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SECURITY RISKS WITH COMMERCIAL DRONES—

How Serious is this Risk and what's the Latest in Detection and Mitigation?

Thursday, November 16, 2017

10 a.m. PST • 11 a.m. MST • Noon CST • 1 EST

WELCOME TO

Security Risks with Commercial Drones—
How Serious is this Risk and What's the Latest in Detection and Mitigation?

Darren McCarthy
A&D Technical Marketing Manager
Rohde & Schwarz

Goetz Mayser
Director of C-UAV Detection and Counter Solutions
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David Romero
Managing Partner
Black Sage

Ross Lamm, Ph.D.
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Co-Moderator: Lori Dearman, Executive Webinar Producer

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Who’s In the Audience?

A diverse audience of over 300 professionals registered from 37 countries, representing the following industries:

24% Government

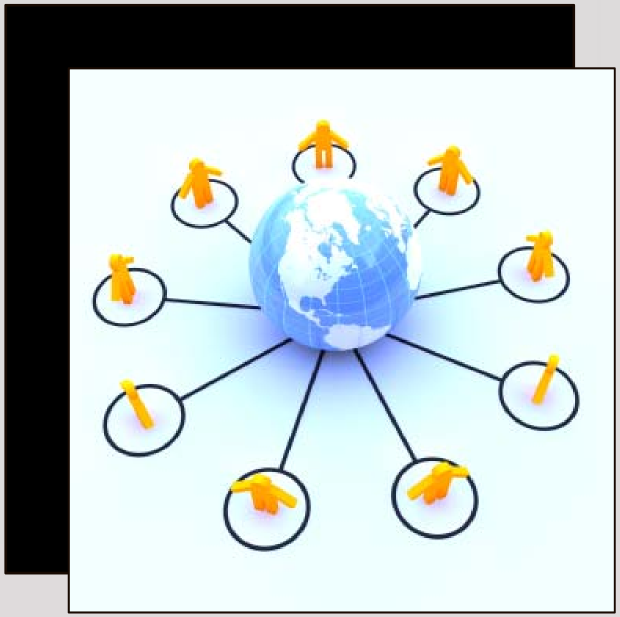
18% System Integrator

14% Product/Application Designer

13% Professional User

6% GNSS equipment manufacturer

25% Other



Welcome from *Inside GNSS*

Richard Fischer
Publisher
Inside GNSS / Inside Unmanned Systems

Security Risks with Commercial Drones—
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James Poss, Maj Gen (ret), USAF
CEO
ISR Ideas

Poll #1

How much do you know about existing counter drone solutions on the market?

- *I am just getting started*
- *I know some basics about the different counter drone solutions*
- *I have a good overview of the technologies available*
- *I have a good overview of the technologies available and tried out some of them*
- *I have expert knowledge and know exactly what I want*

Featured Panel Members

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When good drones go bad

James Poss, Maj Gen (ret), USAF
CEO
ISR Ideas

Bad drones Vs idiots

Bad drones Vs Worse people

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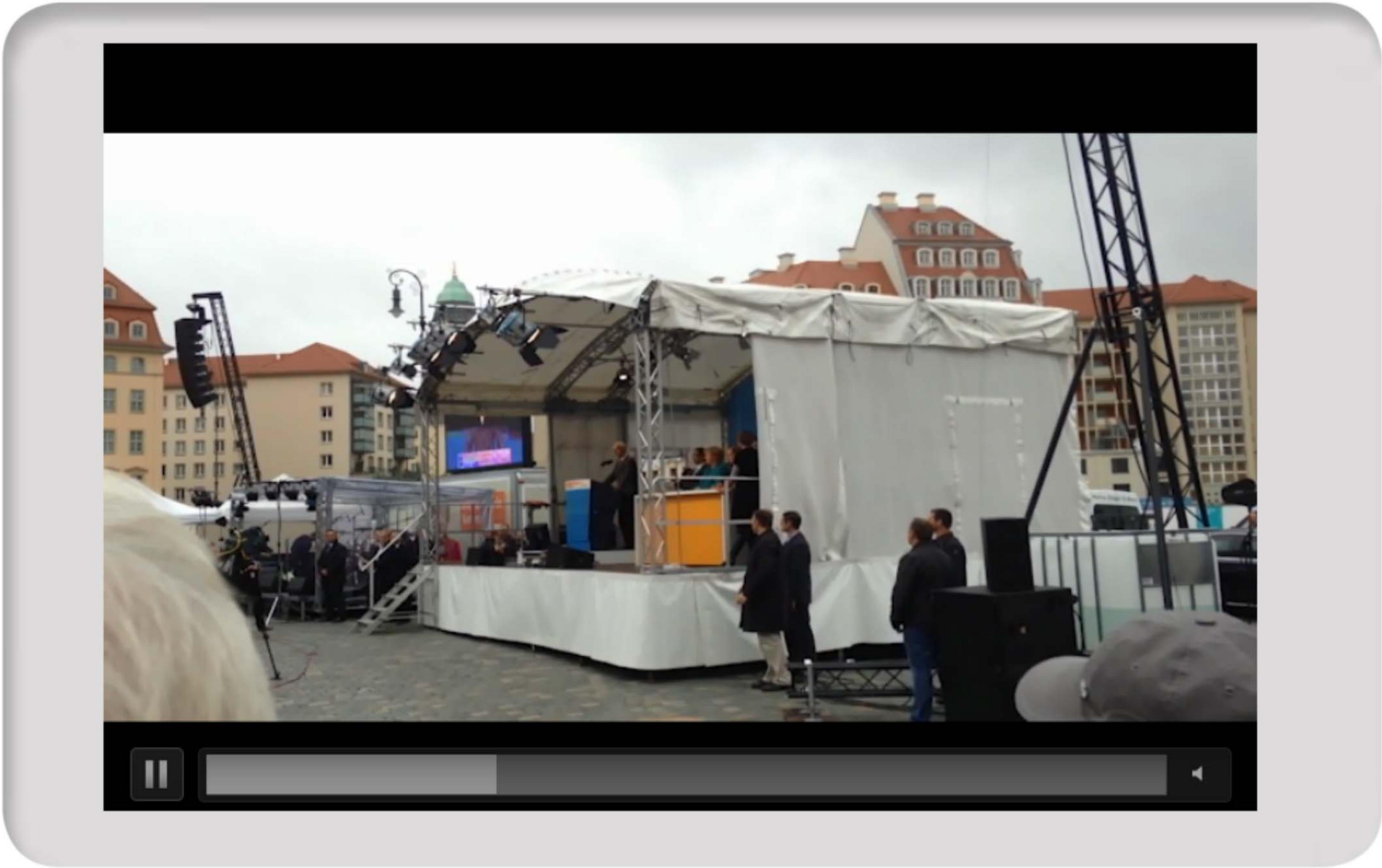
Bad drones Vs Good people



