OPERATOR LOCATION

Only RF can geolocate the biggest threat vector: the operator

## 3D POSITIONING

Latitude, longitude and altitude are continually geolocated in real time and logged for post-analysis

## MULTI-MISSION

Manage RF spectrum, gather intelligence & geolocate other targets of interest while RFeye Drone works in the background

## MULTI-TARGET

Track multiple targets simultaneously in real time with automated live updates

## How it works

RFeye DroneDefense is based around a network of RFeye nodes that are set up around the facility that is to be protected. These intelligent nodes passively detect and identify the presence of RF transmissions that relate to drones, even if the signals are of low power or in complex RF environments. The transmissions can be geolocated in 3-dimensions to give the location of the drone, its flight height and air speed. Furthermore, operational frequencies can be identified and used to cue third party jammers. Multiple drones can be simultaneously tracked and identified. If a drone is detected, the system triggers an alert that can then be acted upon or used to cue other deployed platforms e.g. Radar/EO.

# Common myths

In a rapidly emerging field like drone detection, it can be difficult to separate fact from fiction.

We've collected some of the myths and misconceptions that we've encountered over the last few years, and hope this will help to clear them up.

## All you need for drone detection is a radar

It may be tempting to rely on radar systems for drone detection, especially at airports where the systems are already installed, but they aren't an ideal solution for a number of reasons. Firstly, radar systems require a direct line of sight to objects they are monitoring. When tracking aircraft, this is rarely an issue because aircraft fly high enough to sit above any potential ground clutter. Drones, by contrast, are frequently operated at very low altitudes, which means that objects such as buildings and trees can prevent radar systems from detecting them. RF signals, on the other hand, are able to pass through or around these objects, allowing drones to be detected even when in the shadow of a building.

Secondly, drones are usually physically much smaller than aircraft, which means gives them a correspondingly smaller radar cross section. This cross section is almost identical to that of birds, so radar systems can struggle to differentiate between drones and birds, resulting in a high false-positive rate for drone detection. RF systems, on the other hand, only detect systems that emit RF signals, and are therefore able to ignore any birds that might be present.

## Destroying the drone means problem solved

So you've detected a drone and neutralized it using a jammer, laser or kinetic countermeasure. Job done, right? Well, maybe, but with drones becoming cheaper and easier to access, a determined operator who is intent on causing trouble will likely return soon with a new system. If you really want to solve the problem for good, you'll need to locate and detain the operator. As we've already seen, radar systems can't help here—a user located on the ground will be impossible to pick up on radar. With an RF system, though, you can locate the operator exactly the same way you locate the drone: by detecting the RF transmissions they send.

## All you need is a good signal library

One approach to drone detection using passive RF is to focus on building a library of drone signals. Systems that rely on these libraries analyze control signals from major drone manufacturers, determine the distinctive features of these signals, and then look for signals with those distinct features, often using cheap, low-fidelity receivers.

But a good signal library is not enough to make a successful drone detection system, for two main reasons: Firstly, the library can only be used when signals have actually been detected, which means the quality of the receiver is as important as the quality of the library. RFeye Nodes' market-leading low noise figure means signals can be detected that would otherwise be lost in background noise. Secondly, drones used for malicious or illegal purposes will likely be homemade or hand-modified, so they won't match existing signal libraries. RFeye doesn't just look for library signals—it looks at all RF transmissions and flags any suspicious signals that might be coming from custom drones.

## RF detection can be avoided by pre-programming routes

While it is technically true that an RF system alone cannot detect a drone operating silently with a pre-programmed flight path, using a drone in this manner removes one of its key strengths—the ability to provide video footage. This has real consequences for hostile actors as well as hobbyists. For instance, even operators with malicious intent may rely on video for real-time control and feedback as well as surveillance. Pre-programming also removes a drone's ability to change plans or evade capture if it is spotted, so it can compromise its home location or rendezvous point by proceeding there even while being observed.

In reality, most drone sightings are likely to be hobbyists accidentally straying into the wrong area, all of whom will use RF to control a drone. However, when threats from self-sacrificial drones are valid, we recommend supplementing RFeye Drone with electro-optical (EO) and radar systems where applicable.

## One DF array can locate a drone

DF (direction finding) or AoA (angle of arrival) techniques work by determining the direction that a signal is received from, to work out a bearing from the receiver to the target. A single DF array can only give the bearing – it can't provide any information on how far away the drone is. And for most drone defeat devices, that is not enough information to allow the drone to be disabled. A minimum of two DF arrays is therefore needed if you want to determine the location of an RF emitter—it will be located at the point where the bearings from the two arrays cross. These receivers also need to be geographically separated, as the closer they are, the greater the uncertainty in the determined location.

## Lab-spec performance is achievable in the real world

Product brochures are full of impressive claims about the performance of drone detection systems: "better than 1° accuracy in direction finding," "effectively unlimited range," etc. Demonstration videos show drones' positions with pinpoint accuracy. The problem is, these performance claims are based on lab results at optimum frequencies and conditions, and most videos are either simulations (i.e., theoretical predictions or even outright falsehoods) or else live demonstrations in unrealistically low-RF environments.

