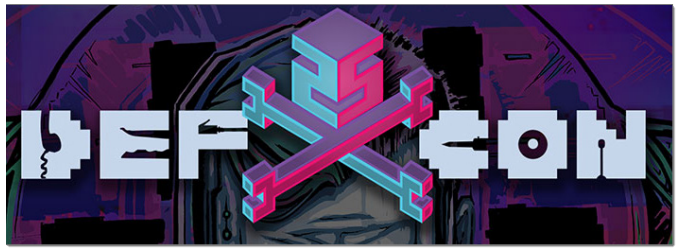
BISHOP FOX

THE DRONES ARE COMING

# Game of Drones

## PUTTING THE EMERGING 'DRONE DEFENSE' MARKET TO THE TEST

DEF CON 25 (2017) – LAS VEGAS, NV




**July 29, 2017**

Presented by:
- Francis 'tastic' Brown
- David Latimer

Bishop Fox, LLC
www.bishopfox.com

# Agenda

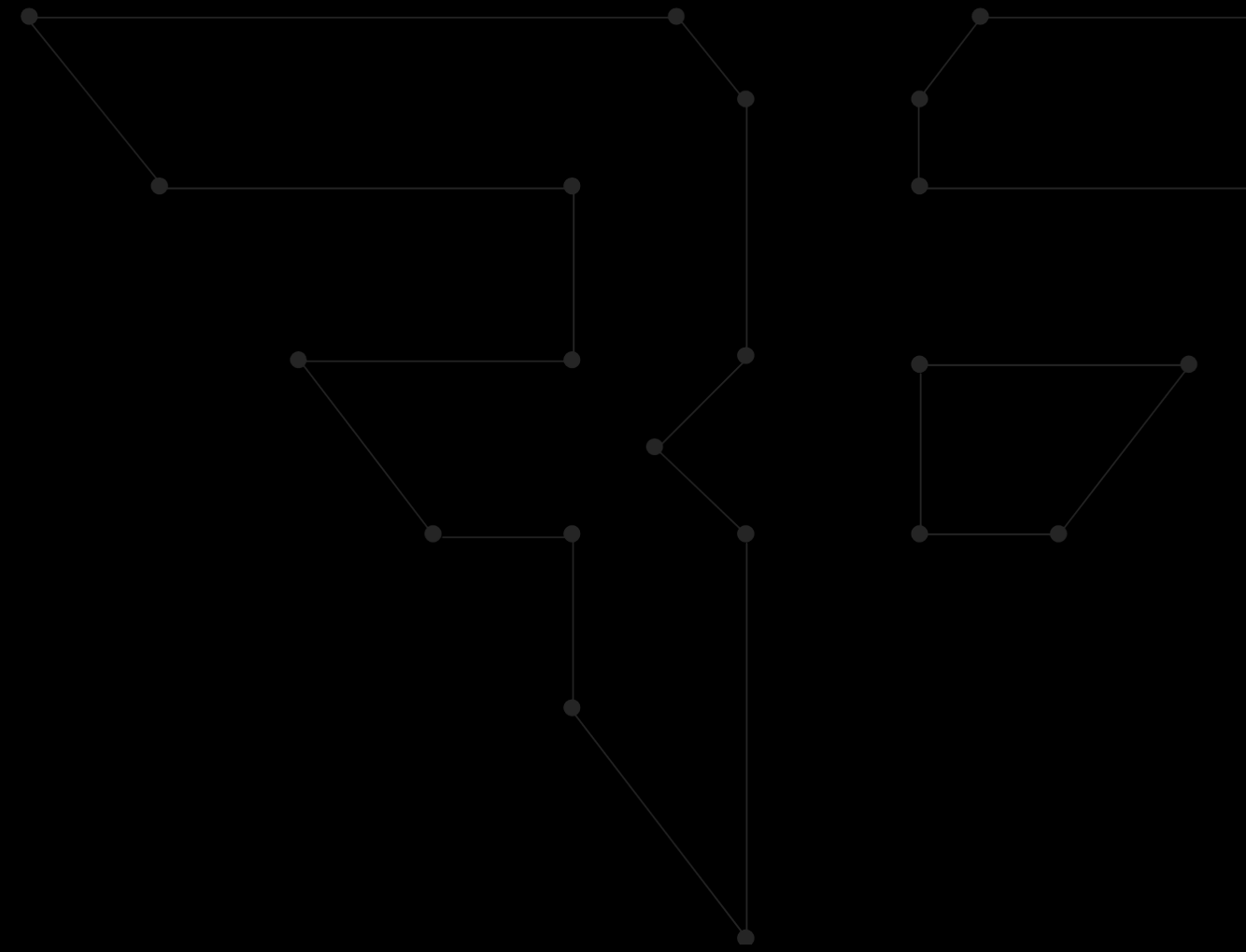
OVERVIEW

1. The Danger Drone by Bishop Fox
2. Crazy State of Drone Defense Market
3. Drone Legal Landscape
4. Future Is Gonna Be Awesome

# No Such Thing as Drone Defense 'Best Practices'

## MOTIVATIONS BEHIND THIS TALK

- Companies are beginning to implement **1st generation drone defense** solutions / products
  - Previous proof of concepts have already demonstrated that the threat is real
- There **are no 'best practices'** or proven methods for defense against drones
- **Practical pentesting tools** are needed to test the effectiveness of these new 'drone defense' deployments
  - Separating real countermeasures from **snake oil**
  - Must be cheap, easy to build, and easy to learn how to use **for security professionals**



# DANGER DRONE

FOR PENETRATION TESTERS

# Welcome to the Danger Drone

FREE PENTESTING DRONE FROM BISHOP FOX

- https://www.bishopfox.com/resources/tools/drones-penetration-testers/

DANGER DRONE

© BISHOP FOX

The Hacking Drone for Penetration Testers


**Raffle: http://tiny.cc/dangerdrone**

# Parts – Hacking 'Over the Air'

## HACKING PERIPHERALS – ADD-ON USB EXAMPLES

- Custom 3D printed "3rd shelf" is convenient for attaching hacking USB peripherals:


3D Printed 3rd Shelf

TP-Link TL-WN722N

# Parts – Hacking 'Over the Air'

## HACKING PERIPHERALS – ADD-ON USB EXAMPLES

- Wi-Fi
- Bluetooth
- RFID / NFC
- ZigBee
- Software Defined Radio
- Wireless Keyboard Sniffers
- …



SENA UD100 Bluetooth USB


Bluetooth 4.0 USB Micro
Adapter (CSR 8510 Chipset)


Wi-Spy DBx Pro –
USB Spectrum Analyzer

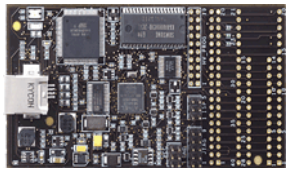

WiFi Pineapple Nano

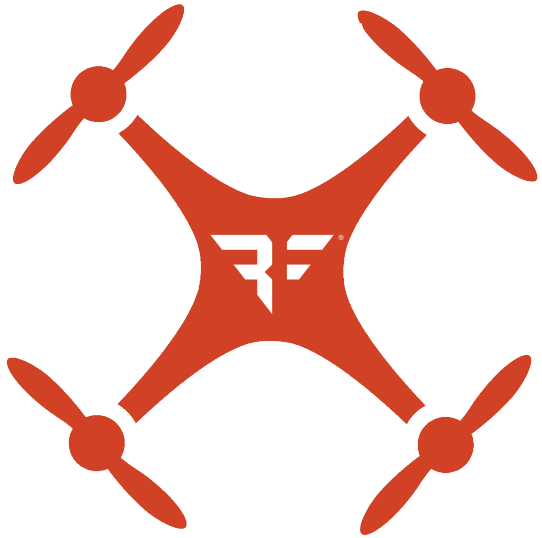

TP-Link TL-WN722N


Asus USB-N53
(dual band)


HackRF One:
Software Defined Radio

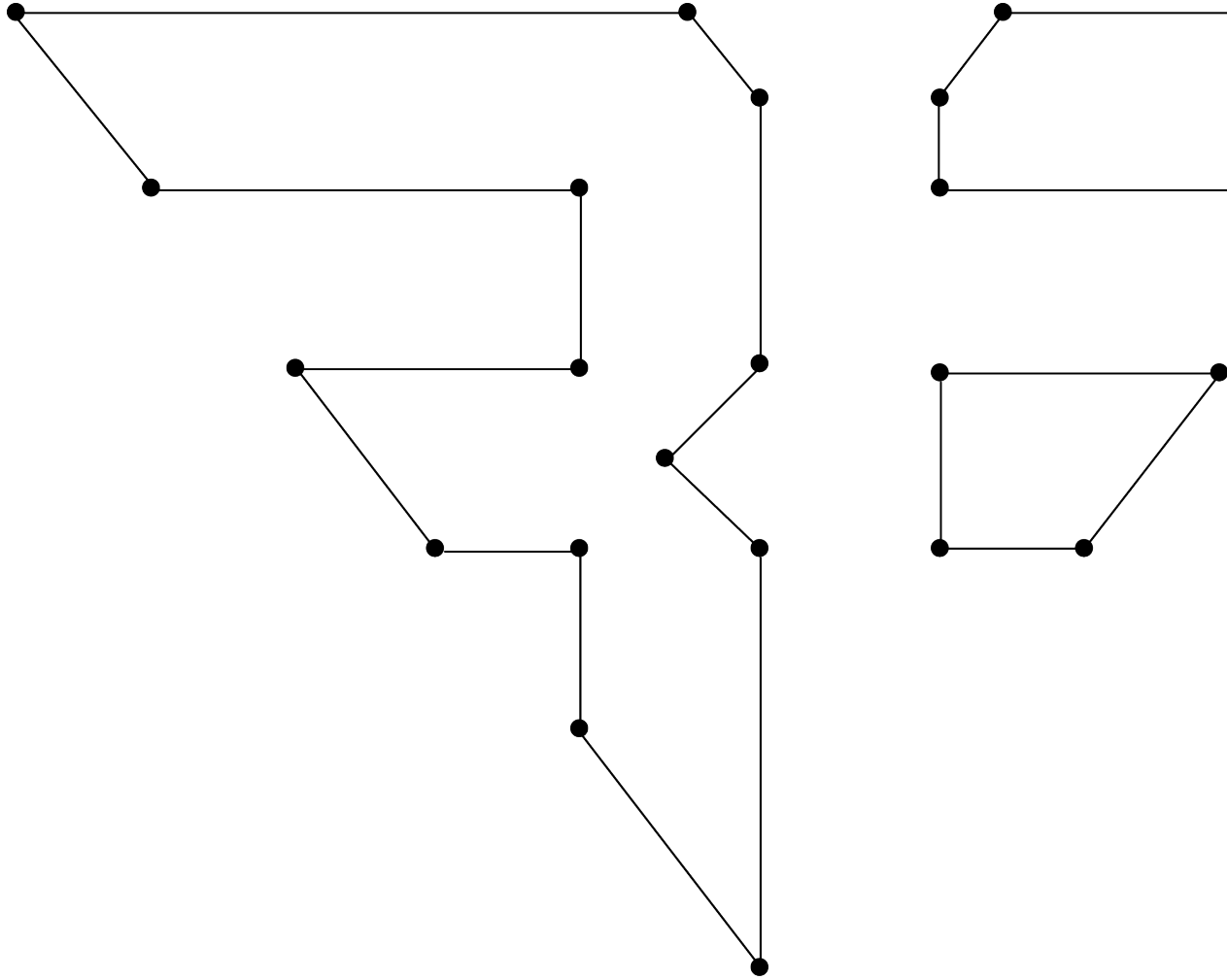
Atmel – ZigBee Hacking Gear



Danger Drone

# DEMO



# DEMO: Exploiting Wireless Mouse via Drone

## FLY-BY DRONE EXPLOITATION, HIT AND RUN HACKING

- http://dangerdrone.io/

DANGER DRONE

The Hacking Drone for Penetration Testers

+

Crazyradio 2.4Ghz nRF24LU1+ USB radio dongle with antenna


Bastille

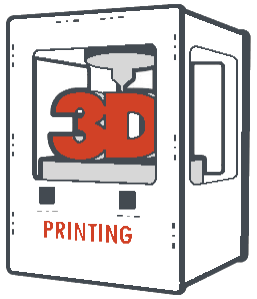
SECURITY FOR THE INTERNET OF RADIOS

https://github.com/insecurityofthings/jackit

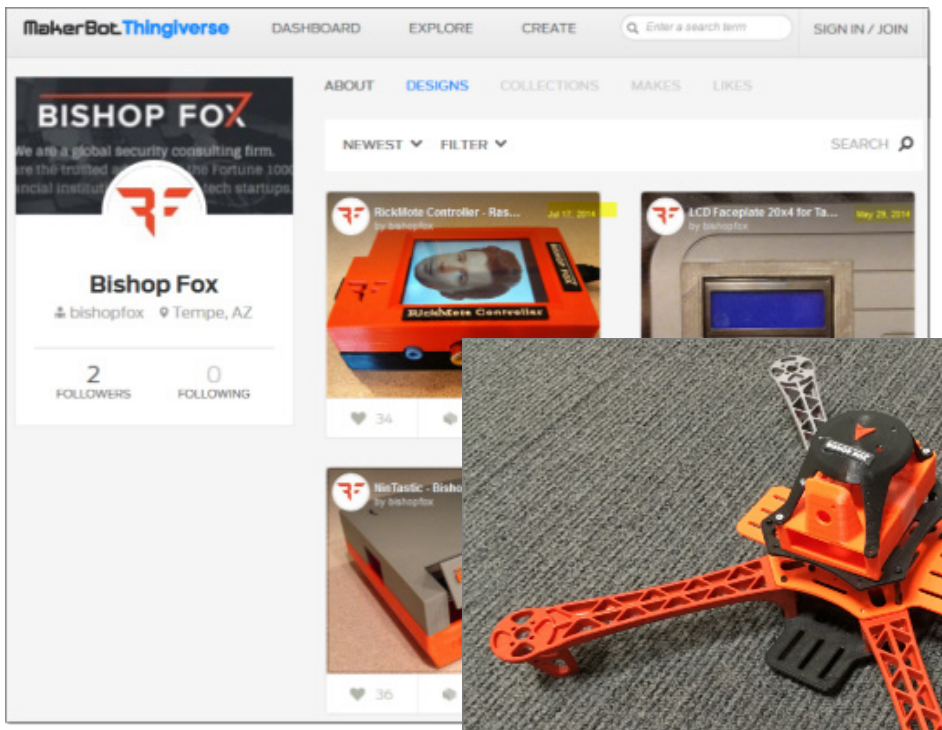
# 3D Designs

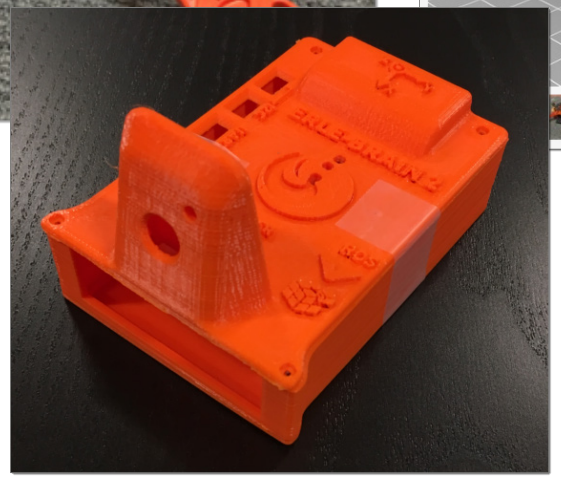
## CHEAPER, LIGHTER, AND CUSTOMIZABLE (EXTRA SHELVES / SPACE)