Bad drones – stuff just got REAL

Overview

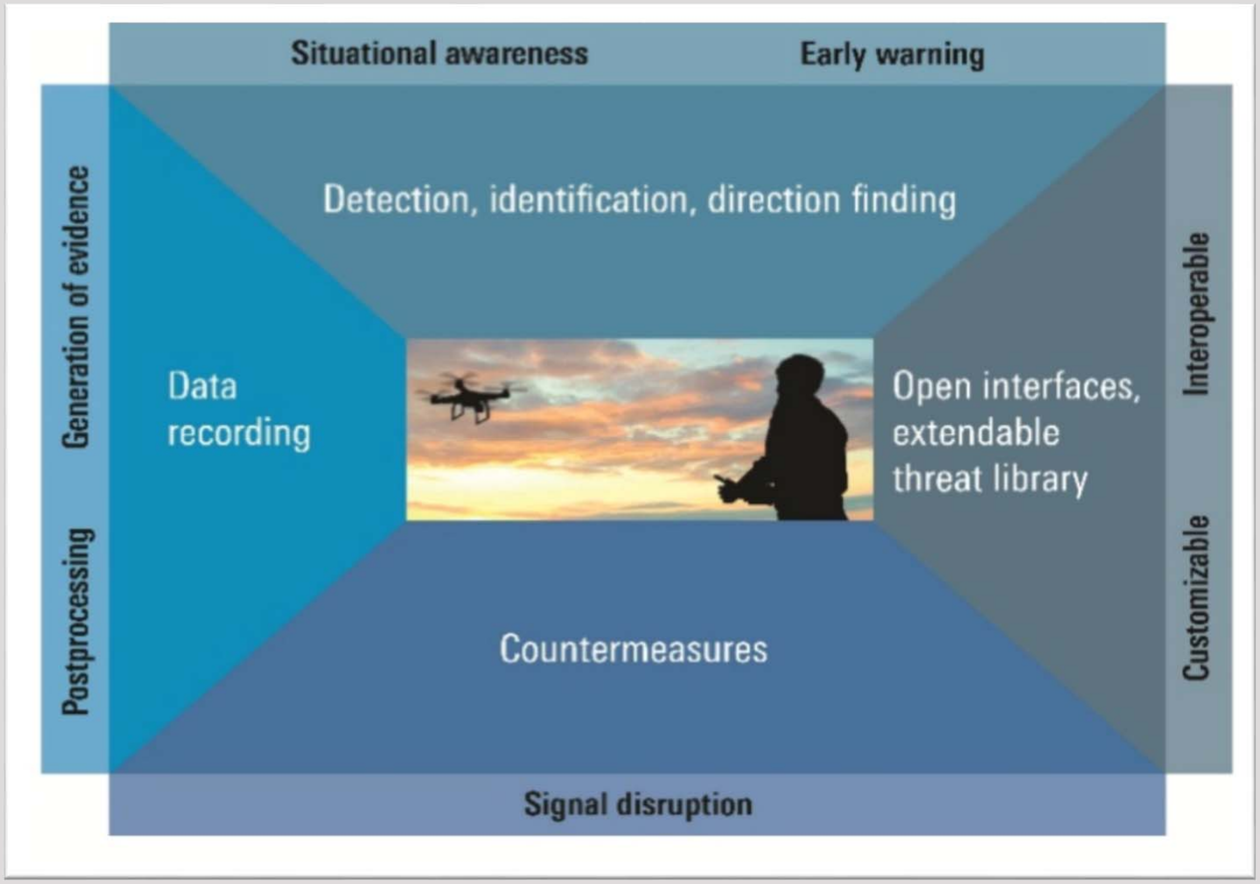
Darren McCarthy
A&D Technical
Marketing Manager
Rohde & Schwarz

Rohde & Schwarz Overview

Over 80 years of RF Engineering

- History
  Established 1933 in Munich, Germany
- Type of enterprise
  Independent family-owned company
- Global presence
  In over 70 countries, approx. 60 subsidiaries
- Net revenue
  - € 1.9 billion (FY 16/17, July to June)
- Employees
  - approximately 10,500 worldwide
  - 6000 in Germany
  - > 500 in US
- Success
  - A leading international supplier in all of its business fields
    - Test & Measurement
    - Broadcast & Media
    - Secure Communications
    - Monitoring and Network Testing
    - Cybersecurity

Drone Defense Workflow



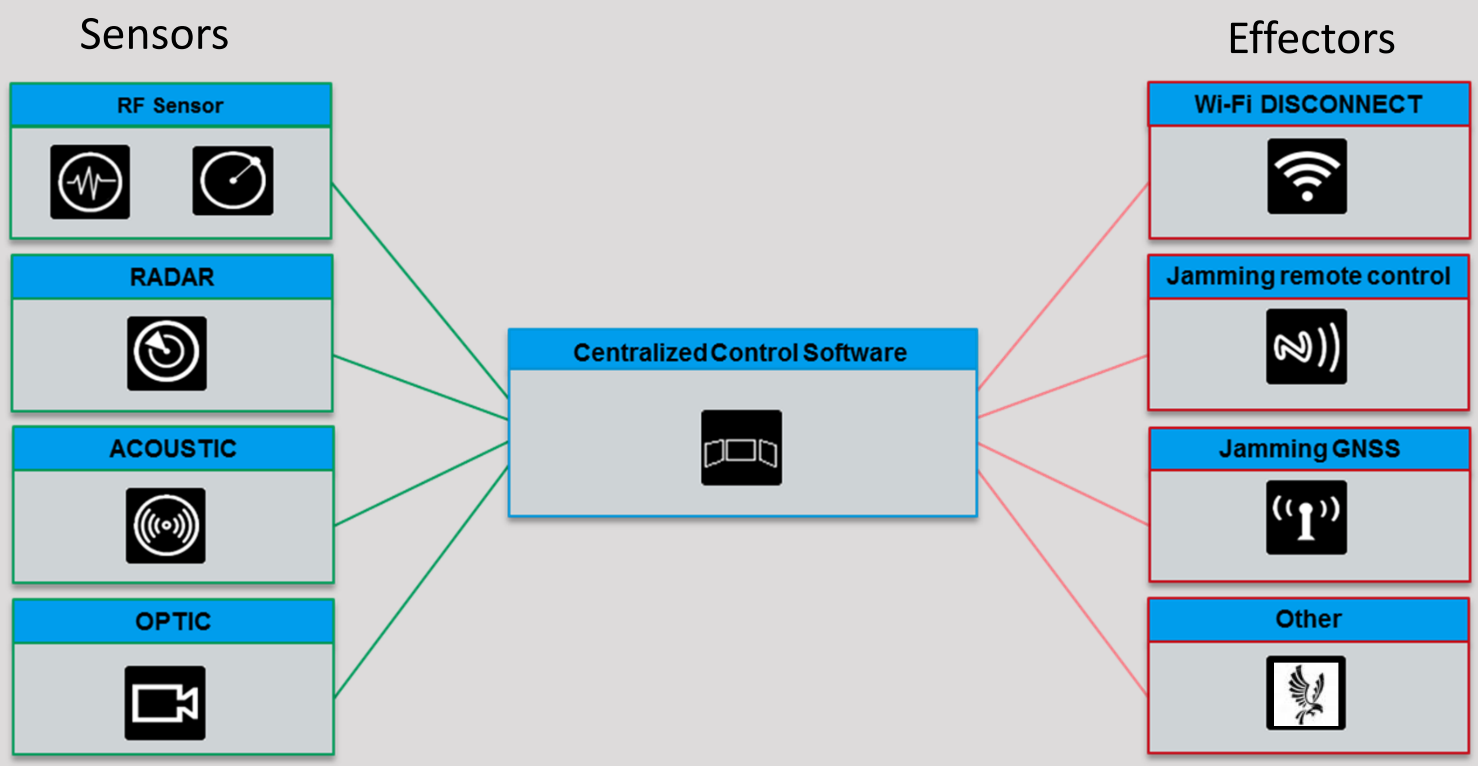
Different Commerical Drone Types

- Single systems are not sufficient to comply with the variety of requirements such as different UAS technologies, threats, scenarios, concept of operations




WiFi Control	Radio Control	Waypoint Navigation	Waypoint Navigation
Data Link	Data Link	GNSS	Inertial Navigation
Smartphone or Tablet	Remote Control	Pre-programmed	Pre-programmed

Multi-sensor fused Workflow



Poll #2

What are the most important detection assets of a counter UAS solution? (Choose up to three)

- *Radar*
- *RF*
- *Acoustic*
- *Optical*
- *Other*

Radio Frequency Detection

Goetz Mayser
Director of C-UAV Detection and Counter Solutions
Rohde & Schwarz

Controlled drones some facts and figures

- > 90 % of drones operate in the ISM band using **proprietary protocols**
  - spread spectrum methods
  - FHSS Frequency Hopping Spread Spectrum
    DSSS Direct Sequence Spread Spectrum
  - Wi-Fi or Bluetooth
- Radio Links:
  - Uplink: Radio control (RC) of drones
  - Downlink Telemetry data and/or video
- Frequency bands:
  - ISM band: 2.4 GHz and 5.8 GHz
    Rarely in use: 433 MHz
  - Outdated frequencies for RCs:
    27 MHz, 35 MHz, 72 MHz
  - Other: country specific

Why RF detection?