So how do these systems perform in a real-world, urban environment, or at a busy commercial airport? At CRFS, we are happy to demonstrate the performance of our systems in real life, with real signals, showing results you can actually obtain in practice. After all, it's highly unlikely that your application will involve detecting drones in an anechoic chamber.

## Drone detection systems are the same thing as counter-drone systems

This is a terminology myth, but still an important one if you're looking to install an counter-drone system. Essentially, a counter-drone or anti-drone system consists of two discrete parts: a drone detection system that alerts you to the presence and location of drones, and a drone defeat system that deploys some kind of countermeasure to disrupt or disable the drone once it has been detected. The detection system might include radar, electro-optical (EO) sensors and/or RF detection, while the defeat system might use a jammer, laser, projectile or control system override. These two parts could be integrated or could be completely separate systems rather than one integrated unit. (In fact, integrating an RF system with a jammer without hefty protections could quickly damage receivers).

# The CRFS difference

CRFS sits at the forefront of new technology for distributed monitoring and geolocation, featuring wideband receivers with lightning-fast sweep speeds and best-in-class noise figures and phase noise. These high-sensitivity receivers are known as RFeye Nodes.

For our military customers, fast sweep speeds and instantaneous bandwidth mean higher probability of intercept (POI). This translates to confidence that potential threats can be detected for real-time tracking, recording and further analysis.

Low noise means that operators can detect and locate lower-power, more distant signals that might otherwise have been missed entirely, providing earlier threat warning indicators (TWIs) and better situational awareness of an area of operations (AO).

RFeye's high-performance hardware and state-of-the-art software enable extremely fast processing to give much faster geolocation updates than other systems. Our TDOA geolocation algorithms typically update 10 times per second compared to similar systems which may only update once every 30 seconds. Fast geolocation updates are crucial in situations where hostile targets may be moving at speeds of over 1,000 mph.

## How we work with our customers

CRFS is recognized as a best-in-class COTS supplier by defense forces, security services and system integrators, and our systems have been widely deployed to great effect over many years.

CRFS is known not just for the hardware and software we provide, but for our support. We have long-term partnerships with many of our military customers, working closely with them not just to ensure the successful deployment of equipment, but also to develop new features to meet their specific mission requirements.

## Military & government contract vehicles

Many of our Mil/Gov customers prefer to purchase CRFS products using an existing approved contract vehicle. Our products are available through a range of different contract vehicles, and the list is always growing. If you have a specific request, please do not hesitate to get in contact with us directly via **enquiries@crfs.com**.

## Product Selection

A selection of CRFS geolocation & intelligence products.
For more, visit www.crfs.com


1: RFeye Array 100/150
2: RFeye Array 50
3: RFeye Array 300
4: RFeye Node + ODK
5: RFeye Node 100-18
6: RFeye SenS Portable Recorder

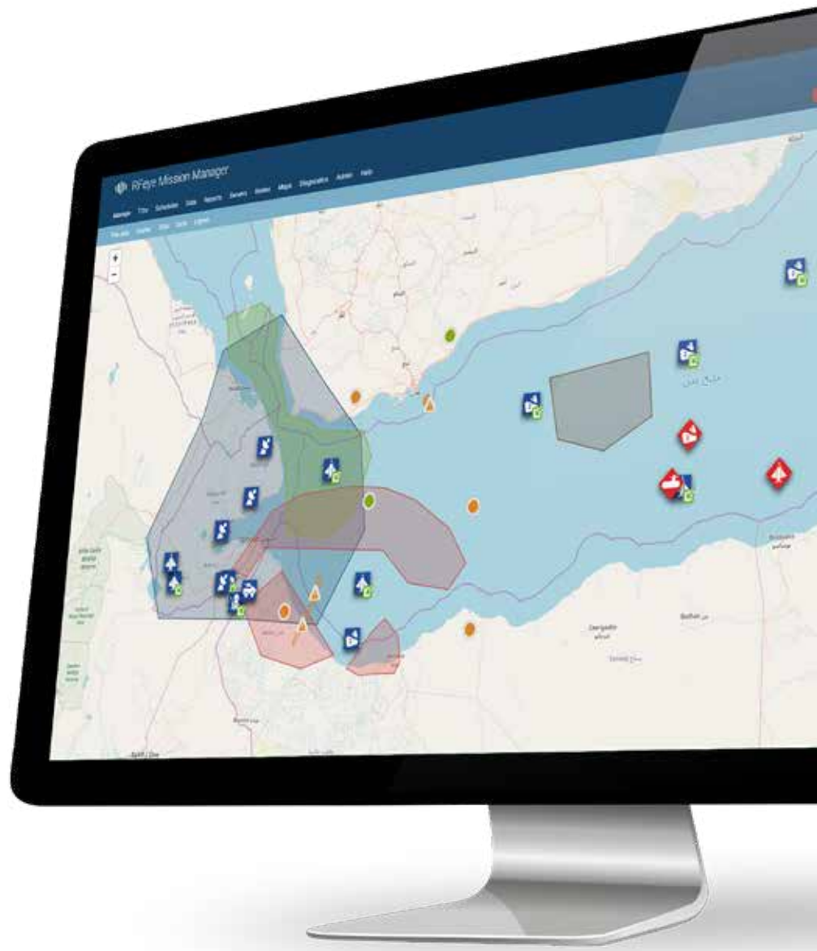
## RFeye Mission

MN

### Automated RF situational awareness

RFeye Mission is CRFS's flagship solution for automated spectrum operations. It enables spectrum stakeholders to derive useful and actionable intelligence from their deployed RFeye receivers without the need for teams of RF experts. It has been designed for use with RFeye assets deployed over wide areas such as ranges, test sites, borders and cities, as well as small networks such as indoor technical surveillance countermeasures (TSCM).