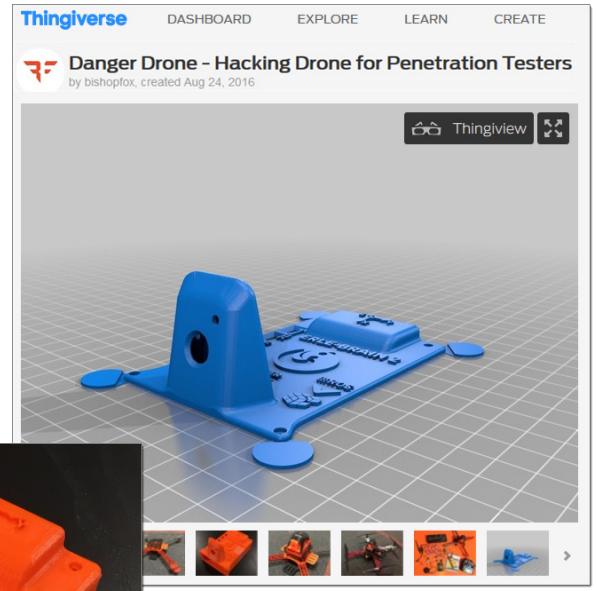
MakerBot Thingiverse




- http://www.thingiverse.com/bishopfox/designs
- 3D Print Parts - Danger Drone – Hacking Drone for Penetration Testers by bishopfox – Thingiverse



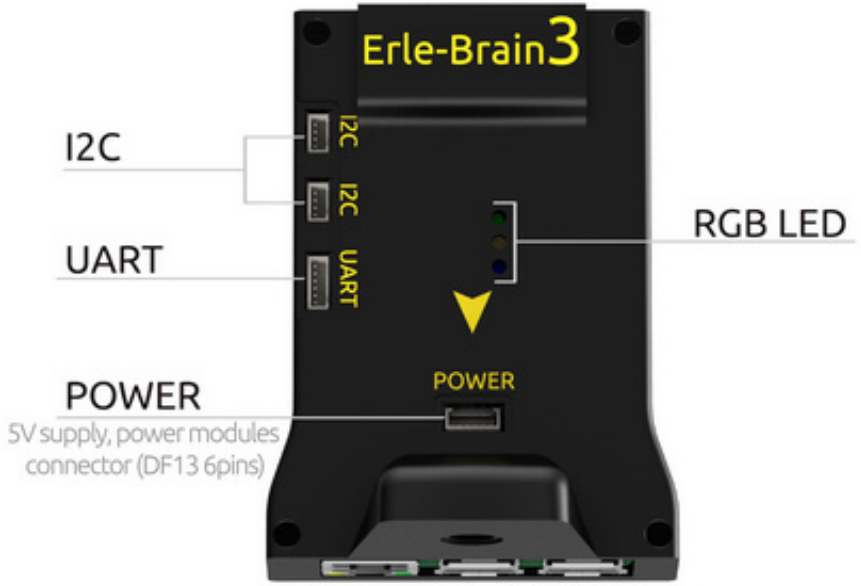


# Drone Brain = Raspberry Pi

HEAVILY SUPPORTED IN **DRONE** AND **HACKER** COMMUNITIES

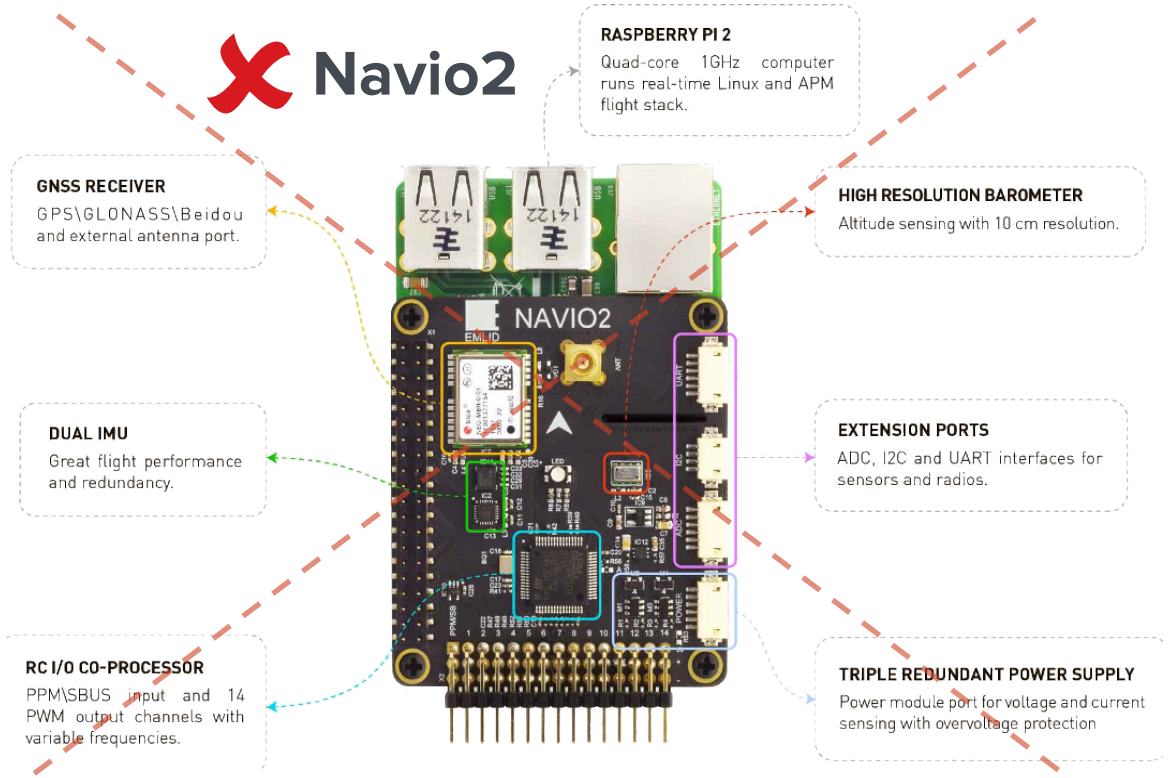
- Raspberry Pi based copters have the obvious appeal of being heavily developed and supported by both the drone and hacker communities.
- The 2 most popular Raspberry Pi based flight controllers are the **Erle-Brain 3** and the **Navio 2**:

## Erle-Brain 3




http://erlerobotics.com/blog/product/erle-brain-3/

## Navio2



# Parts and Pieces – Piecemeal

## CHEAPER TO BUILD YOURSELF - SLIGHTLY

- Essentially starting with working / flying Erle-Copter and then adding hacking capability (without breaking flying ability):
  - Adding Hardware – e.g. USB peripherals to Raspberry Pi, shelves
  - Adding Software – e.g. drivers, config changes, installs, etc.

$490.53


**Danger Drone - Individual Parts Costs**

| # | Description | Cost | Product Link |
|---|---|---|---|
| 1 | Flight Controller | $199.00 | Erle Brain 2, a Linux brain for robots and drones |
| 2 | GPS | $50.68 | Ublox Neo-M8N GPS with Compass |
| 3 | RC Controller and Receiver | $49.00 | Turnigy TGY-i6 AFHDS Transmitter and 6CH Receiver (Mode 2) |
| 4 | Motors x4 | $45.99 | Tiger Motors 6th Anniversary Limited Edition 4x MN2213 Motors + 2 p |
| 5 | Telemetry | $40.88 | HobbyKing - HKPilot Transceiver Telemetry Radio Set V2 (915Mhz) |
| 6 | Battery (4 cell) | $39.99 | FLOUREON 4S 35C 14.8V 5500mAh Li-Polymer RC Battery Pack (5.98* |
| 7 | ESCs x4 | $23.57 | Amazon - Andoer 4Pcs Simonk 30AMP 30A SimonK Firmware Brushles |
| 8 | Frame (F450) | $19.99 | Amazon.com - RipaFire F450 4-Axis Multi-Rotor Quadcopter Flame Airf |
| 9 | Power Module | $14.29 | Amazon - Ericoco Power Supply Module w/BEC APM2 2.5 APM Flight C |
| 10 | PPM Encoder | $7.14 | HobbyKing - PPM Encoder Module HKPilot 32 |
| | | | |
| | Total: | $490.53 | |

Bishop Fox – Danger Drone Research – Parts Lists, Assembly, and Config Guidance see:

- https://www.bishopfox.com/resources/tools/drones-penetration-testers/

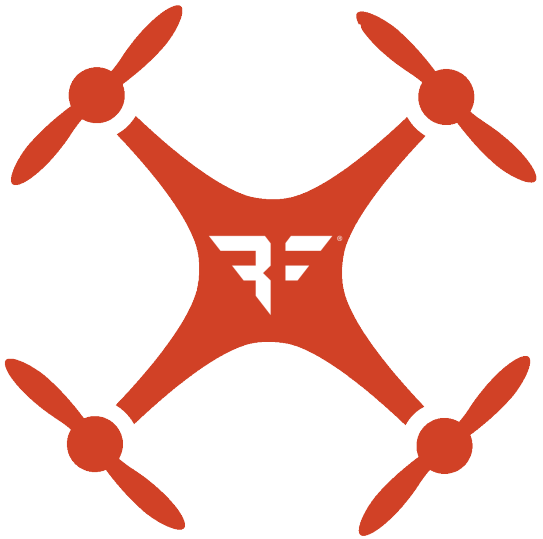
# IoT = Target Rich Environment

LOTS OF NEW TARGETS FOR '**OVER THE AIR**' ATTACKS

- Ideal platform to launch 'over the air' attacks against new IoT products popping up in both the home & office
- Drone hacking threats need to be considered by consumers, security pros, and **IoT product manufacturers**


Internet of Things (IoT)

+



Danger Drone

=


Target Rich Environment

# IN THE NEWS

## DRONE-STRAVAGANZA

# Data Exfiltration Via Drones and Lights

THREATS EVOLVING, NOW DEFENSES NEED TO AS WELL


Feb 2017

## Researchers exfiltrate data by blinking the LEDs on the hard drives

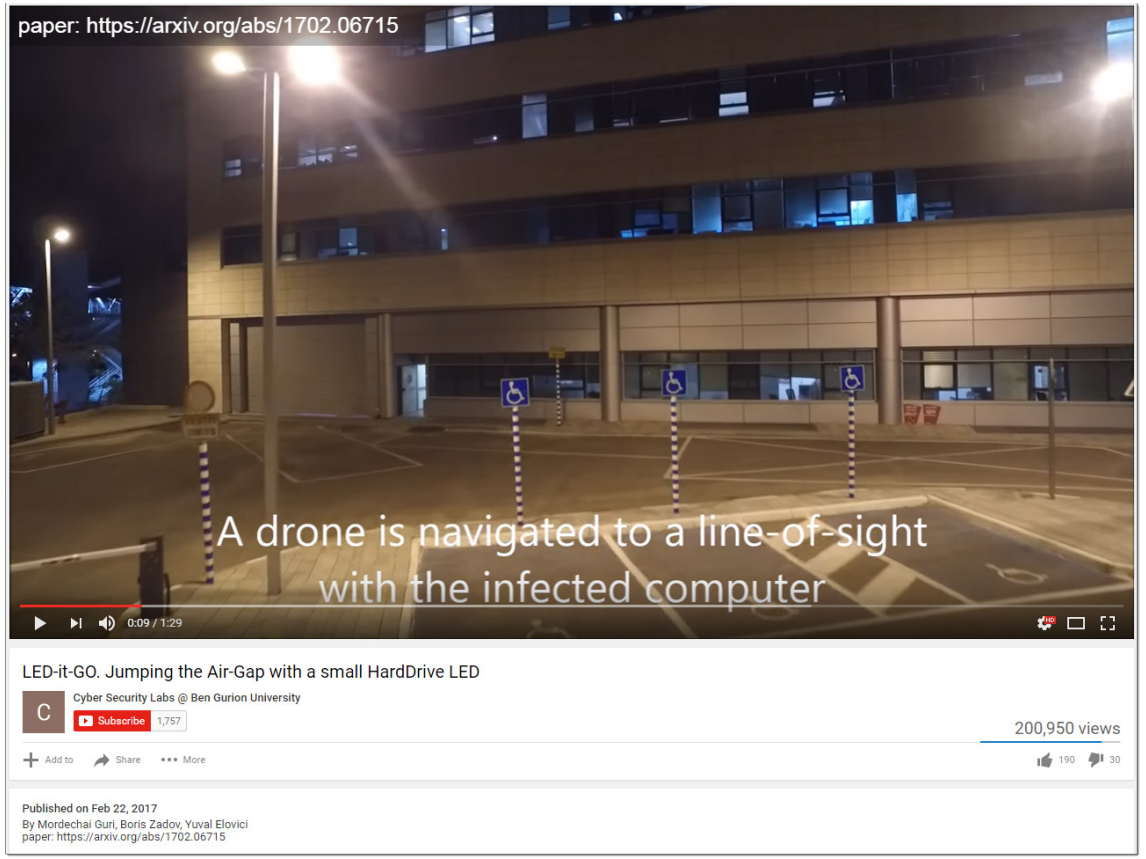
February 23, 2017 By Pierluigi Paganini

### A team of Israeli researchers has devised a new technique to exfiltrate data from a machine by using a malware that controls hard drive LEDs.

Across the years, numerous studies demonstrated that it is possible to exfiltrate data from air-gapped networks in various ways and security experts warned to cover our webcam to avoid being spied by sophisticated malware.

Now a group of researchers from Ben-Gurion University of the Negev's Cyber Security Research Center has devised a new technique to exfiltrate data from a machine by using a malware that controls hard drive LEDs.