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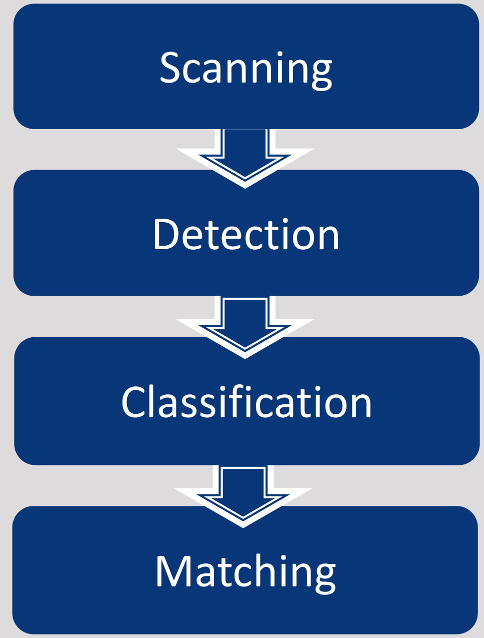
RF detection steps

The following steps are necessary

- Scanning the frequency bands
  - Automatic configurable sequencer
- Finding best analysis window
  - realtime < hopper bandwidth
- Detect the signal
- Automatic classification
  - Spectrum based
  - IQ based
- Profile matching
- Reliable alarm



Reliable detection in the ISM band

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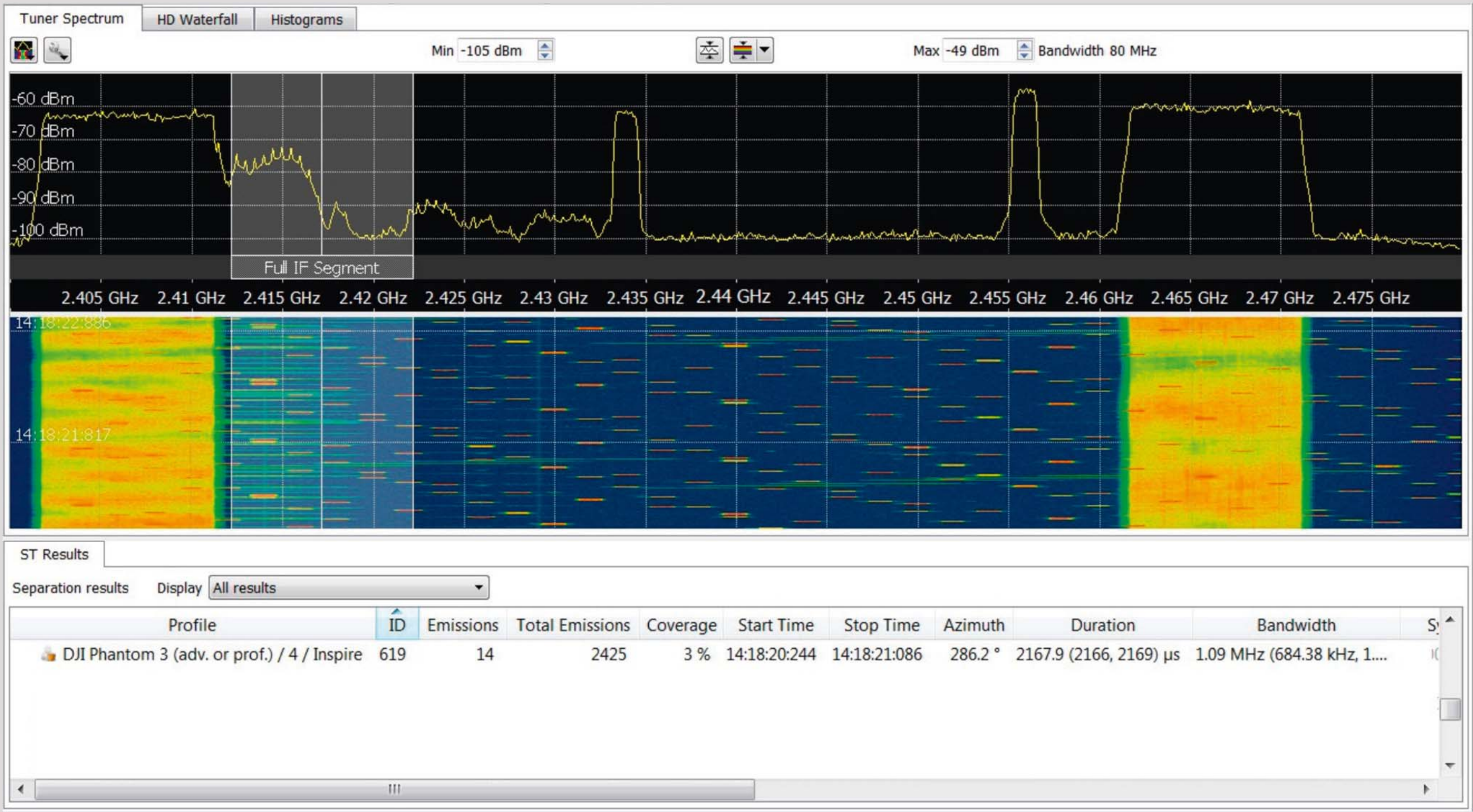
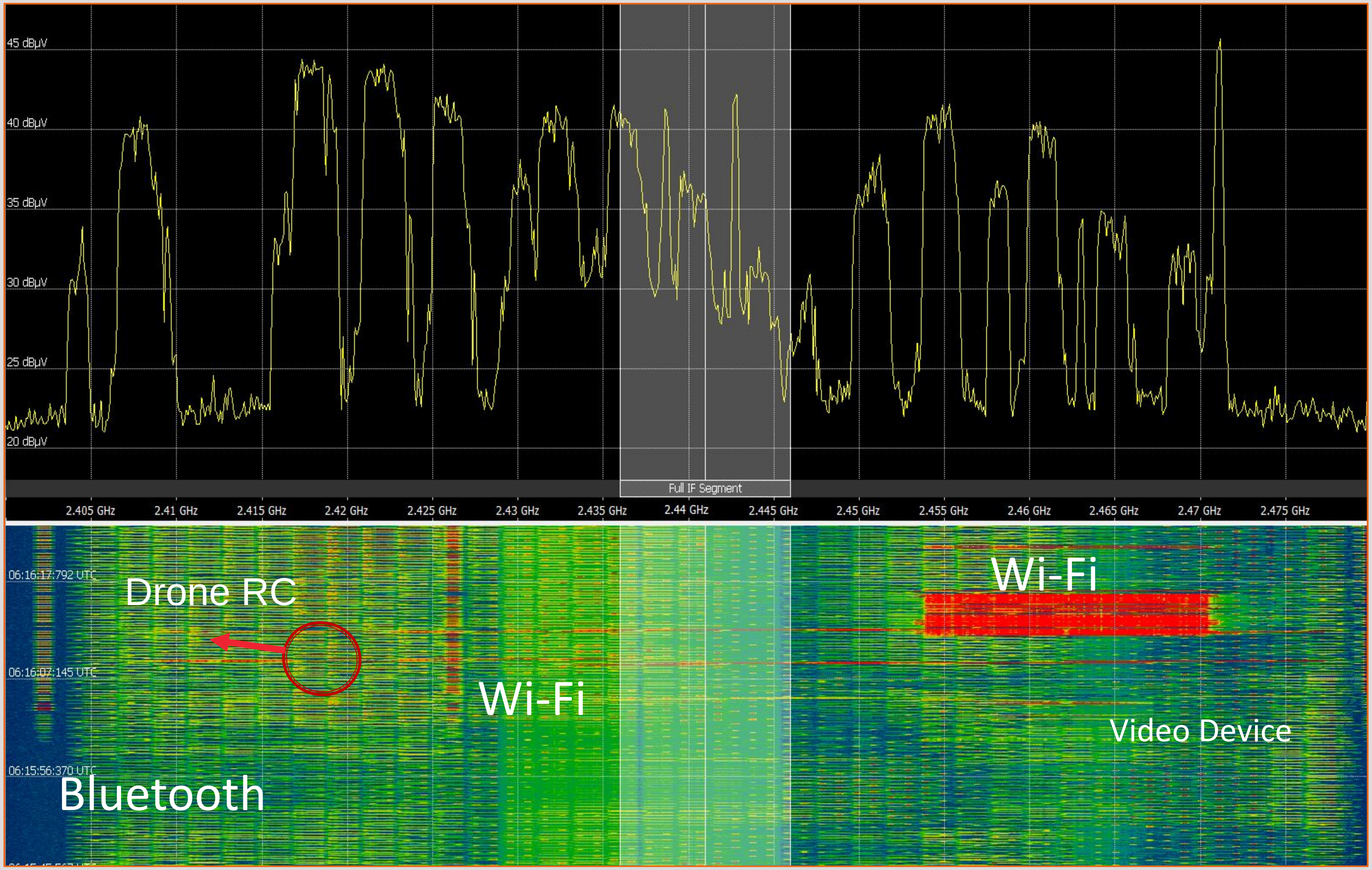