RFeye Mission is controlled via a web browser interface. It allows even novice operators to automate spectrum monitoring task schedules without having to view a "wall of spectrum data." Sweeps, scans and surveys can be set up quick-ly, and operating zones, geolocations and authorized transmitters are clearly displayed alongside immediate alarms as incident logs as violations happen.



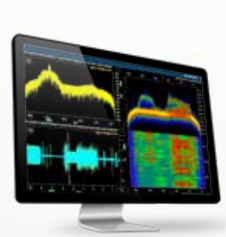

## Software Solutions

ST

### Site

RFeye® Site is our state-of-the-art desktop application for real-time monitoring and geolocation requirements.

Monitoring, Geolocation, Indoor Geolocation, 3DTDOA MLAT, Signal Classification, Propagation, Map, Signal Verification



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### DeepView

RFeye® DeepView software is the ultimate forensic tool for searching through multi-terabyte datasets for signals of interest.

Big data view: time/spectrogram & heatmap, Live mode: Real-time Spectrum Analyzer, Fast zoom/scroll through IQ data, Select export: filtered IQ data, Full dataset or selection playback, Marker: Delta function with live recording, Unlimited file duration, Screens: Dataset, Analysis region overview, Analysis region Spectrum, Time cursor Spectrum, Power/Time

ST

### RFeye AirDefense

3D TDOA (or MLAT) is a recent advance in our geolocation software enabling passive tracking of targets in three dimensions even with a ground-based network of Nodes.

This is used to track objects such as military/civilian aircraft, commercial drones and more advanced military UAVs. As the method is entirely passive it allows targets to be tracked without any emissions which may alert those targets.

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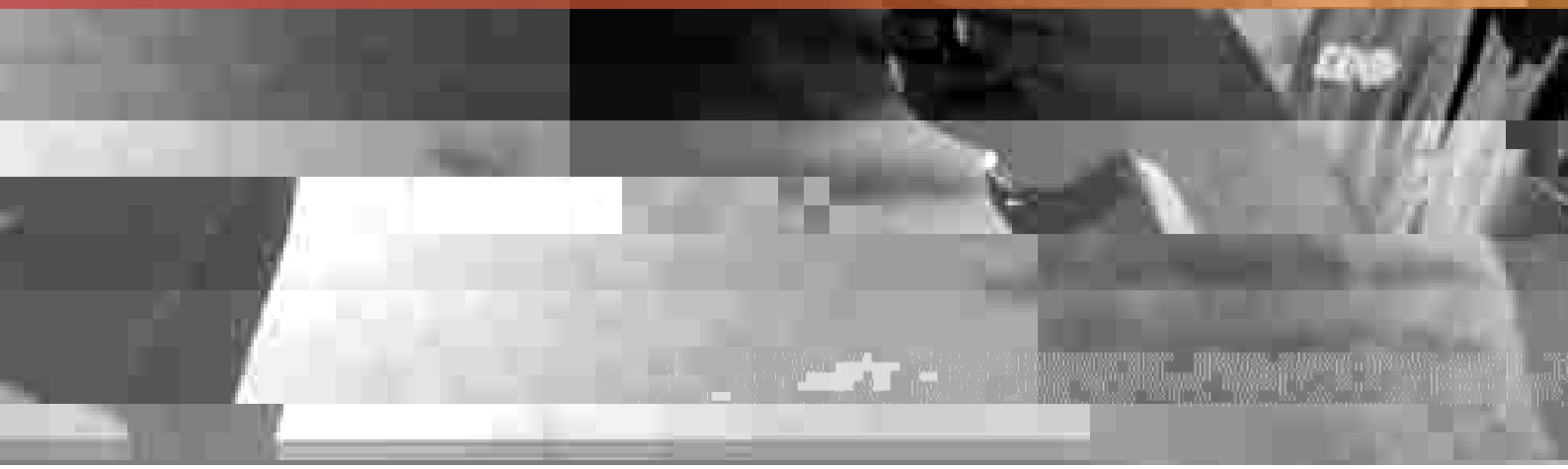
## About CRFS

CRFS provides best-in-class solutions for radio spectrum monitoring, management and geolocation.

CRFS offers a new generation of technology for the detection, identification and geolocation of signals in complex RF environments.

CRFS is recognized as delivering truly “best in class” technology - our RFeye systems are deployed worldwide by regulatory, military, law enforcement and intelligence agencies.



For further information or to schedule a demonstration visit:

crfs.com

CRFS

See through the noise

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