*"We show that a malware can indirectly control the HDD LED, turning it on and off rapidly (up to 5800 blinks per second) – a rate that exceeds the visual perception capabilities of humans. Sensitive information can be encoded and leaked over the LED signals, which can then be received remotely by different kinds of cameras and light sensors." reads the paper published by the researchers. "Compared to other LED methods, our method is unique, because it is also covert – the HDD activity LED routinely flickers frequently, and therefore the user may not be suspicious to changes in its activity."*




SecurityAffairs.co - Researchers exfiltrate data with drone by blinking the LEDs on the hard drives - 23Feb2017

- http://securityaffairs.co/wordpress/56583/breaking-news/data-exfiltration-hdd-leds.html

# Military and Drones

## THREATS EVOLVING, NOW DEFENSES NEED TO AS WELL


Mar 2017

[The Verge - A US ally shot down a $200 drone with a $3 million Patriot missile - 16Mar2017]

### A US ally shot down a $200 drone with a $3 million Patriot missile

*This will be a bigger problem as more drones show up on the battlefield*

by Andrew Liptak | @AndrewLiptak | Mar 16, 2017, 10:13am EDT


**USING A $3.4 MILLION MISSILE TO DESTROY A CIVILIAN DRONE IS OVERKILL**

Earlier this week, General David Perkins, the commander of the US Army Training and Doctrine Command (TRADOC) spoke at the Association of the US Army's Global Force symposium, where he discussed the threats that the US military would begin to face in the coming years. One notable example is how a US ally recently shot down a $200 consumer drone with a Patriot Missile.

Perkins' talk during the symposium focused on the complexity of a military organization in the field, and how the interconnected nature of air, ground, and sea forces can lead to a fragmented response to a threat between the commanders who are in charge of specific areas. He specifically spoke about the necessity for commanders to address threats holistically. He used one specific example of how this occurs on the battlefield: hostile, civilian Unmanned Aerial Systems (UASs). "The gut instinct was," he explains, "that's an air defense problem, because they're in the air."

*This drone was used by Iraqi government forces against ISIS in Mosul. It shows the the weapon carriage and arming method, using two attachments. The weapons are maintained safe and could be armed just before takeoff.*

*"Flying IED's"*

# Prison Break Thanks to Drone

## DRONE-SHANK REDEMPTION


July 2017

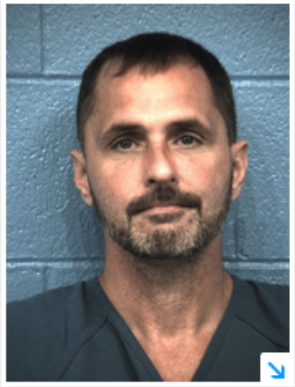
[USA Today - Jimmy Causey, escaped inmate, likely used wire cutters dropped by drone - 07July2017]

USA TODAY

Search

**Prison officials say escaped inmate likely used wire cutters dropped by drone**

Doug Stanglin , USA TODAY Published 2:38 p.m. ET July 7, 2017 | Updated 3:05 p.m. ET July 7, 2017



(Photo: Williamson County, Texas, jail via AP)

A fugitive South Carolina inmate recaptured in Texas this week had chopped his way through a prison fence using wire cutters apparently dropped by a drone, prison officials said Friday.

Jimmy Causey, 46, fled the Lieber Correctional Institution in Ridgeville, S.C., on the evening of July 4th after leaving a paper mache doll in his bed to fool guards into thinking he was asleep. He was not discovered missing until Wednesday afternoon.

Causey was captured early Friday 1,200 miles away in a motel in Austin by Texas Rangers acting on a tip, WLTX-TV reported.

Officers found a semi-automatic handgun, shotgun, ammo, four cell phones and $47,000 in cash on Causey, who also carried a South Carolina ID.

"We believe a drone was used to fly in the tools that allow(ed) him to escape," South Carolina Corrections Director

"*Prison Break via Drone*"

# Fire Crews Forced to ‘Let It Burn’ in Arizona

FIRST RESPONDERS AND EMERGENCY SERVICES NEED DRONE DEFENSES

July 2017

[AZCentral.com - Arrest made in drone flights over Goodwin Fire - 01July2017]

*The face of the new threat of rogue drones.*

azcentral.
PART OF THE USA TODAY NETWORK

## Arrest made in drone flights over Goodwin Fire

BrieAnna J Frank, The Republic | azcentral.com Published 3:04 p.m. MT July 1, 2017

(Photo: Yavapai County Sheriff's Office)

A 54-year-old Prescott Valley man suspected of flying a drone that grounded Goodwin Fire firefighting efforts last week has been arrested.

The Yavapai County Sheriff's Office reported Saturday that Gene Alan Carpenter was arrested on charges of endangerment and unlawful operation of an unmanned aircraft.

Carpenter is accused of endangering 14 aircraft and air crews as well as ground fire crews with a "substantial risk of imminent death or physical injury" by flying a drone in the fire's airspace.

**RELATED:** Drone forces firefighting aircraft at Goodwin Fire to land

The Arizona Legislature and Gov. Doug Ducey last year passed a law making it illegal for a drone to interfere with emergency or law-enforcement efforts. There are also federal laws regulating drone flights.

AZ - SB 1449 - Drone Law - May2016 - Crime for drones to interfere with law enforcement or emergency operations

- https://apps.azleg.gov/BillStatus/BillOverview?billnumber=1449&Sessionid=115

# DRONE DEFENSE MARKET

EMERGING MARKET OVERVIEW

# Drone Defenses - Categories

BY PRODUCT TYPE - EMERGING LEADERS IN 'ROGUE DRONE' DEFENSE

PREDATOR BIRD

DRONE NETTING

DRONE SHOOTING

DRONE SHOOTING

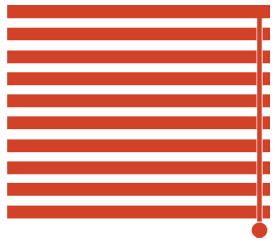
JAMMING

EMP

CYBER

GEOFENCING

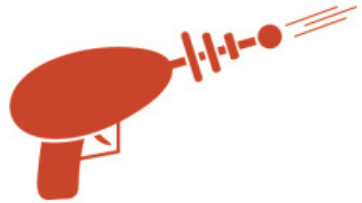
NO-FLY ZONES



SHUTTERS

CONFETTI GUN

MISSILE



LASER

# Examples: Common Drone Defenses

INSIDE LOOK AT WHO ARE CONSIDERED EMERGING LEADERS IN 'ROGUE DRONE' DEFENSE

*Eagles Trained to Hunt Drones*

*Net Cannons*


*Hunter Drones Shooting Nets*

*Drones Swooping with Big Nets*


*Jammer Cannons*

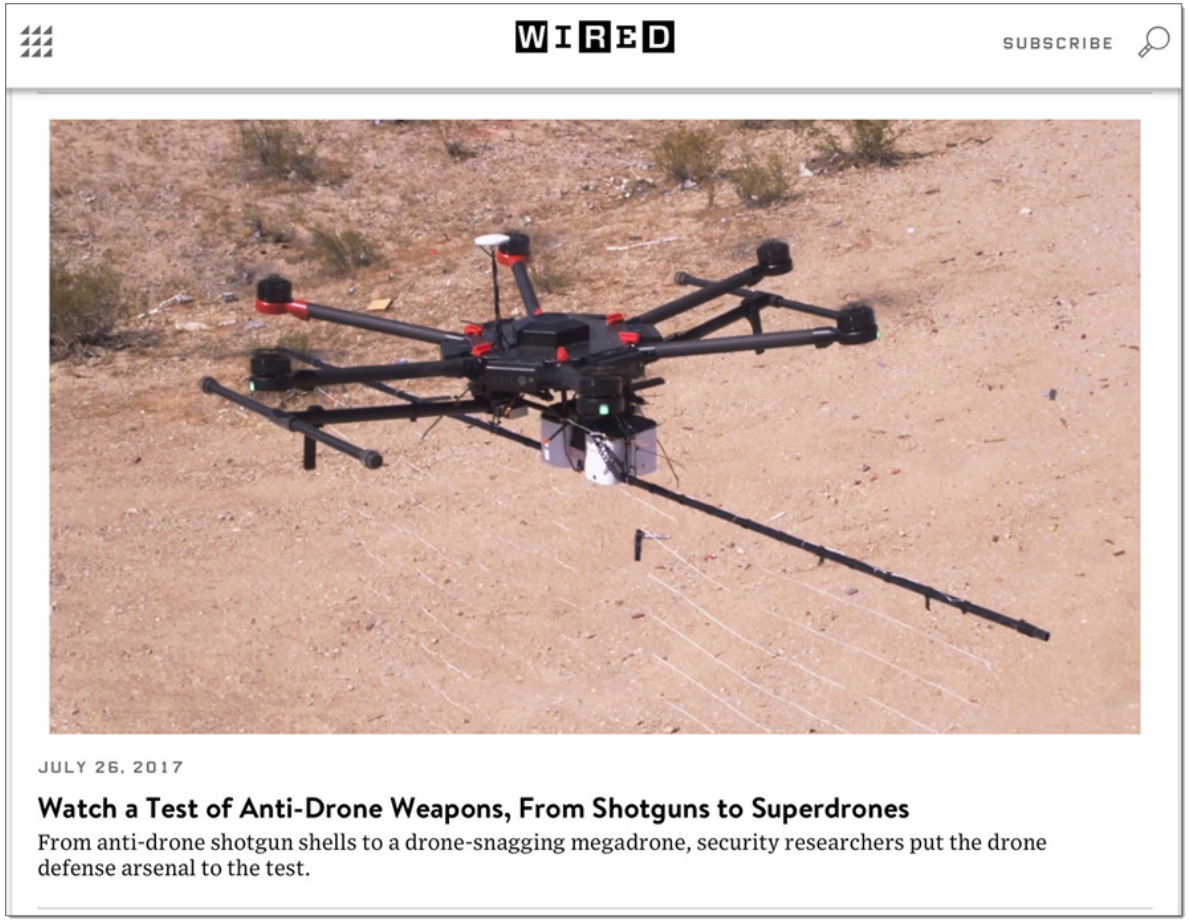
*Hunter Drones Shooting Nets*

# Exclusive Video: Drone Defenses Testing

BISHOP FOX WENT TO THE DESERT TO TEST DRONE DEFENSE PRODUCTS

https://www.wired.com/story/watch-anti-drone-weapons-test/

https://www.youtube.com/watch?v=jlGdPrhRvBA




+ WIRED

# Drone and Defenses Markets Growing

## EVERYONE WANTS A PIECE OF THAT FUTURE ANTI-DRONE DEFENSE MARKET $$$

**Fortune.com - Drone Sales Are about To Go Crazy - FAA Projects Drone Sales To Soar By 2020 - 25Mar2016**

- "*The FAA believes that 2017 will be the big turning point in drone adoption by businesses, which use them for everything from scanning power lines to inspecting rooftops for insurance companies. Commercial sales are expected to reach 2.5 million, after which sales will increase only slightly for the next few years.*" -- Forbes

**https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/Unmanned_Aircraft_Systems.pdf**

- "*Drone sales are expected to grow from 2.5 million this year to 7 million in 2020, according to report released this week by the Federal Aviation Administration... Hobbyist sales will more than double from 1.9 million drones in 2016 to 4.3 million in 2020, the agency said. Meanwhile, business sales will triple over the period from 600,000 to 2.7 million.*"

http://blog.executivebiz.com/2016/03/reportlinker-global-anti-drone-market-to-reach-1-14b-by-2022/

### ReportLinker: Global Anti-Drone Market to Reach $1.14B by 2022

Posted By: Ramona Adams on: March 17, 2016 In: Industry News, News Print Email

MarketsandMarkets' new report on the global counter-drone systems market states that the anti-drone industry is projected to reach $1.14 billion by 2022 and achieve a 23.89 percent compound annual growth rate from 2017 to 2022.

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**Exhibit 7: Recent Anti-Drone Funding** https://www.droneshield.com/sites/default/files/JAW_Drop_V27_04-25-17.pdf

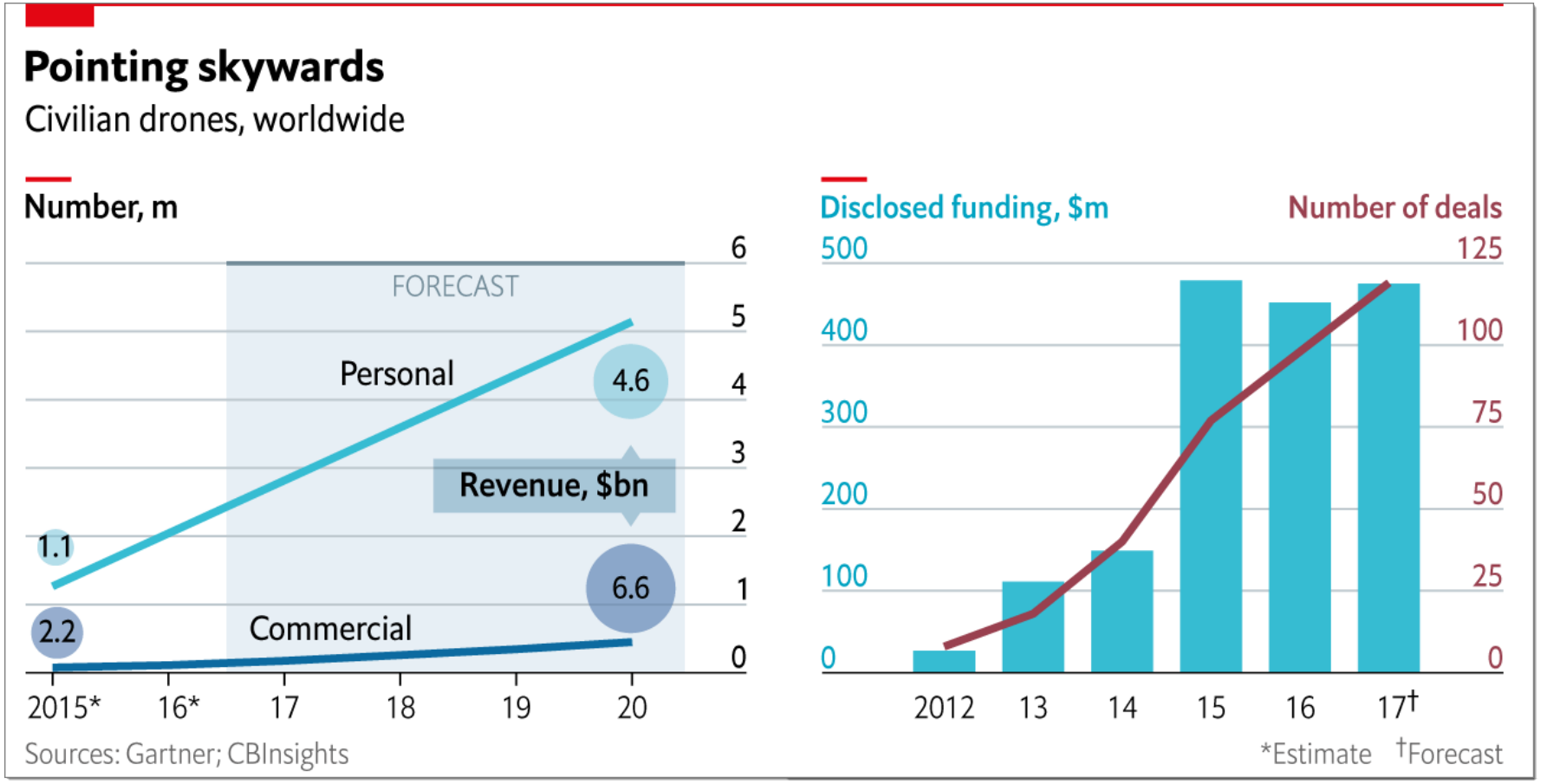
| Date | Company | Type | Amount | Total Raised |
|---|---|---|---|---|
| 2/1/16 | Advanced Protection Systems | Grant | $750k | $1.0m |
| 4/20/16 | SkySafe | Seed | $3m | $3.0m |
| 5/17/16 | Dedrone | Series A | $10m | $12.9m |
| 6/22/16 | DroneShield | Venture | ~$5.3M USD | ~$6.3M USD |
| 8/22/16 | Quanergy Systems | Series B | $90M | $135.3m |
| 8/24/16 | ApolloShield | Seed | $500k | $120k |
| 11/18/16 | Airspace Systems | Seed | $5m | $5.0m |
| 1/15/17 | Advanced Protection Systems | Grant | $500k | $1.5m |
| 2/2/17 | SRC, Inc. | US Army Contract | $65M | - |
| 2/13/17 | Dedrone | Series B | $15m | $27.9m |

Source: Crunchbase.com; Angelist.com; Company reports; Oppenheimer & Co. Inc.