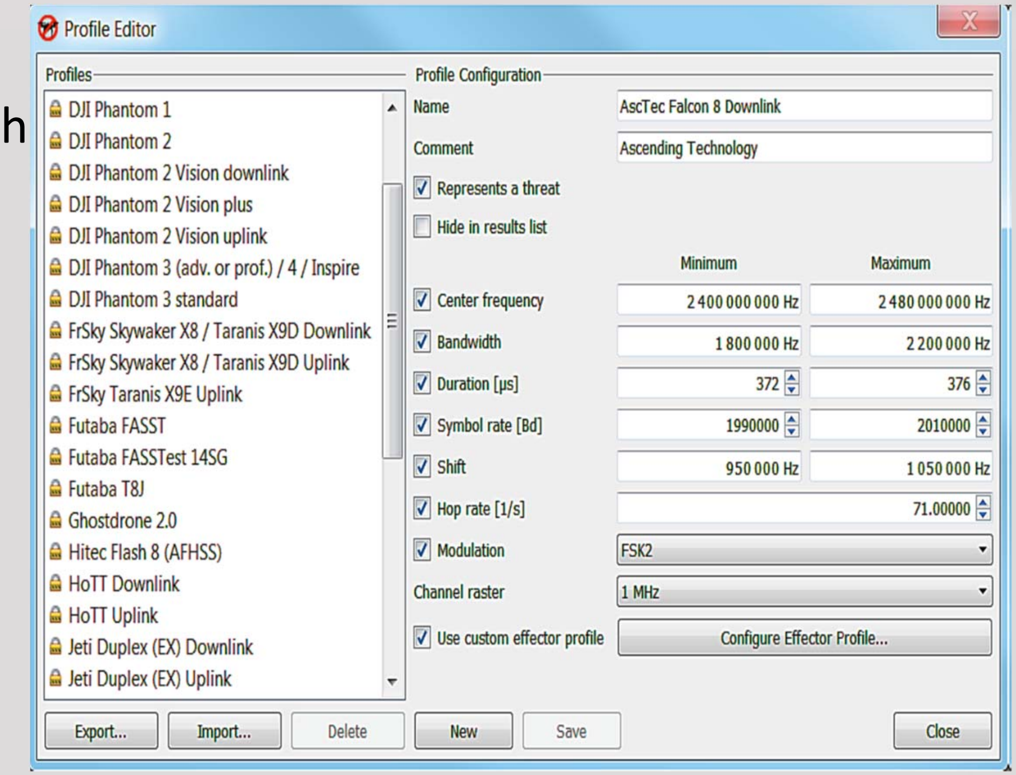
And in the real life?



Drone profile characteristic criteria

Characteristic criteria:

- Center frequency and bandwidth
- Duration
- Symbol rate
- Shift
- Hop rate
- Modulation



The more characteristic criteria identified the better the results

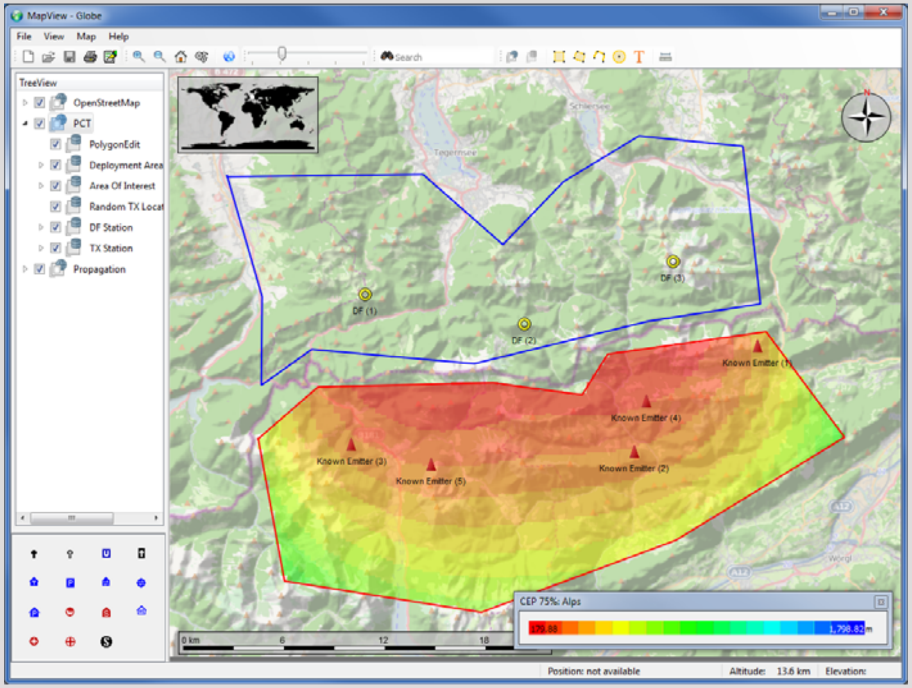
- Identify
- Differentiate between similar profiles
- **Low false alarm rate**

Ranges

- Detection coverage is tentatively the distance covered by the radio control link under the similar propagation conditions

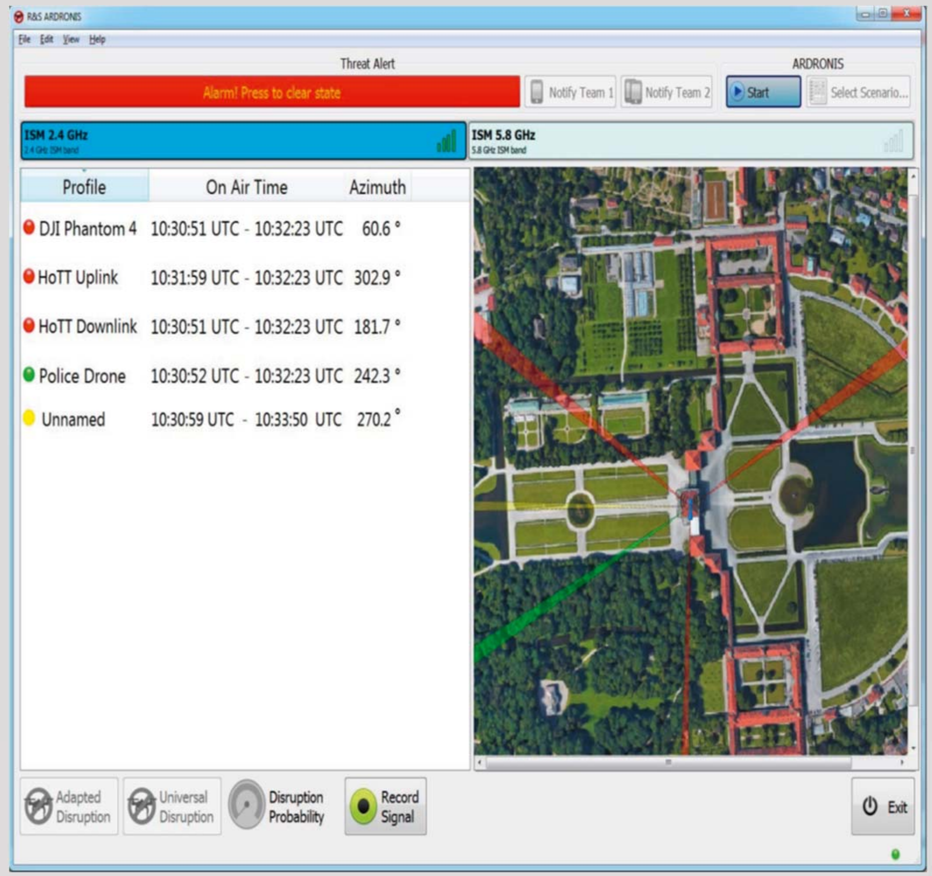
- Depending on power
  - Standard remote control 1 -2 km

- Depending on used bands
  - 2.4 GHz max. 3 km
  - Wi-Fi 500m
  - 5.8 GHz max. 1 km
  - 430 MHz several km



Identify different controller types

- All type of controlled drones have to be identified
  - Full-band hopper
  - Partial band hopper
  - Fixed-frequency
- Automatic classification allows categorizing:
  - Black list (i.e. threat)
  - White list (i.e. own drone)



What's important?

- Works **reliable** in **real environment**
  → works in congested environments
  → detects all type of controllers in all bands

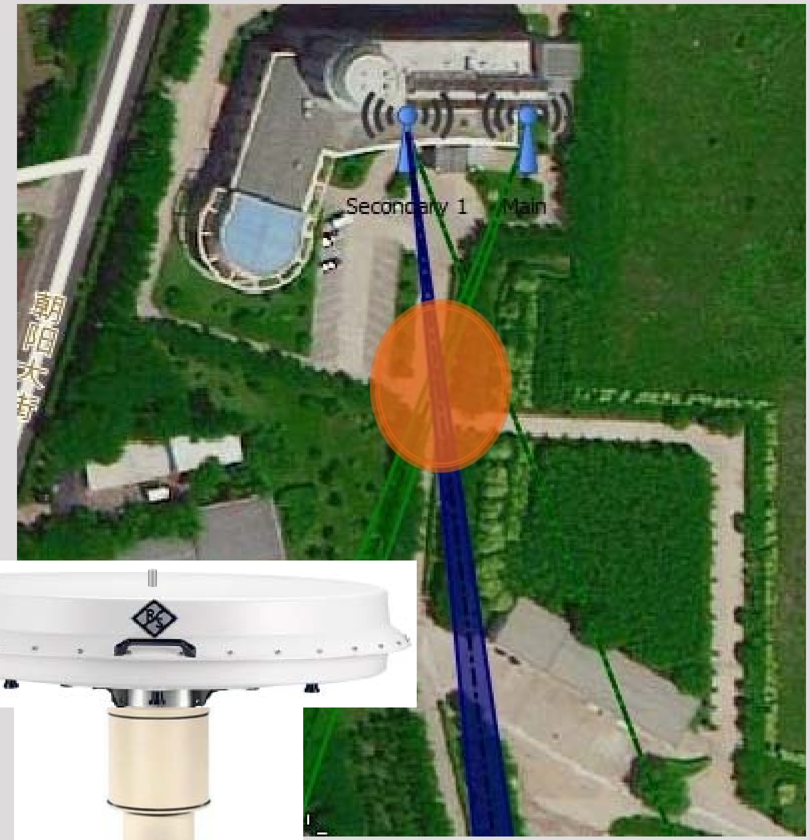
- Allows **24/7 operation**
  → easy operation
  → low false alarm rates
  → classification of different drones

- **Expandable**
  → frequency bands
  → easy creation of new profiles

Locating drone signals

Challenges:
- Short duration (some hundreds us)
- Frequency agile (hop across entire band)
- Co-channel interferences
- Multipath propagation

Direction finding:
- Fast, automatic direction finding
- Immunity to reflections
- Based on pulse, not channel
  → 2 channel necessary
- Several bearings simultaneously
- Combine several DFs to get exact position



Summary

The only sensor …

- Early warning
- Localization of operator

- It’s important that …
  - Works reliable in real environment
  - Allows 24/7 operation
  - Expandable

R&S®ARDRONIS solution

- But what about autonomous drones?

Ask the Experts – Part 1

James Poss, Maj Gen (ret), USAF
CEO, ISR Ideas

Goetz Mayser
Director of C-UAV Detection and Counter Solutions
Rohde & Schwarz

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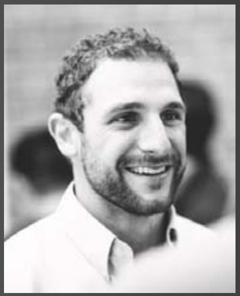
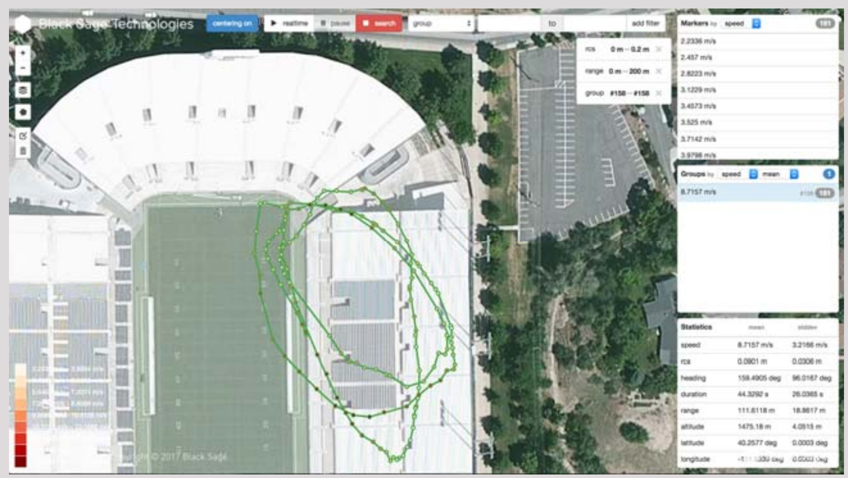
Radar



David Romero
Managing Partner
Black Sage

Active Detection

- Passive early warning leads to increased operator vigilance for detections in actively monitored airspace
- Radar picks up where passive detection leaves off: all moving objects including UAS flying autonomously
- A valuable detection modality for a layered CUAS system
- CUAS radar surveils airspace in volumes