# Drone and Defenses Markets Growing

EVERYONE WANTS A PIECE OF THAT FUTURE ANTI-DRONE DEFENSE MARKET $$$

[The Economist - Taking flight - Civilian Drones - 08Jun2017]



# Drone Defenses Gone Wild

## INSIDE LOOK AT WHO ARE CONSIDERED EMERGING LEADERS IN 'ROGUE DRONE' DEFENSE

| 1. Drone Detection & Alerting Systems | 2. Air-to-Air: Fighter Drones That Hunt & Shoot Nets at Drones | 7. Jamming Cannons Shooting Signals or EMPs |
|---|---|---|
| 3DEO - LIDAR Detection | Airspace Systems - One-Touch Interceptor | Advanced Protection Systems (DetectDrones.com) - SafeSky |
| Aaronia - Drone Detector | DelftDynamics.nl - DroneCatcher | Battelle - DroneDefender |
| Adsys Controls Inc - Sat32 | Fortem - DroneHunter - (Formerly Excipio - theissuav.com) | Blighter - AUDS (Anti-UAV Defence System) |
| Anti-Drone.eu – GROK | Michigan Tech - Robotic Falconry | China's $19k Drone-Jamming Gun |
| Aveillant - Gamekeeper 16U - Holographic Radar | Search Systems - SparrowHawk Phase One C-UAV | CTS Technology - Drone Jammer Gun |
| Black Sage - BST-UAVX (built with SpotterRF) | **3. Air-to-Air: Drones with Large Nets That Swoop in & Snag** | Digital RF - Cell-block |
| C Speed LLC - LightWave Radar | Malou Tech - Drone Interceptor MP200 | Drone Defense UK - Dynopis E1000MP |
| CACI - SkyTracker | Search Systems - SparrowHawk v2 C-UAV (2017) | DroneShield - DroneGun |
| CerbAir - DroneWatch | Tokyo Police - Drone Interceptor | H.P. Wüst - T-Series - RCIEDD Jammers |
| Chess Dynamics Ltd - AUDS | **4. Surface-to-Air Projectiles: Shooting Nets from the Ground** | Hensoldt.net (formerly Airbus) - Xpeller C-UAV |
| DDC LLC - Domestic Drone Countermeasures | BigUrb - Tactical Net Gun | HiGH + MiGHTY (Anti-Drones.net) - SKYNET Rifle |
| DeDrone.com - DroneTracker | CODA Enterprises - Net Gun | Liteye Systems - AUDS C-UAV |
| DeTect - DroneWatcher | DIY - Drone Net Gun | MAKE - Build a Raspberry Pi Drone Gun |
| Digital Global Systems (DGS) - SigBASE | Drone Defense UK - Net Gun X1 | MC2 Technologies - Scrambler 300 Rifle |
| Dronatec - D-FENCE | OpenWorks Engineering - SkyWall 100 Launcher | MCTECH - MC-HORIZON |
| Drone Labs, LLC - DroneDetector.com | SkyNet - 12 Gauge Shotgun Shell Nets for Drones | Radio Hill - Block 3 Dronebuster and Dronebuster-LE |
| DroneShield - FarAlert/WideAlert Sensors | Snake River Shooting Products - Drone Munition - 12 Gauge | SESP Group - Drone Defeater |
| Gryphon Sensors - Skylight | The Net Gun (thenetgunstore.com) | **8. Laser Guns – "Directed Energy" Weapons** |
| Kelvin Hughes Limited - SharpEye SxV Radar | X Products - Can Cannon (w Net Gun Ammo) | Boeing - Compact Laser Weapons System |
| Microflown AVISA - Skysentry AMMS | **5. Remotely Hacking Command & Control Signal to Hijack** | Lockheed Martin - ALADIN/ATHENA/ICARUS |
| Mistral Solutions - Sky Archer | AeroTargets International - Gnat C-UAS | MBDA - Laser Effector |
| ORELIA - Drone-Detector | ApolloShield - CyberBox and Command Center | Poly Technologies - Silent Hunter |
| Quanergy Systems - Q-Guard - LiDAR X-Drone | Department 13 - Mesmer | Rafael - Iron Beam |
| Rinicom - SKY PATRIOT | Drone Go Home (DGH) | Raytheon - Phalanx CIWS |
| Rinicom and METIS Aerospace - SKYPERION | Elbit Systems - ReDrone | Rheinmetall - Oerlikon Skyshield |
| ROBIN Radar Systems - ELVIRA | Israel Aerospace Industries (IAI) - ELTA Systems - Drone Guard | U.S. Navy - XN-1 LaWS - AN/SEQ-3 Laser Weapon System |
| Rohde & Schwarz - R&S ARDRONIS-I | Leonardo-Finmeccanica - Selex ES - Falcon Shield | **9. Other** |
| SAAB Group - Giraffee AMB Radar - ELSS | Maldrone - First Backdoor for Drones | Confetti Guns |
| Sensofusion - AIRFENCE | SkyJack - Samy.pl | Patriot Missiles - $3 million |
| SpotterRF - A2000 Radar UAVX | SkySafe | |
| Squarehead Technology - DiscovAir | SRC, Inc. - Silent Archer | |
| TCI International - Blackbird | **6. Falcons & Eagles That Hunt Drones** | |
| Thales - SQUIRE | Guard From Above - Drone Hunting Eagles | |

**Drone Defenses:**

- **~89** products researched

89

# More Pricing and Comparisons

## PUBLIC EVALUATIONS OF ANTI-DRONE DEFENSIVE PRODUCTS

[DronesX.com - The Anti-Drone Revolution - 22 Companies Building Killer Drone Tech Today - 07Jan2017]

[MarketsandMarkets.com - Anti-Drone Market by Technology - 2022 - Feb2016]

**TABLE 65** ANTI-DRONE MARKET- COMPETITIVE ANALYSIS, 2014–2015

http://www.marketsandmarkets.com/Market-Reports/anti-drone-market-177013645.html

| Company Name | Launch Date | Unit Price (USD) | Technology |
|---|---|---|---|
| The Boeing Company (U.S.) | October 2015 | 11,000,000 | Laser System |
| Lockheed Martin Corporation (U.S.) | October 2015 | NA | Electronic System |
| Israel Aerospace Industries (Israel) | October 2015 | NA | Electronic System |
| Raytheon Company (U.S.) | October 2014 | 6,360,000 | Laser Systems |
| Dedrone GMBH (Germany) | October 2015 | NA | Electronic System |
| Orelia (France) | October 2015 | 36,000 | Electronic System |
| Rafael Advanced Defense Systems Ltd. (Israel) | October 2015 | NA | Laser System |
| Airbus Group SE (Netherlands) | September 2015 | 500,000 | Electronic System |
| Saab AB (Sweden) | September 2015 | NA | Electronic System |
| Thales Group (France) | September 2015 | NA | Electronic System |
| Rheinmetall Defense Electronics GmbH (Germany) | September 2015 | NA | Laser System |
| Selex ES SPA (Italy) | September 2015 | 311,000 | Electronic System |
| SRC Inc. (U.S.) | August 2015 | NA | Electronic System |
| DDC-LLC (U.S.) | June 2014 | 40,000 | Sensors/Acoustic |
| Droneshield (U.S.) | May 2015 | 5000 | Sensor Systems |
| Blighter Surveillance Systems (U.K.) | May 2015 | 1,200,000 | Electronic System |
| Search Systems Ltd. (U.K.) | May 2015 | NA | Electronic System |
| China Jiuyuan Hi-Tech Equipment Corporation (China) | November 2014 | NA | Laser System |
| Pwnie Express (U.S.) | NA | 1,500 | Anti-hacking solutions and software |
| Detect, Inc. (U.S.) | NA | NA | Electronic System |

*Source: Annual Reports, Press Releases, and MarketsandMarkets Analysis*

**Table 35: Detection and tracking systems evaluation results**

| | Weighted Performance Score | Minimum Durability Standards | Initial Cost ($ k) | Operational Cost ($ k) | Recommendation Notes |
|---|---|---|---|---|---|
| DeTect, DroneWatcher | 83.8* | Meets Standards* | 400 | 22 | Strong |
| Gryphon Sensors, Skylight | 80.0 | Meets Standards | <1000 | 50 | Strong |
| Adsys Controls, SATS2 | 74.5 | Meets Standards | 200 | 20 | Strong |
| Drone Go Home | 71.9 | Meets Standards* | 0 | 54 | Acceptable |
| Gryphon Sensors, Hawk | 68.9 | Meets Standards | 235 | 15 | Acceptable |
| Robin Radar Systems, ELVIRA | 67.7 | Meets Standards | 190 | 28 | Acceptable |
| C Speed, LightWave Radar | 64.7* | Meets Standards | <1000 | 20 | Acceptable |

**Table 36: Interdiction systems evaluation results**

| | Weighted Performance Score | Minimum Durability Standards | Initial Cost ($ k) | Operational Cost ($ k) | Recommendation Notes |
|---|---|---|---|---|---|
| HiGH + MiGHTY, SKYNET | 70.2* | No | 35 | unknown | Unacceptable* |
| Battelle, DroneDefender | 59.6 | Meets Standards | unknown | unknown | Acceptable* |
| Theiss, EXCIPIO | 54.7 | No | 12 | unknown | Unacceptable* |
| OpenWorks, SkyWall | 46.0* | No* | unknown | unknown | Unacceptable |

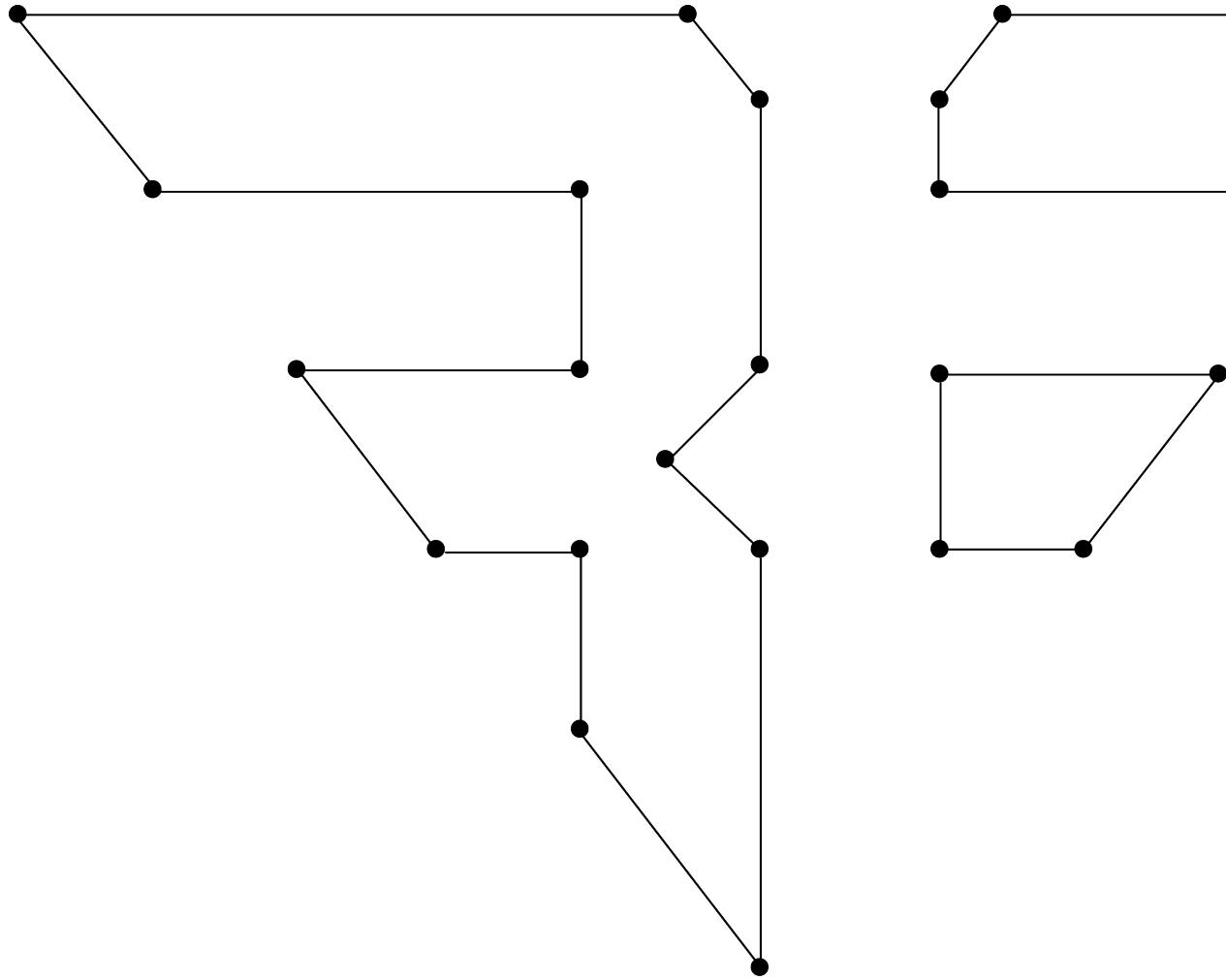
**Table 37: Detection and interdiction hybrid systems evaluation results**

| | Weighted Performance Score | Minimum Durability Standards | Initial Cost ($ k) | Operational Cost ($ k) | Recommendation Notes |
|---|---|---|---|---|---|
| Liteye, AUDS | 82.5* | Unknown* | unknown | unknown | Strong |
| Airbus, Counter UAV System | 77.5* | Meets Standards | unknown | unknown | Strong |
| R&S, ARDRONIS-1 | 72.6* | Meets Standards* | 700 | unknown | Strong |
| DeDrone, DroneTracker | 72.4* | Meets Standards* | unknown | unknown | Acceptable |
| Department 13, MESMER | 72.2* | Meets Standards | 200 | 400 | Acceptable |