Coverage by Volume

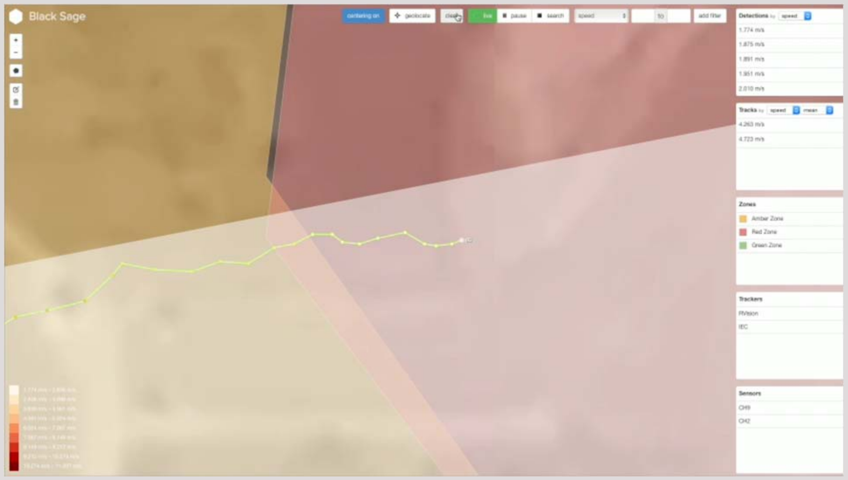
- CUAS necessitates a paradigm shift from 2D to 3D detection
- Radars used in multiples with large horizonal *and* vertical fields of view
- Security systems now must be designed with empathy toward high altitude threats traveling vertically
- Active vertical coverage equally important as horizontal coverage and range capability

Comparison of three common CUAS radars

Image	Type	Range	Sensors	Coverage	Weight	Cost
	Compact Flat Panel Pulse Doppler	1km	qty 4	360°H X 20°V	18lbs	~$150k
	Compact Flat Panel ESA	700m	qty 4	360°H X 80°V	14lbs	~$120k
	Rotating ESA	7km	qty 1	360°H X 90°V	160lbs	~$700k

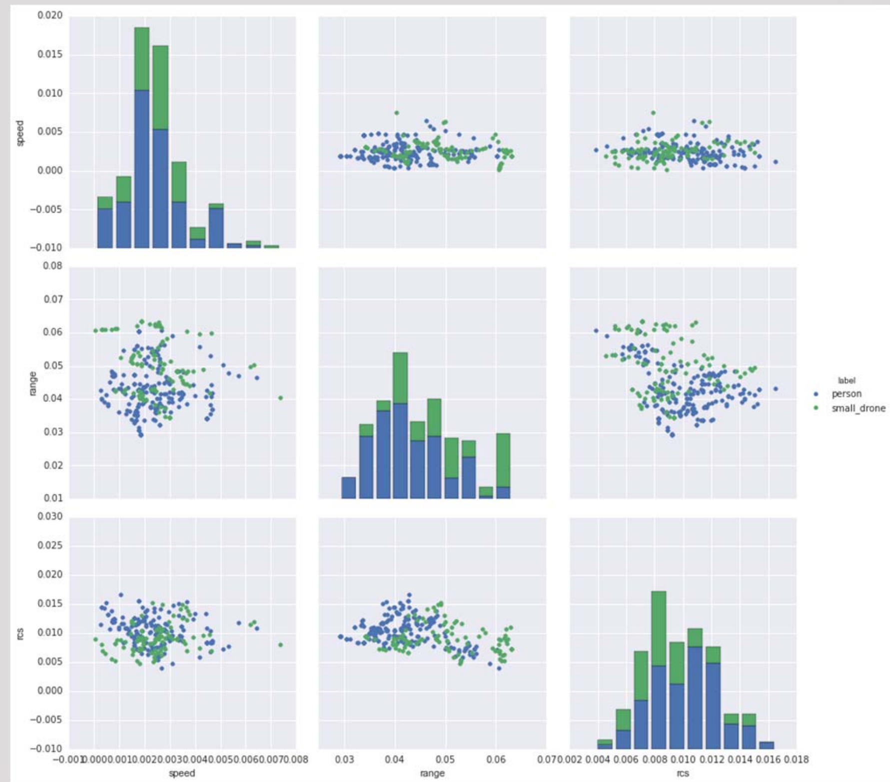
Why Radar for CUAS?

- Detects all moving objects within sensor fields of view
- Coverage can be easily scaled across large and complex sites by adding more sensors
- Provides 3D geolocation of moving objects
- Provides characteristic data that describes moving objects



Object Characteristics

- Effective CUAS radar provides high quality data and multiple characteristics
- Targets distinguished with pattern recognition algorithms using all available characteristics
- Computed characteristics over time create very strong signatures for different classes of moving objects
- Allows differentiation between UAS, birds, manned aircraft and more



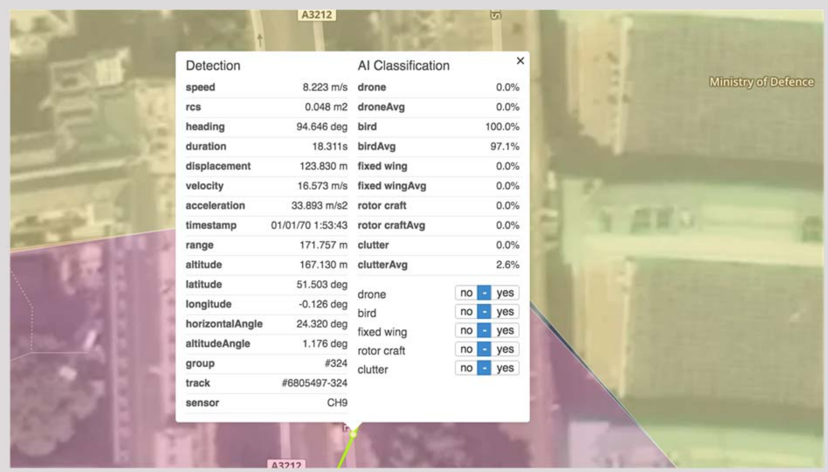
Target Classification

- Detections hold multiple object characteristics and are provided by sensors every 1-5 seconds

- Detections pass through a target classifier: artificial neural network

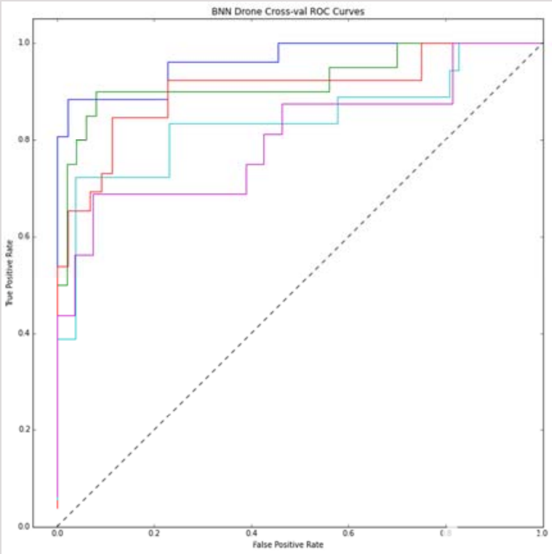
- Classifier is trained to recognize multiple types for moving objects and produces probabilities for every new detection

- Classification enables probabilistic alarms which are better than deterministic ‘boy who cried wolf’ threshold alarms



Confidence

- Performance of target classification dependent on data quality and classifier training
- Automatic cross-validation of classification probabilities using objective statistical technique
- Classifier is reinforced in realtime by operator; cross-validation and performance metrics generated within 60 seconds
- Performance improves over time with increased true positive and true negative classification rate



3D Target Geolocation

- Radars provide horizontal angle and vertical angle of target relative to the sensor
- Precise latitude, longitude and altitude are extrapolated
- Classification and precise geolocation enable intelligent allocation of other CUAS assets
- Including positioners, cameras and effectors which can be automatically cued on target

Automatic Slew-to-Cue

- Multiple positioners are scaled across large sites and orchestrated

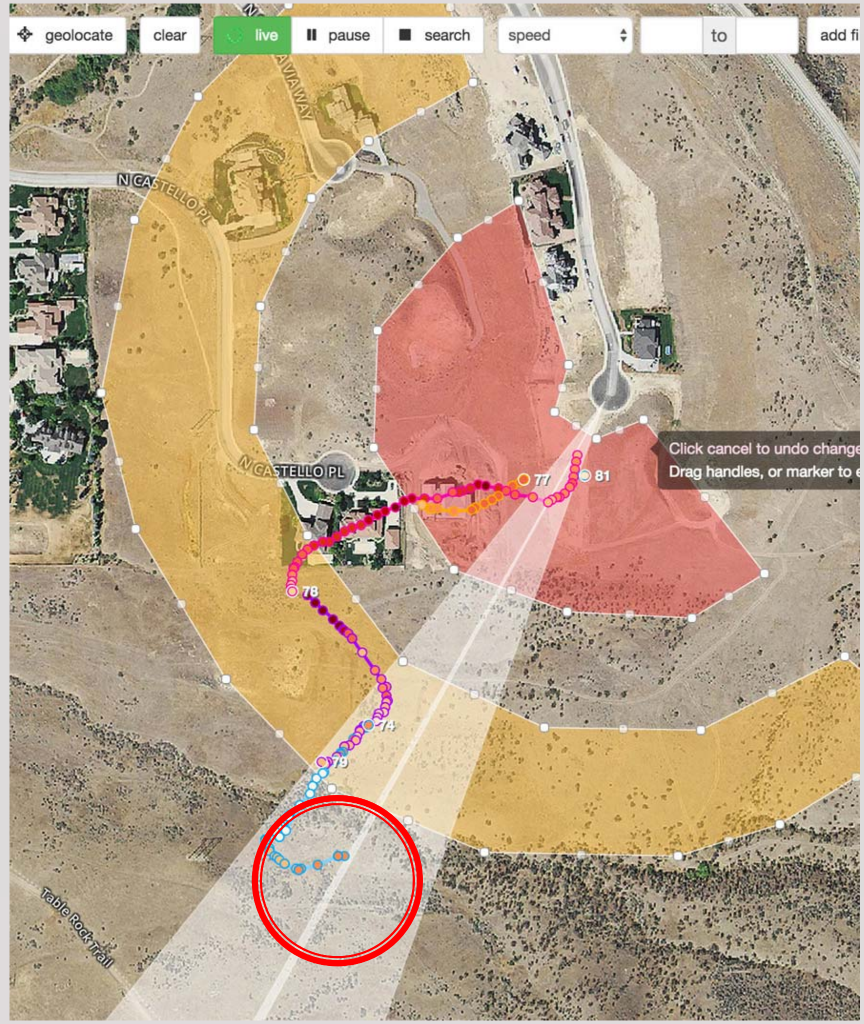
- Positioners have precise pan/tilt motors and can be pointed anywhere within 360°H by 90°V

- Geopointing: imaginary line drawn from each positioner to the target to slew at appropriate pan/tilt angles

- Multiple simultaneous threats prioritized with software: every positioner assigned a ‘job’ and divides tasks

Shortcomings of Radar

- Number of radars detections per second dictates frequency of automatic slew-to-cue and other follow-on actions
- When precise pointing is required for narrow zoom cameras or directional effectors, cueing frequency limits amount of time for energy on target
- Within 1-5 second waiting time for next detection (and cue), the target can leave field of view of sensors and effectors



Cameras & Video Tracking

Ross Lamm, Ph.D.
Managing Partner
Black Sage

Why Cameras for CUAS?

- Why would we want to use cameras for counter UAS?
- What can cameras do that other sensors don’t?
- What are the shortcomings of cameras in CUAS?

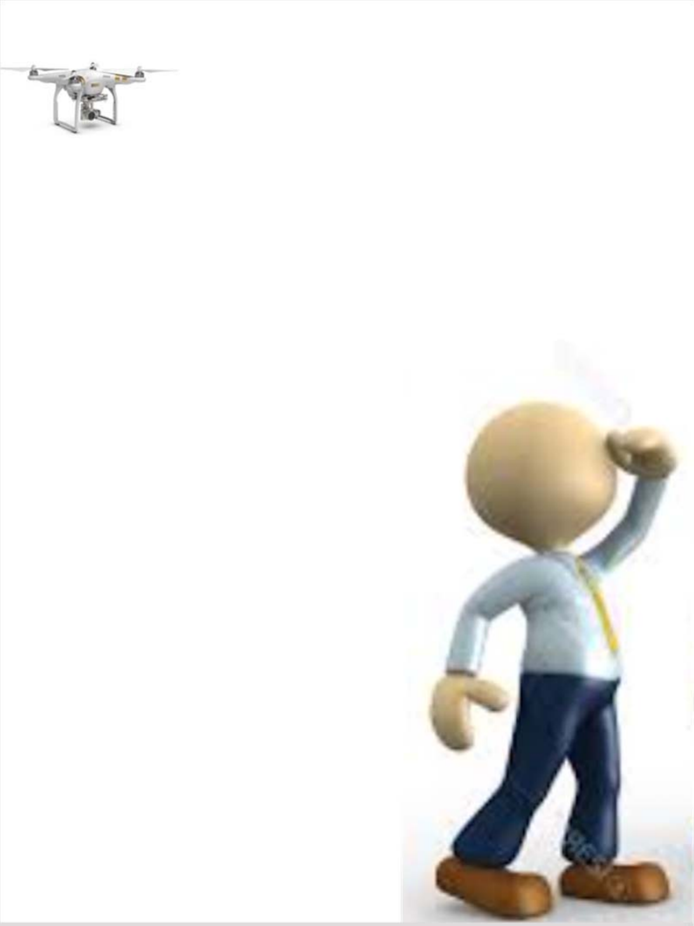
(the need for a layered approach)

Shortcomings of Cameras

Cameras are not good at initial detection while trying to cover a large area.

In other words, cameras are not good at wide area situational awareness.

RF detection and radar excel in this area



Why Cameras Are Needed

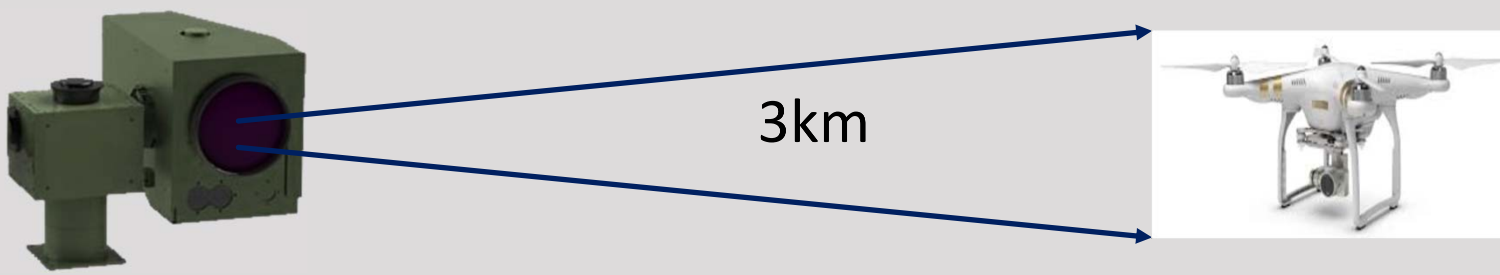
Being cued by radar or RF is not accurate enough

Radar or RF gets us pointed in generally the correct direction but is not accurate enough to allow zooming in on the target

+/- 2-3° Angle Accuracy

Long Range Zoom

Cameras have the ability to zoom in very narrow to see small objects at long distances.



Video Target Tracking

However, in order to do this with moving targets, we need the aid of another piece: "video target tracking"

Video Target Tracking

Video tracking is the process of analyzing the pixels in an image to determine the target location and then to steer the camera automatically at the moving target.