UMassTransportationCenter.org - Final_Report_Counter_Drone.pdf – 24 Jan 2017

- http://www.umasstransportationcenter.org/Document.asp?DocID=281

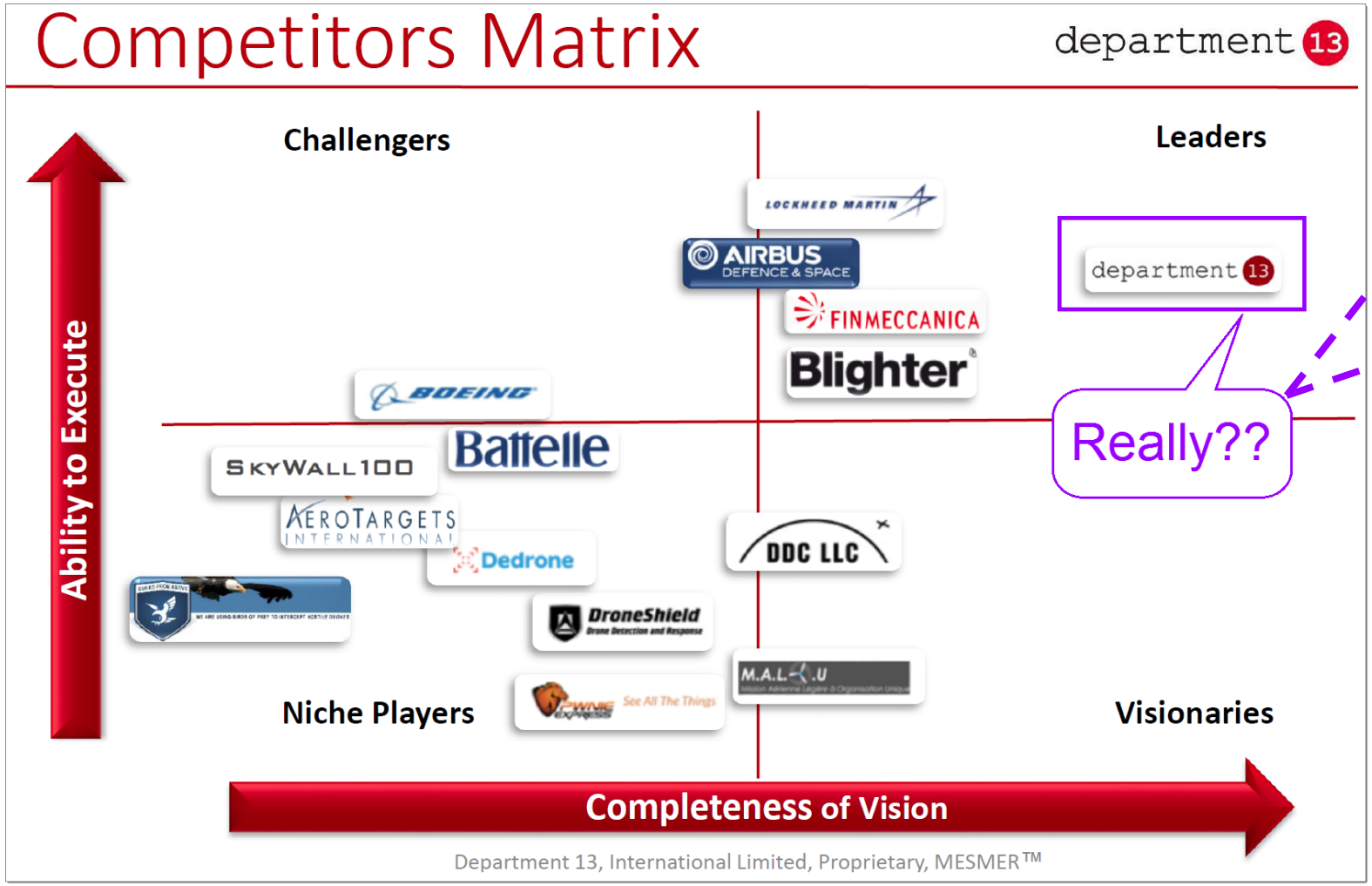
MESMER
COUNTER DRONE
DEPARTMENT 13



# EXAMPLE HIGHLIGHT:
# MARKETING GETTING A LITTLE AHEAD OF ITSELF

# Example: Marketing a Little Ahead of Itself

SIGNS OF AN IMMATURE 'DRONE DEFENSE' INDUSTRY – MARKETING MATERIALS VS. REALITY




**Date of PDF:**

- 04 July 2016

**Date of v1.0 Product Released:**

- 23 Jan 2017

*Apparently, they considered themselves ahead of Boeing, Lockheed, etc. -- even though they were **still 6 months away** from their **v1.0 release.***

Department 13 - Mesmer - Counter Drone System - 04July2016 - Slide 9 - Competitor's Matrix

- http://www.department13.com/wp-content/sharelink/20160704-mesmer---investor-presentation-a5824ff7cc200fd305fee33cbf73c5f1.pdf

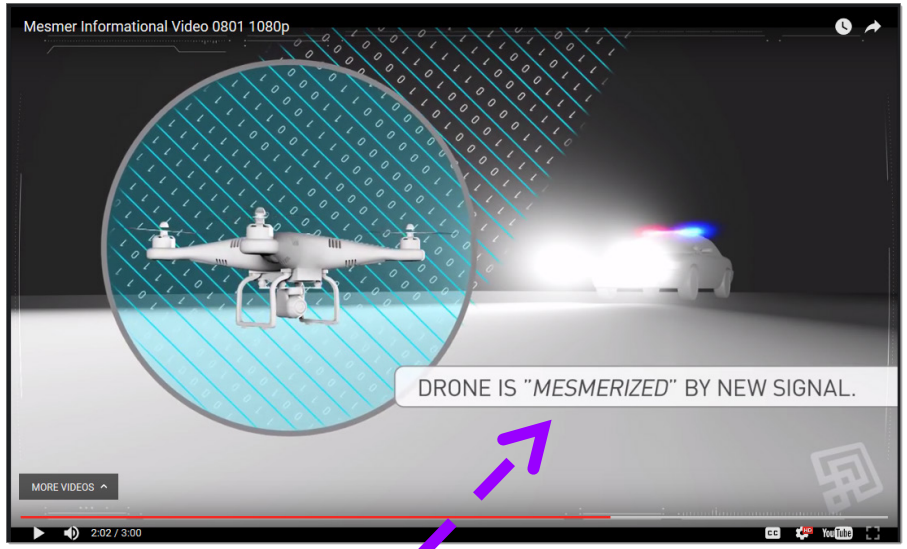
# Example: Marketing a Little Ahead of Itself

SIGNS OF AN IMMATURE 'DRONE DEFENSE' INDUSTRY – MARKETING MATERIALS VS. REALITY

~$200k

Hijacking command and control signal, or "*mesmerizing*" the drone (as they say)

MESMER
COUNTER DRONE
DEPARTMENT 13



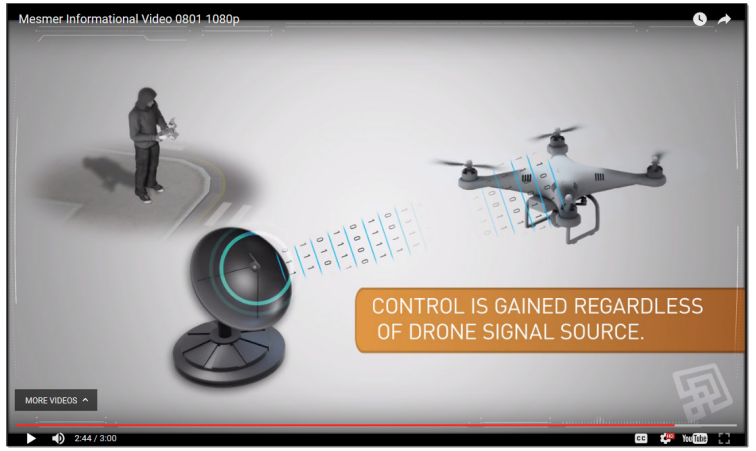





Figure 1 Mesmer V1

"Mesmerized"???


Mesmer - Department 13 - Counter Drone System - Hijack Command and Control Signal

- https://department13.com/mesmer/

# Example: Marketing a Little Ahead of Itself

SIGNS OF AN IMMATURE 'DRONE DEFENSE' INDUSTRY – MARKETING MATERIALS VS. REALITY

[Popular Science - No one knows the best way to stop a drone - 09Feb2017]


A new system competing in this space is MESMER, by Virginia-based Department13. MESMER debuted last month in a segment on drone countermeasures on the *Today Show*. According to Department13 CEO Jonathan Hunter, it's "a non-kinetic means of taking commercial drones and controlling, truly controlling the airspace." Which is to say: if it works as designed and tested, MESMER can stop drones without crashing them or shooting them.

To block those radio signals, the U.S. Army spent $17 billion on jammers, with mixed results. Department 13's approach, which led them to MESMER, wasn't to jam the radio signals, but instead find out everything about the radio sending the signals and then send a more sophisticated signal to override it instead.

"What we're doing is we're essentially communicating the same language of the drone," says Hunter. "So when we do our transmission to take over the drone, essentially we're talking the same language, we're not beating it with power. I don't have to yell louder, I just have to speak the same language. Once we're speaking the same language, it will only listen to me."

What if the drone signal is encrypted?

Yeah, good question!!

"Most people don't implement encryption well," says Hunter, after noting that MESMER doesn't decrypt encryption. It can do a password search if need be, but mostly the software is looking to find pathways into the drone's controls that don't require breaking through any secure channels.

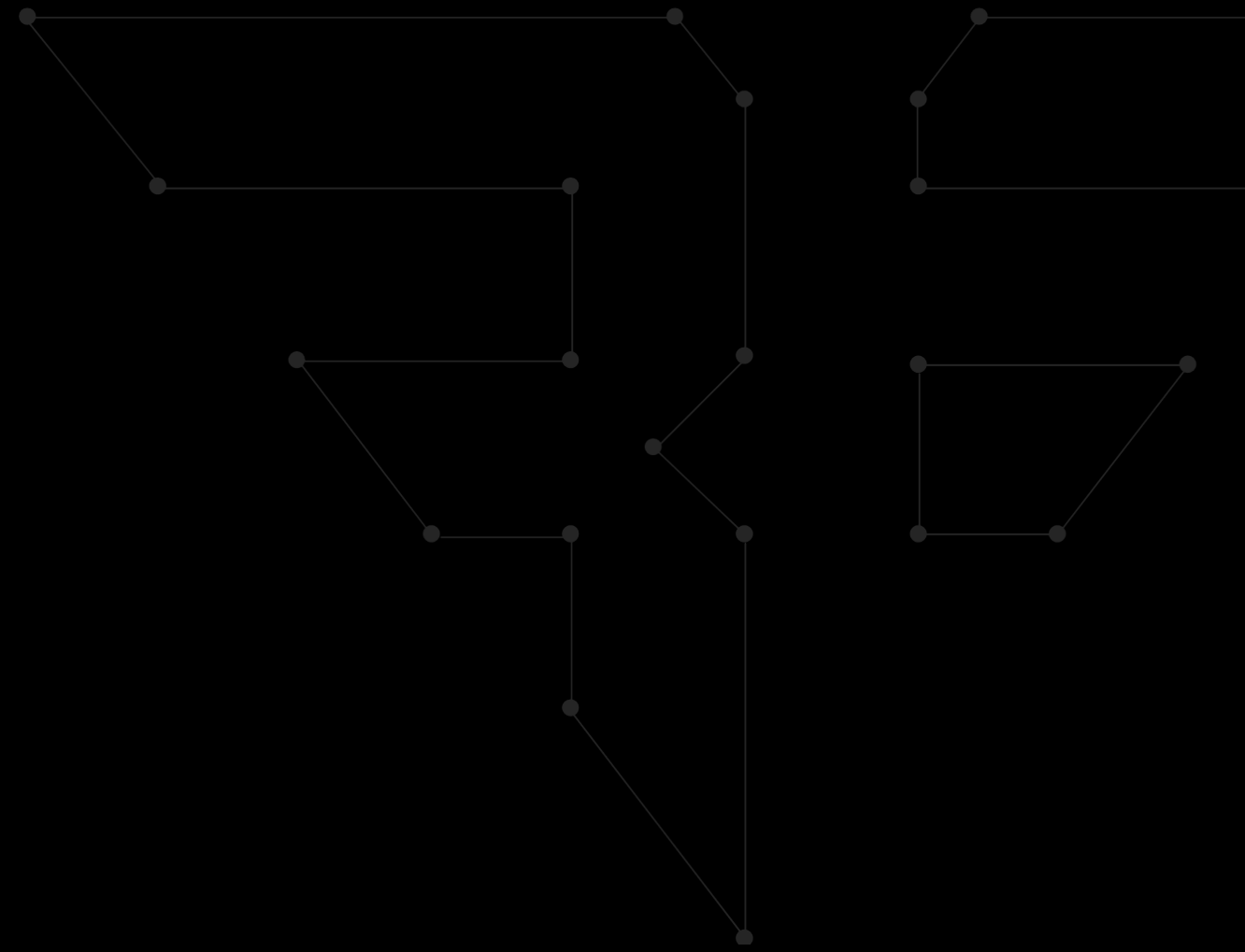
I should note, at this point, that *Popular Science* hasn't witnessed MESMER in demonstration yet. There is footage of it on the today show and in an explainer video at Department13's site, and Hunter says they've demonstrated the technology for a long list of potential customers, including the Department of Defense and the Australian Defense Forces. And, perhaps most confusingly, MESMER is both a system-in-a-box and a kind of software than customers will ultimately work into their existing networks of sensors and jammers.

"We also like to think of it as software, but in order to sell software you have to have hardware, so what we do is build a reference platform," says Hunter. "We've found most people have a hard time wrapping their heads around it. People want to buy a black box, so here's a black box."

*"Here is to hoping the bad guys didn't actually take any time to secure their drone's command and control signal..."*

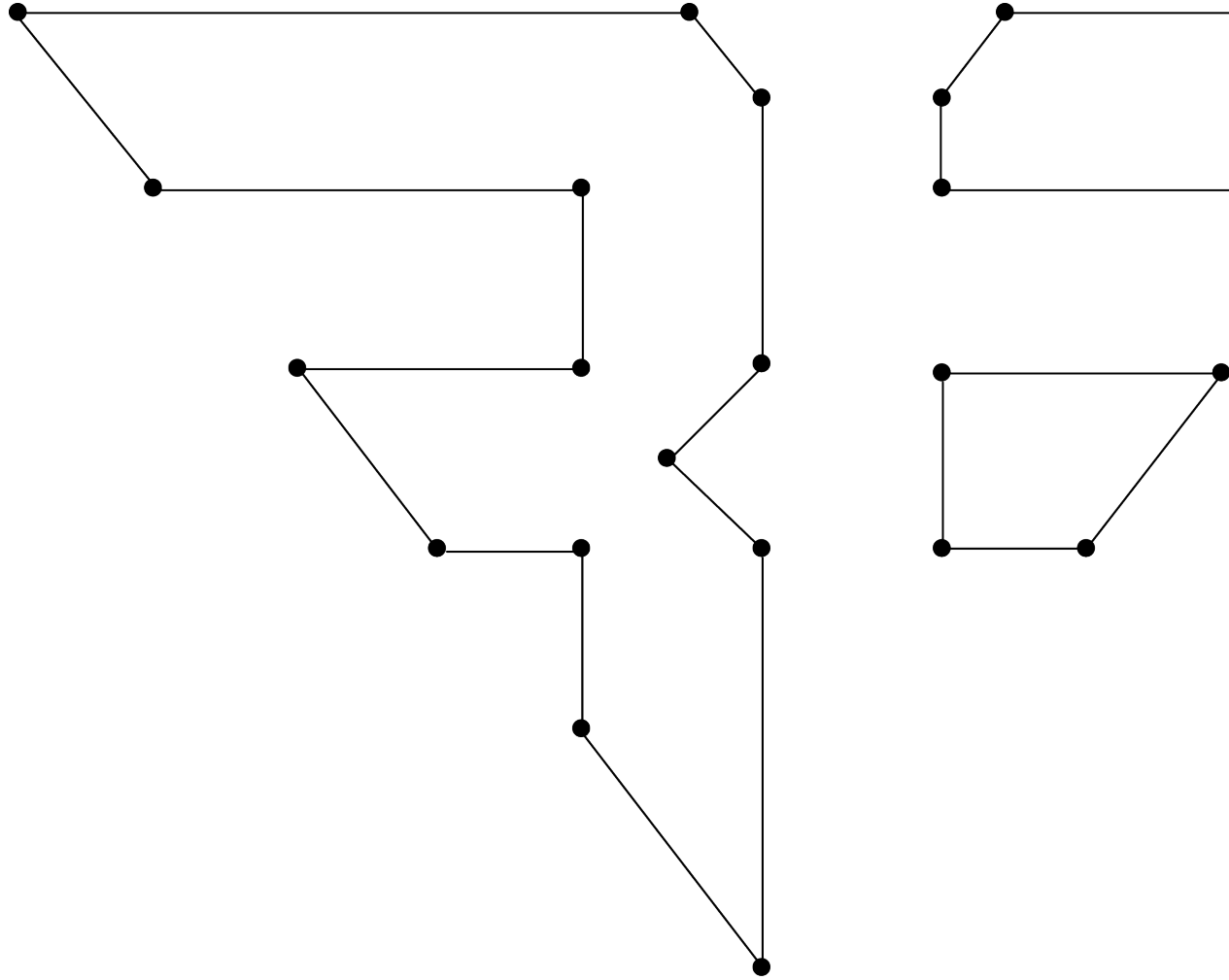
Not surprising, it seems that most drone defense companies just don't want to actually show or sell you their product. It's always a prototype that is '*about to come out*'.

Yeah, sure! Who would really want to know how your product works before buying it???



# DRONE DEFENSES

## THERE ARE NO BEST PRACTICES … YET



# DRONE DETECTION & ALERTING SYSTEMS

# Drone Detection and Alerting Systems

LOTS OF WAYS TO FIND / TRACK 'ROGUE DRONES'

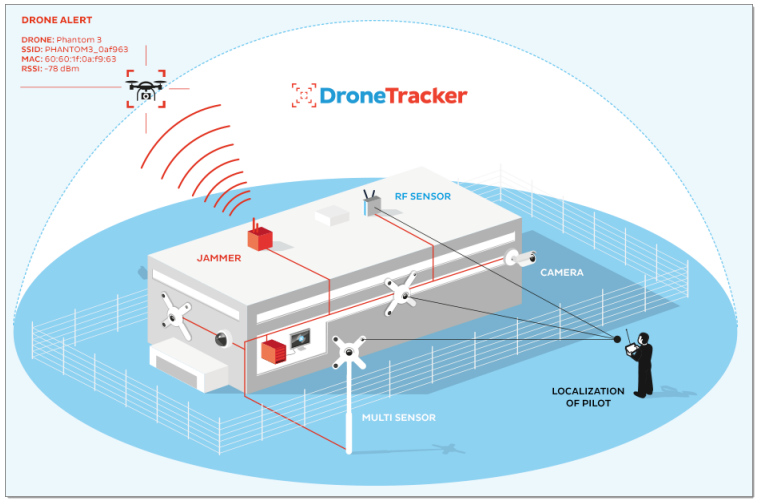
- Acoustic
- Sonic/Ultrasonic
- LIDAR
- Radar
- RF
- Visual/Optical/Video
- Infrared (IR)
- Lasers
- Thermal
- WiFi
- ADS-B (Automatic Dependent Surveillance-Broadcast)
- Holographic Radar
- …

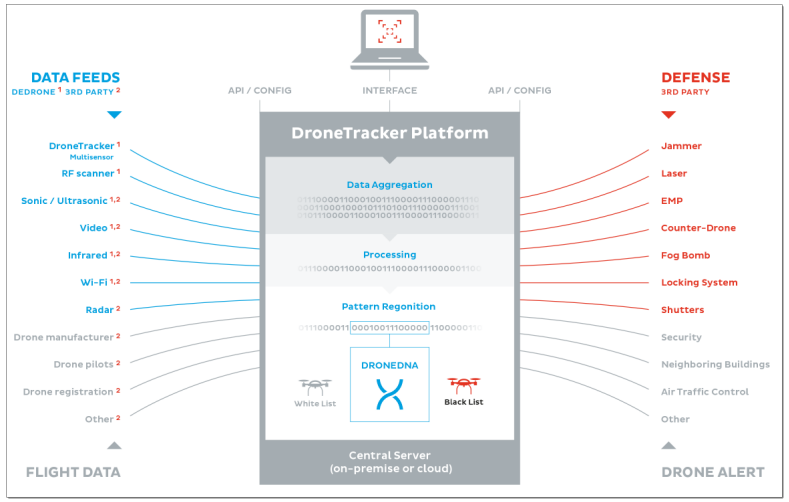
# Drone Defenses Gone Wild

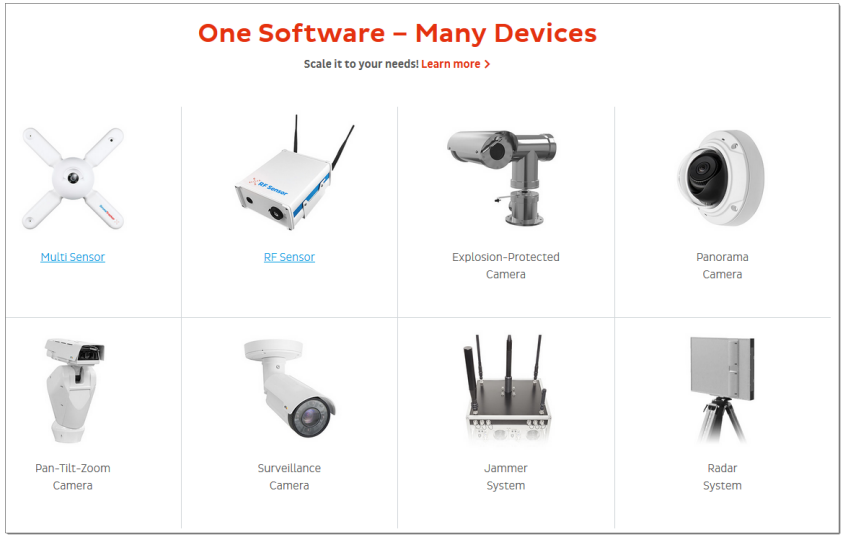
## NO BEST PRACTICES, SO PENTEST TOOLS NEEDED TO VALIDATE THESE ARE WORKING

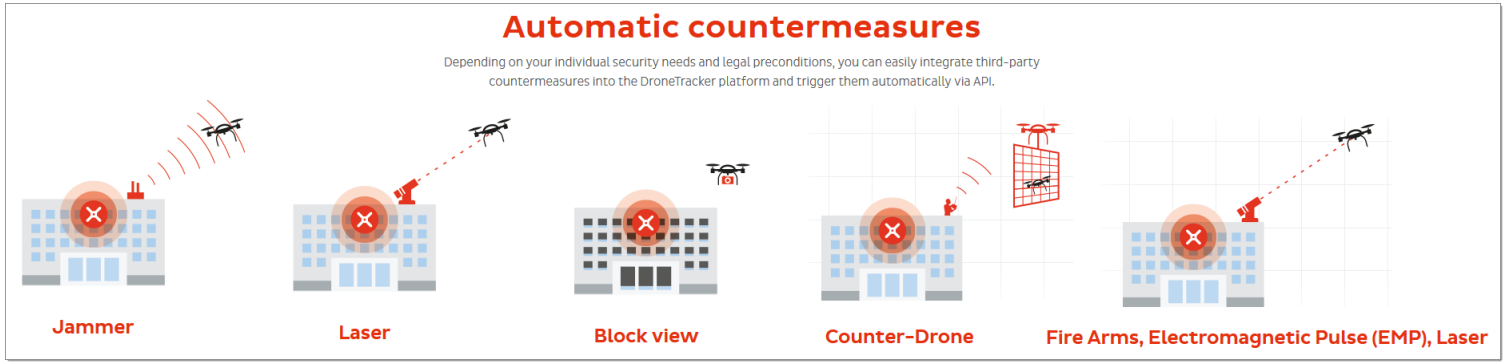
[ZDNet- Cisco chairman backs drone security startup (Dedrone) in $15m Series B round - 14Feb2017]

[The Register - Airbus doesn't just make aircraft – now it designs drone killers - 27July2016]




Dedrone

- http://www.dedrone.com

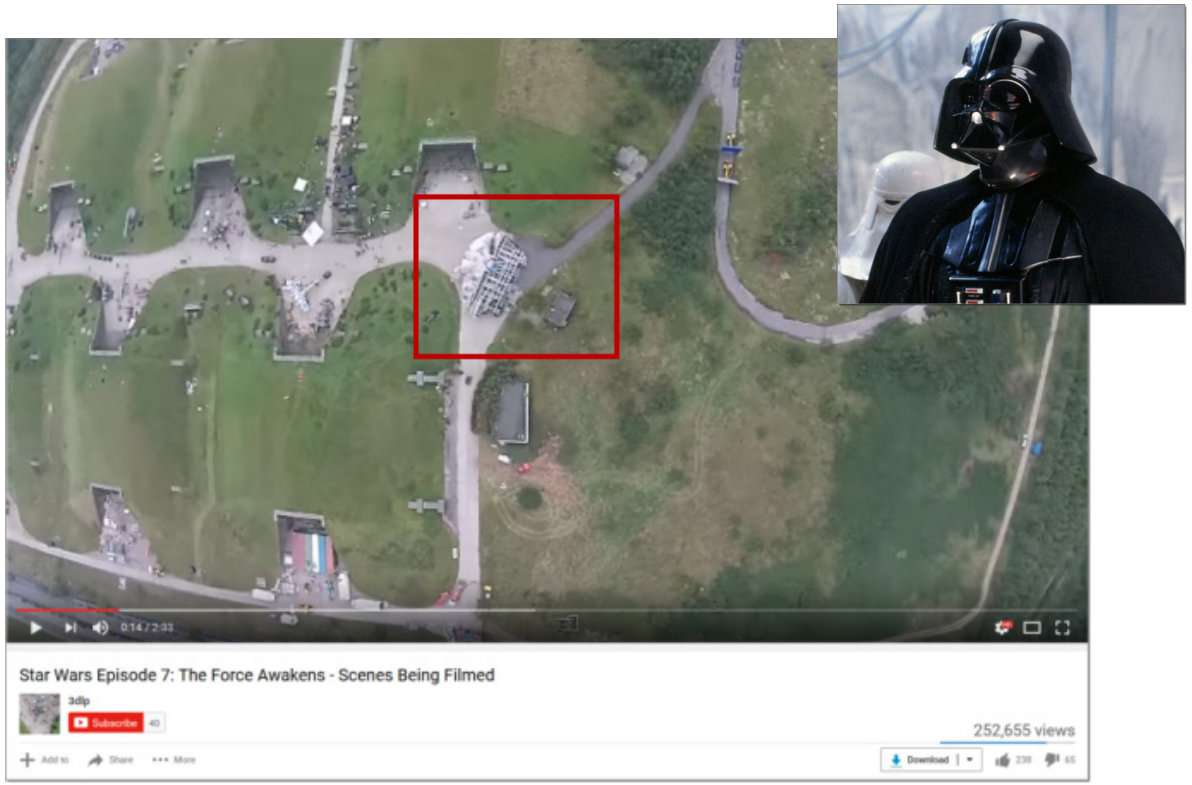
# Drone Defenses Gone Wild

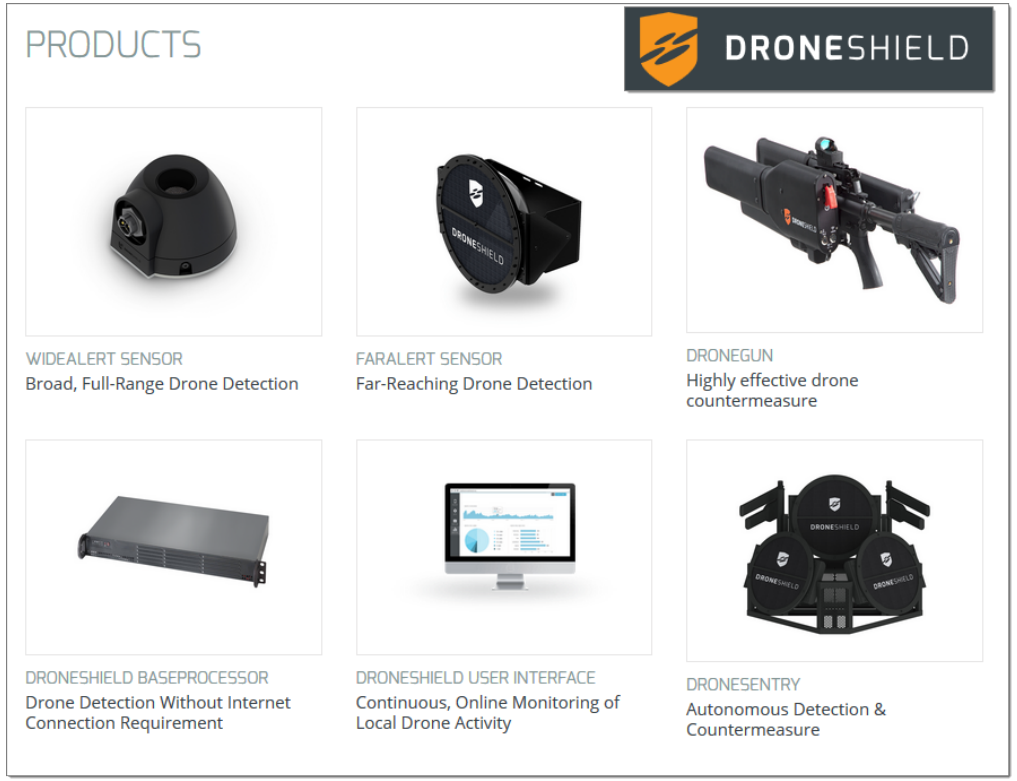
NO BEST PRACTICES, SO PENTEST TOOLS NEEDED TO VALIDATE THESE ARE WORKING

[Gizmodo - The Next Star Wars Movie Has Recruited a Team of Drones to Protect Its Secrets - 22Feb2016]