Video analysis at the frame rate of the camera (30 times per second) allows accurate following of a target at long distances.

Strengths of Cameras in CUAS

Cameras in conjunction with video target tracking can:

1) Zoom in very close to allow visual identification (drone vs. bird, dangerous payload or not). Often times visual identification is necessary to allow countermeasures.

2) Cameras along with video target tracking can point effectors very accurately. Examples of effectors include: jammers, spotlights, net guns, kinetic weapons

Aircraft & Payload Identification

Video Tracking allows us to zoom in and "lock on" to follow the object precisely which allows visual identification
(drone vs. bird, dangerous payload or not).

Accurate Pointing

Cameras with video tracking afford the ability to accurately point effectors
(jammer, spotlight, net gun, etc…)

The ability to point accurately extends the effectors useful range.

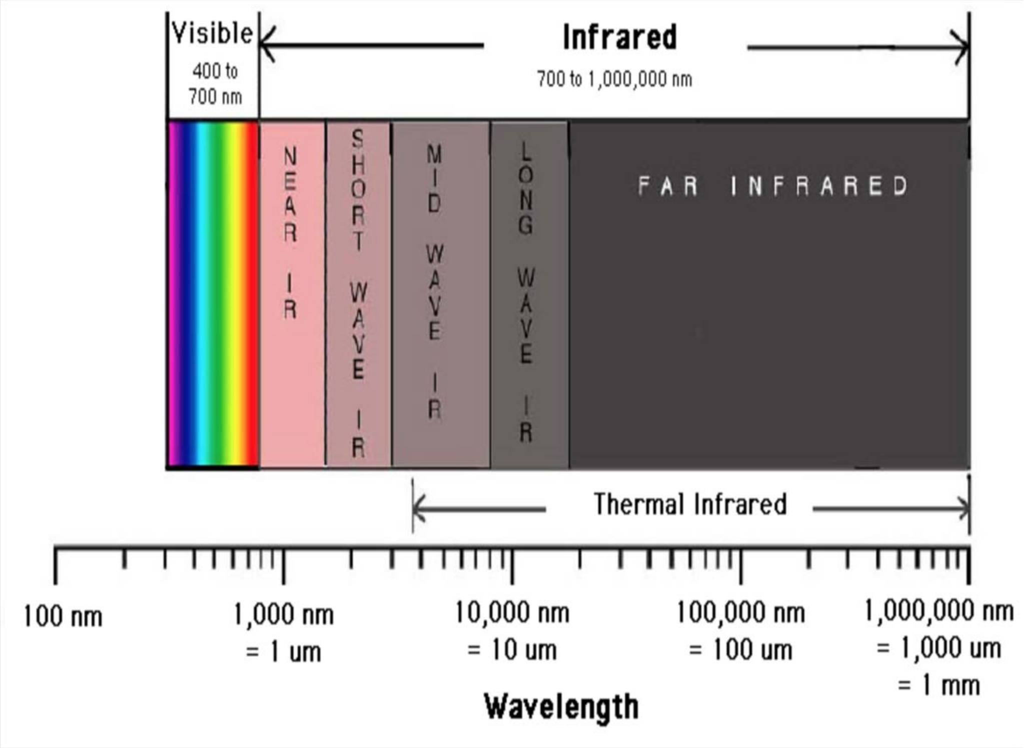
Examples:
Directional jamming antenna
Narrow beam spotlight

Successful video analysis is dependent on the nature of the imagery

EO (Electro Optical):
Daylight Camera

LWIR (Long Wave Infrared):
Uncooled Thermal

MWIR (Mid Wave Infrared)
Cooled Thermal



Capability Vs Price

Comparison of 'camera systems' (positioners w/ cameras)

Image	Type	IR Zoom	Target Spec	Range	Weight	Cost
	LWIR (uncooled)	100mm	DJI Phantom	~500m	25lbs	~$50k
	MWIR (cooled)	300mm	DJI Phantom	~1km	75lbs	~$120k
	MWIR (cooled)	825mm	DJI Phantom	~3km	160lbs	~$300k

Thermal Vs. Daylight

Objects tend to "pop out" in <u>thermal</u> imagery against the sky background.

This is useful in the transition from cuing to video tracking (benefit of IR over EO).

Cameras for CUAS

Good at:

Pinpointing on distant targets for:

1) Visual identification

2) Pointing effectors

Not good at:

Initial detection and wide area situational awareness

Mitigation

Darren McCarthy
A&D Technical
Marketing Manager
Rohde & Schwarz

Understanding the CUAS "Solution"

Detection

RF	• Monitoring of uplink/ downlink between radio-controlled (RC) drones and remote controls • Sensor: Antennas, receiver • Range: ~1 km - 3 km (depends on RC power, covers ≥ range of the RC)
DF	• Direction finding (bearing) of the drones and pilots • Sensor: DF antennas, direction finder • Range: ~1 km - 3 km (depends on RC power, covers ≥ range of the RC)
EO/IR	• Visualization/ image processing of drones • Sensor: HDTV video, cameras, IR camera • Range: nx 100 m (depends on the resolution of the optical sensors)
Radar	• Radar technology and doppler processing • Sensor: X Band radar • Range: classification: 1.1 km; detection: 3 km
Acoustics	• Audio capture and acoustical zoom for the acoustic emissions • Sensor: Microphone array system • Range: ~300 m

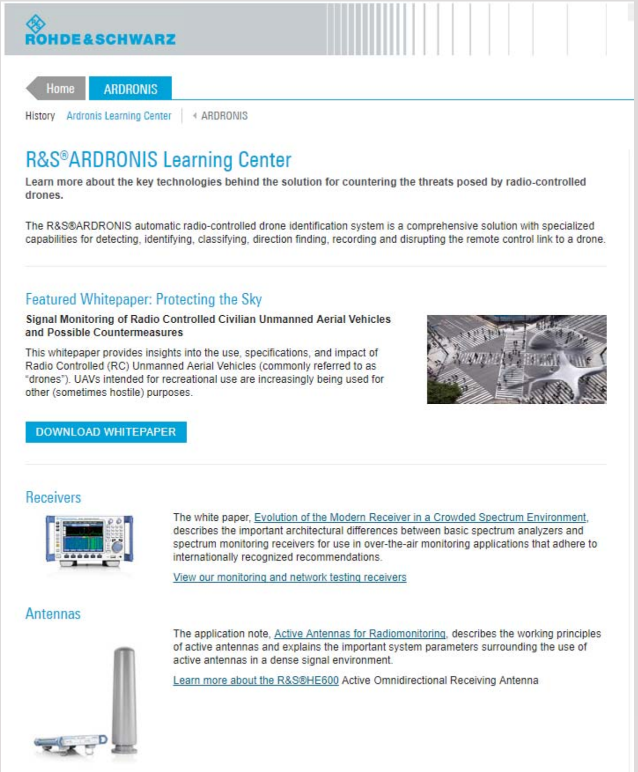
Mitigation

Smart Jammer	• Low power (2x 3W), selective follower jamming technology (other comm. signals unaffected) • Sensor: Omni/ directional antenna, smart jammer • Range: typically 2/3 of detection range
Barrage Jammer	• High power (>100 W), disrupt all comm. signals • Sensor: Tx antenna, barrage jammer • Range: several km (depends on power)
GNSS Jammer	• GNSS jamming • Sensor: antenna, signal generator • Range: > 1 km (depends on the power)
Laser/ EMP	• High energy laser, electro- magnetics pulse • Sensor: laser, high energy pulse • Range: ~300 m
Other	• Creative approach with net bazooka, eagle etc. • Sensor: projectile with net (net bazooka) etc. • Range: ~150 m (net bazooka)

Additional Resources

To find out more:

- Visit R&S®ARDRONIS Learning Center
- Download Whitepaper
- Or Contact Directly



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