[Motherboard - Star Wars Ordered a 'DroneShield' to Prevent Leaks On Set - 10Sept2014]

- *Why monitor a problem if you don't do anything about it, though?*




DroneShield – Drone Detection and Response Products

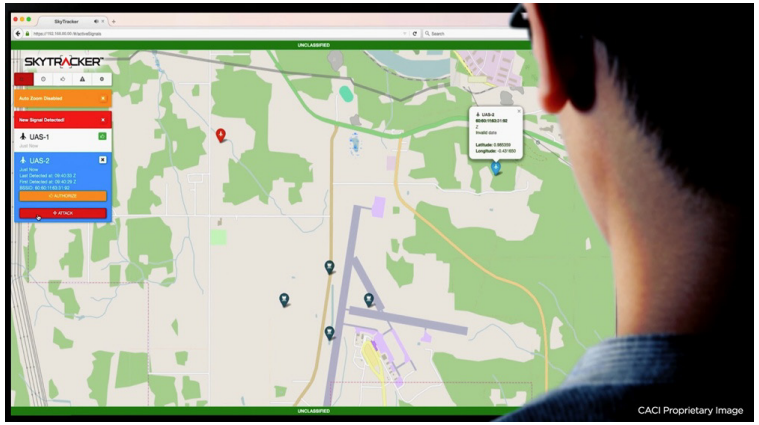
- https://www.droneshield.com/products

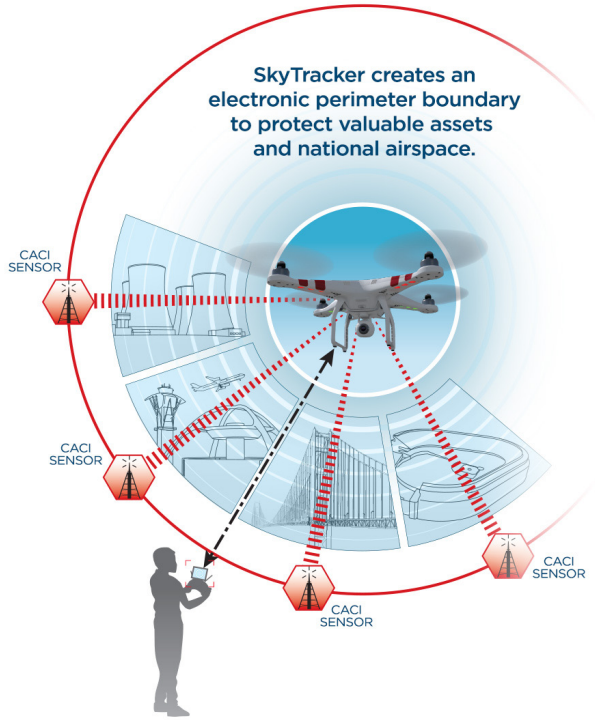
# Drone Defenses Gone Wild

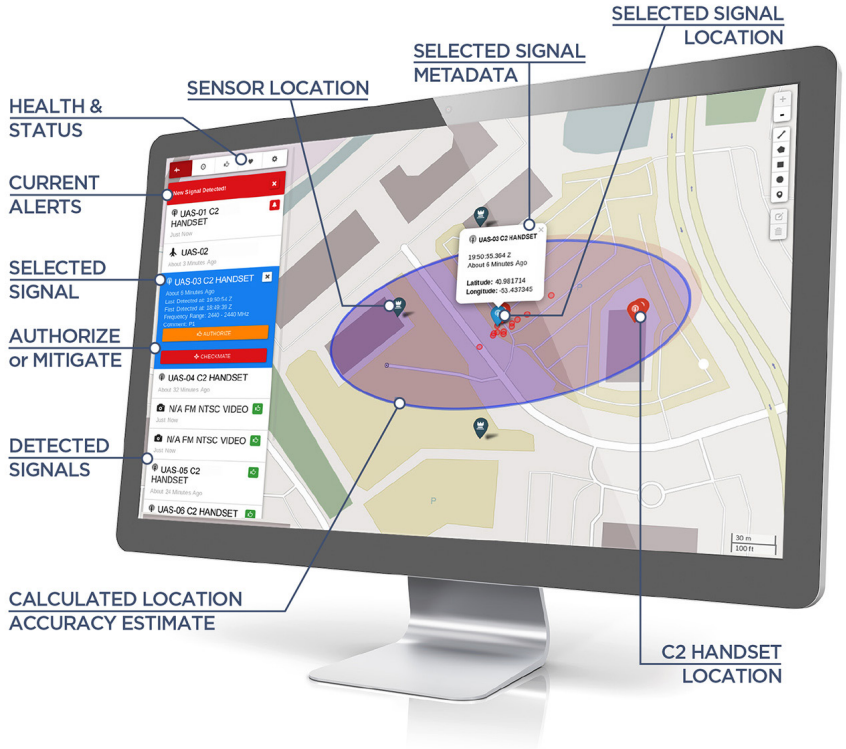
## DRONE DETECTION AND ALERTING SYSTEMS

[DRONELIFE - What's So Secret About the FAA Contract with CACI? - 06Apr2016]

- *"The FAA announced a partnership with CACI, an information services company, and the Department of Homeland Security to create a drone detection system, according to a press release."*


SkyTracker - by CACI - UAS Precision Tracking System

- http://www.caci.com/skytracker/

# Drone Defenses Gone Wild

## DRONE DETECTION AND ALERTING SYSTEMS

[AOPA.org - Sensofusion AIRFENCE - Drone fence arriving in Denver - 03Nov2016]



DRONE FENCE ARRIVING IN DENVER

November 3, 2016 | By Jim Moore

Drones approaching sensitive facilities can be instantly identified and tracked; their operators located; and, if need be, the defense system developed by a company called Sensofusion can even force the offending drone to land at a location designated in advance—all without need for human intervention. The essential equipment is roughly the size of a wireless router commonly found in homes and offices, or a set-top cable television box. Add an antenna and a computer, and you're up and running. Soon there will be an Airfence at Denver International Airport.

The Airfence system by Sensofusion uses a small electronic device to detect and control drones that enter sensetive areas, and will soon be installed at Denver International Airport. Airfence device photo courtesy of Sensofusion.

Sensofusion – AIRFENCE – Drone Detection and Tracking System

- https://www.sensofusion.com/

# Drone Defenses Gone Wild

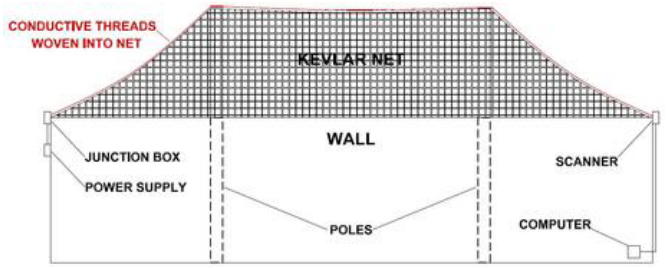
## DRONE DETECTION AND ALERTING SYSTEMS

~$40k

[DDC LLC - Domestic Drone Countermeasures - Drone Detection Systems]

- The Basic Personal Drone Detection System consists of three boxes: a Primary Command and Control Module and two Detection Sensor Nodes. These three boxes create a mesh network that can triangulate moving transmitters.






DDC LLC - Domestic Drone Countermeasures - Drone Detection Systems

- http://www.domesticdronecountermeasures.com/home.html

# Drone Defenses Gone Wild

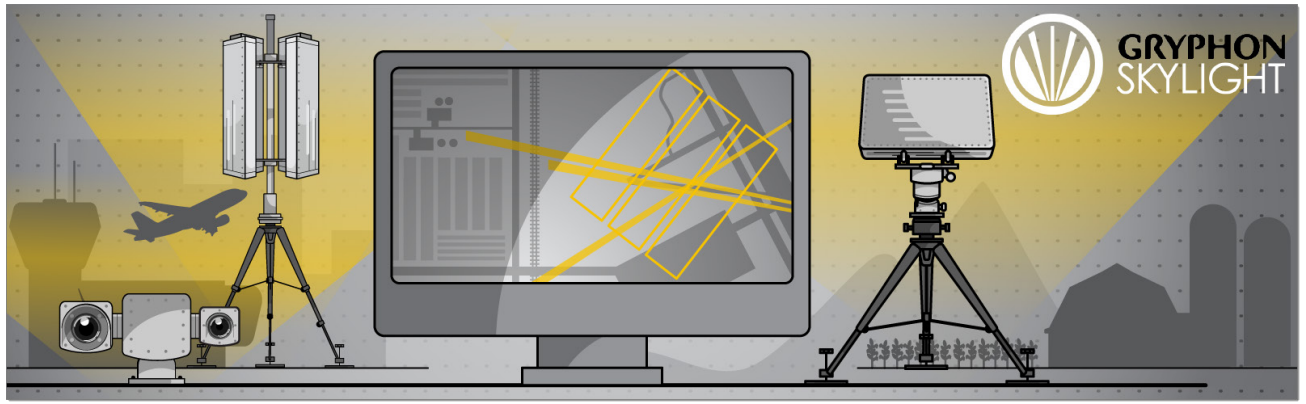
## DRONE DETECTION AND ALERTING SYSTEMS

~$235k

GRYPHON SKYLIGHT

### SAMI

SAMI (Skylight Airspace Monitor Interface) is the glue that brings our sensors together to give you a complete airspace picture.



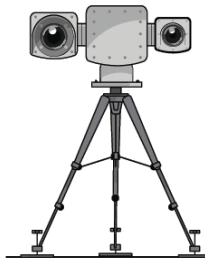

### SKYLIGHT SYSTEM MULTISPECTRAL SENSORS

**R1400* - PRIMARY RADAR**

- Large area, precision surveillance
- Drone security and Detect & Avoid applications
- 10km (sUAS), 27km (General Aviation)
- Low false alarm rate
- Low size, weight and power (SWaP); man transportable

**SPECTRUM SENSING (S2)**

- Fast target acquisition
- Strong positive confirmation for targets of interest
- Provides line of bearing
- Up to 5km detection range
- Up to 360° coverage



**SLEW-TO-CUE CAMERA**

- Visual Target Identification
- Optical Tracking
- Thermal and EO lenses
- 3km detection range
- 360° Pan Rotation
- 180° Tilt Rotation

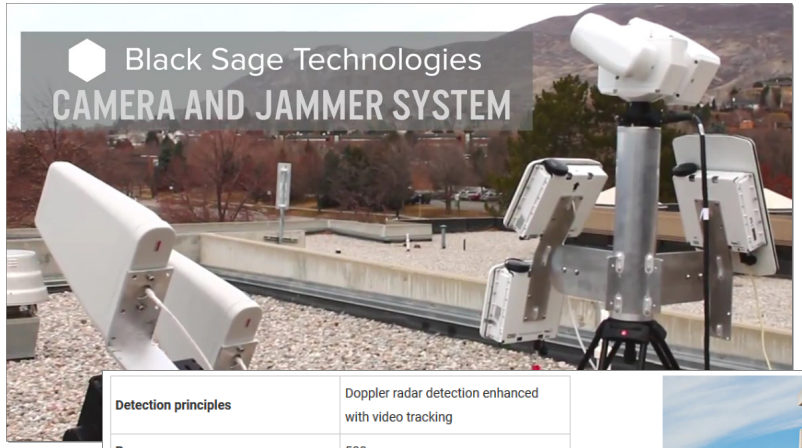
Gryphon Sensors - Skylight - Drone Detection and Tracking

- http://gryphonsensors.com/products/

# Drone Defenses Gone Wild

## DRONE DETECTION AND ALERTING SYSTEMS

[Wired.com - An Amazing (Illegal) Plan to Defeat Terrorist Drone Attacks - 28Feb2017]




| | |
|---|---|
| **Detection principles** | Doppler radar detection enhanced with video tracking |
| **Range** | 500 m |
| **Coverage angle** | 90° |
| **Constant Internet connection** | Not required |

The Black Sage Technologies BST-UAVX detection and tracking system comprises the Compact Surveillance Radar augmented by the Daylight Camera and the Thermal Camera, the Mobile Supercomputer for incoming signals processing, and the software for UAVs visualization and saving forensics.

Compact Surveillance Radar with Camera

Mobile Supercomputer

Black Sage's UAVX was recently used in a staged event at a major college campus open-air football stadium with a seating capacity in excess of 60,000 people. The goal of this event was to simulate a terrorist attack using a UAV to fly over the stadium and disperse a nerve agent on the crowd. The test was conducted jointly with Black Sage, The University (which cannot be named), The National Guard, local fire and police departments, and Emergency Management Services.

Event officials utilized a DJI Inspire quadcopter UAV to simulate the attack by flying over the stadi-


Figure 12-13 - UAVX mounted on tripod at skybox-level with thermal camera system and radar

Black Sage Technologies

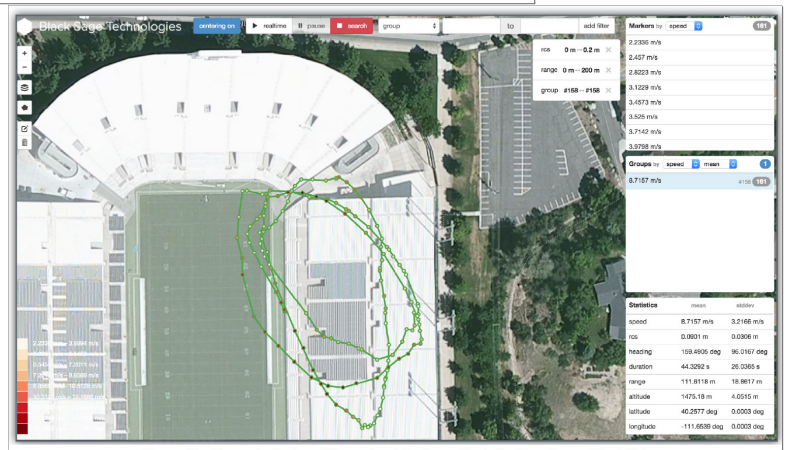
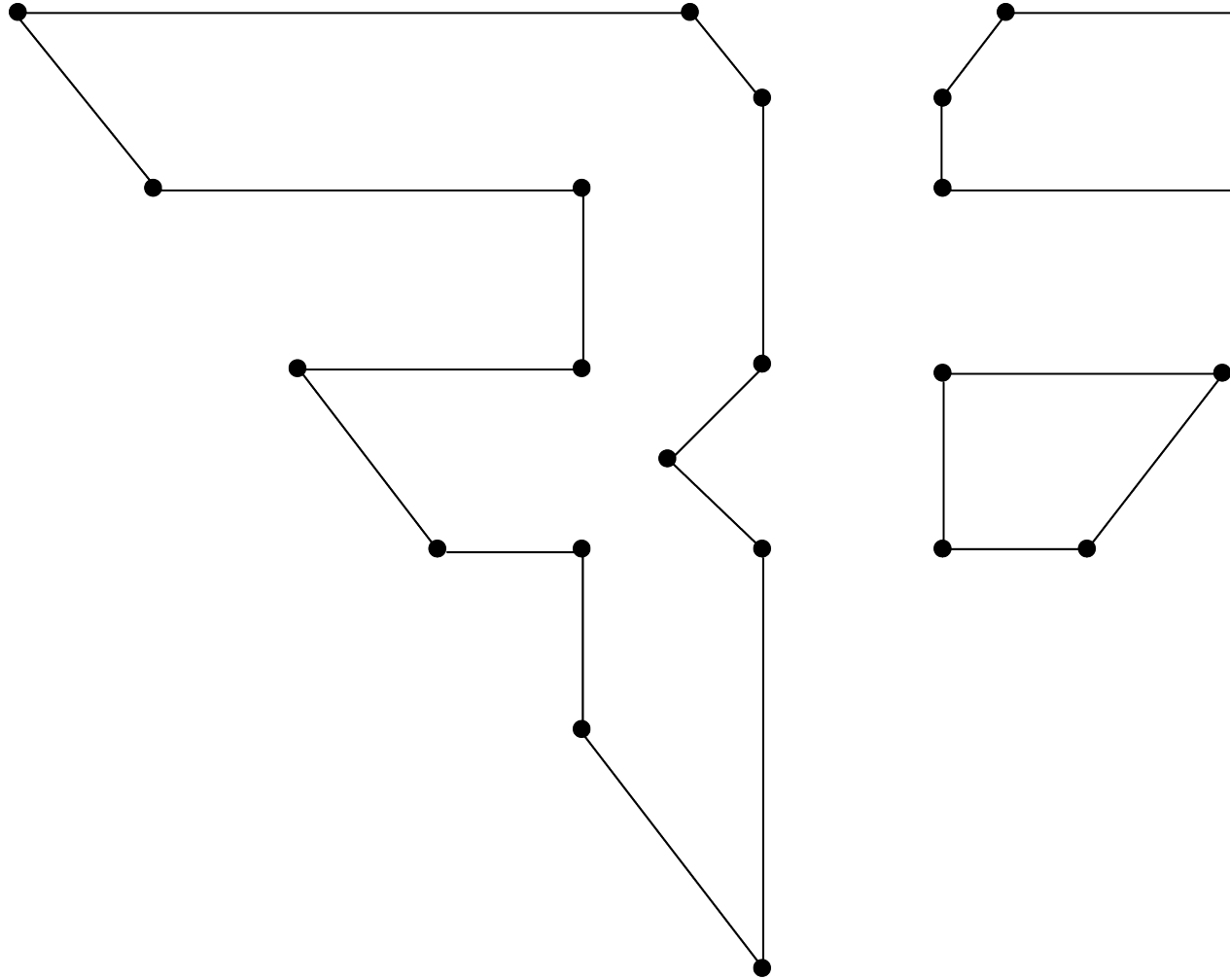



Figure 14 – Forensic display of the radar detection with plotted locations of the UAV

Black Sage - UAVX - BST-UAVX - AI-Based Counter-UAV Radar Detection and Video Tracking System (built with SpotterRF)

- https://www.blacksagetech.com/whitepapers/2015/9/26/uav-detection-and-tracking

PREDATOR BIRD



# EAGLES & FALCONS PLUCKING DRONES FROM SKY

# Drone Defenses Gone Wild

## FALCONS AND EAGLES TRAINED TO ATTACK DRONES

[The Washington Post - Terrorists are building drones. France is destroying them with eagles. - 21Feb2017]

[Fox News - Watch a police eagle take down a drone - 01Feb2016]

*"I'd like to spend my security training budget on falconry classes, please." –*

**Every Security Professional Next Year**



Guard From Above - Using birds of prey to intercept hostile drones

- http://guardfromabove.com/

# Drone Defenses Gone Wild

FALCONS AND EAGLES TRAINED TO ATTACK DRONES

## Initial Investment *(example) Prices excluding VAT and depending on availability of birds*

**1 GFA Team (Bird and Birdhandler training):**

| | | |
|---|---|---|
| GFA Bird (*365 days specialist training, caretaking and drones*) | EUR 98.000,-- | USD 104.370,-- |
| GFA Birdhandler Training (20 days) | EUR 25.000,-- | USD 26.625,-- |
| GFA Training/Deployment equipment | EUR 4.000,-- | USD 4.260,-- |
| Additional advice ((estimate)For example: export/transport) | EUR 20.000,-- | USD 21.300,-- |
| **Total Investment:** | **EUR 147.000,--** | **USD 156.555,--** |

**Long term Investment**

- Eagles live around 60-80 years
- Deployable for 40 years

Guard From Above - Using birds of prey to intercept hostile drones

- http://guardfromabove.com/

# Drone Defenses Gone Wild

FALCONS AND EAGLES TRAINED TO ATTACK DRONES


## Life-cycle cost analysis (LCCA) example


**Yearly cost per 1 GFA trained Bird of prey for 1 year (365 days):**

| | | |
|---|---|---|
| Bird quarters Construction (Basic) | EUR 2.000,-- | USD 2.130,-- |
| Food | EUR 1.000,-- | USD 1.065,-- |
| Medical care (Perodic checks and basic care) | EUR 1.500,-- | USD 1.597,50 |
| Individual Equipment (yearly) | EUR 1.500,-- | USD 1.597,50 |
| Contingencies | EUR 500,-- | USD 532,50 |
| Training drones (depending on the client demand: Brand/type) | EUR ..... | USD ..... |
| Daily caretaking and training (by client staff 365x 1,5 h (547,5 hours)) | EUR ..... | USD ..... |
| **Total yearly investment (for 1 bird)** | **EUR 6.500,--** | **USD 6.922,50** |

Guard From Above - Using birds of prey to intercept hostile drones

- http://guardfromabove.com/

# Defeating Birds of Prey Defenses

## FALCONS AND EAGLES TRAINED TO ATTACK DRONES

Detection and response to incoming eagles or falcons.

Detect Incoming Eagles:

HACKADAY

HACKADAY PRIZE ENTRY: AUTOMATED WILDLIFE RECOGNITION

by: Donald Papp

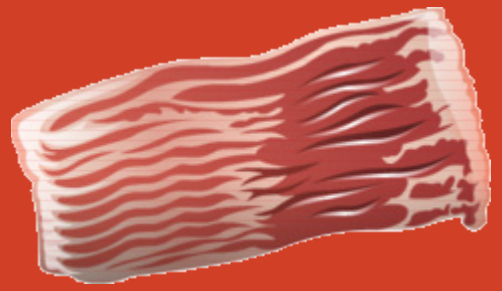
11 Comments

June 14, 2017

Trail and wildlife cameras are commonly available nowadays, but the Wild Eye project aims to go beyond simply taking digital snapshots of critters. [Brenda Armour] uses a Raspberry Pi to not only take photos of wildlife who wander into the camera's field of view, but to also automatically identify and categorize the animals seen using a visual recognition API from IBM via the Node-RED infrastructure. The result is a system that captures an image when motion is detected, sends the image to the visual recognition API, and attempts to identify any wildlife based on the returned data.

+

Responses: Carrot or Stick



Bacon Countermeasures

OR

Offensive Countermeasures

# Won’t “Fly” in the United States

EAGLES ARE PROTECTED AND LIMITED IN PERMITTED USAGE IN THE STATES


https://www.fws.gov/midwest/eagle/protect/laws.html

U.S. Fish & Wildlife Service

## Bald Eagle

Midwest Region

Search

- Home
- About Bald Eagles and Their Recovery
- Numbers of Bald Eagles
- Places to See Eagles and Eagle Images
- Laws that Protect Bald Eagles
- Post Delisting Monitoring Plan
- Eagle Permits
- Archives: Proposed and Final Rules to Delist
- Links for More Information
- Midwest Region Endangered Species
- Midwest Migratory Birds

### Federal Laws that Protect Bald Eagles

### Bald and Golden Eagle Protection Act

The bald eagle will continue to be protected by the Bald and Golden Eagle Protection Act even though it has been delisted under the Endangered Species Act. This law, originally passed in 1940, provides for the protection of the bald eagle and the golden eagle (as amended in 1962) by prohibiting the take, possession, sale, purchase, barter, offer to sell, purchase or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit (16 U.S.C. 668(a); 50 CFR 22). "Take" includes pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb (16 U.S.C. 668c; 50 CFR 22.3). The 1972 amendments increased civil penalties for violating provisions of the Act to a maximum fine of $5,000 or one year imprisonment with $10,000 or not more than two years in prison for a second conviction. Felony convictions carry a maximum fine of $250,000 or two years of imprisonment. The fine doubles for an organization. Rewards are provided for information leading to arrest and conviction for violation of the Act.

Go here for more information about the Bald and Golden Eagle Protection Act and permits issued under that Act.


# SHOOTING NETS AT DRONES FROM THE GROUND

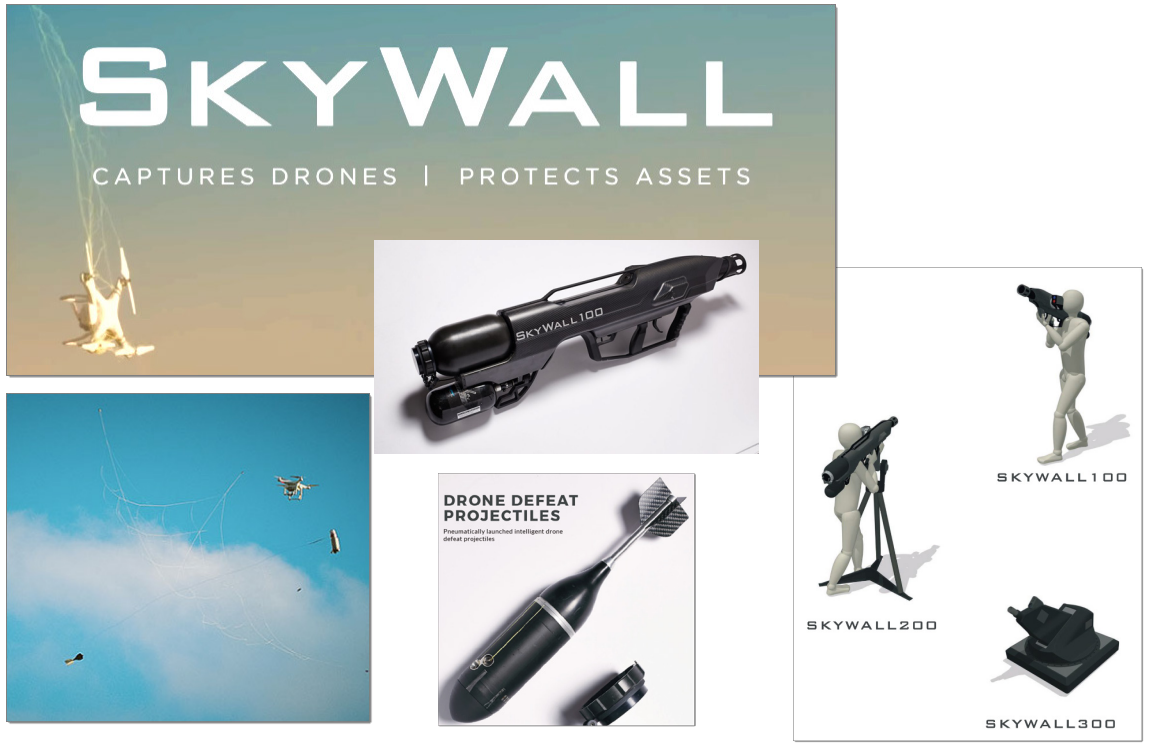
# Drone Defenses Gone Wild

## BAZOOKA SHOOTING NETS WITH PARACHUTE AT DRONES

~$70k - $80k

[Mashable - SkyWall gun stops drones dead with net, then gives a parachute landing - 05Mar2016]

[Popular Science - SkyWall Is A New Anti-Drone Net Bazooka For Police - 07Mar2016]






OpenWorks Engineering - SkyWall

- https://openworksengineering.com/skywall

# Drone Defenses Gone Wild

## DRONE NET GUN – SMALL FLASHLIGHT SIZED

[DroneDefence.co.uk - Net Gun X1]

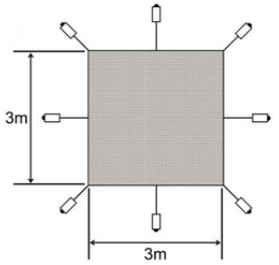

DRONEDEFENCE

### Net Gun X1 Operation

The Drone Defence Net Gun X1 is a simple to use, versatile & economical device for Law Enforcement & Security Officers to tackle unwanted drone incursions. With two types of capture net the operator can select the appropriate configuration, dependent on the environment. The Type 1 capture net provides an protective barrier wall, which a drone cannot penetrate. Type 2 allows the operator to attempt the direct capture of a drone in flight.

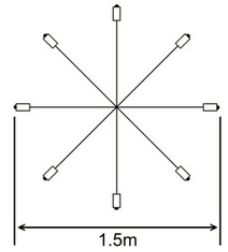

*Depending on capture net type and weather conditions.


### Multiple Capture Net Types




**Type 1 - Mesh**

Effective Range: up to 10m
Net Size: 9 meters squared (3m x 3m)
Mesh Size: 15cm
Deployment Time: 1 second
Velocity: 10 meters per second




**Type 2 - Spider**

Effective Range: up to 15m
Net Size: 2 meters squared (1.5m radial)
Deployment Time: 1 second
Velocity: 10 meters per second

Drone Defence - Net Gun X1

- http://www.dronedefence.co.uk/net-gun-x1
- http://www.net-gun.com/net-gun-spider-brochure.pdf

# Drone Defenses Gone Wild

## DRONE NET GUN – SMALL FLASHLIGHT SIZED

~$500







BigUrb - Tactical Net Gun

- https://www.amazon.com/BigUrb-Tactical-Net-Gun/dp/B01N6VRY9D/
- http://www.net-gun.com/net-gun-spider-brochure.pdf

# Drone Defenses Gone Wild

## DRONE NET GUN – SMALL FLASHLIGHT SIZED

~$600 - $800

Shoots up to ~45 feet

[TheNetGunStore.com - Net Guns for Drone Defense - 20Nov2014]


TheNetGunStore – Net Gun

- http://www.thenetgunstore.com/product/the-hero-net-gun/

# DEMO: Defeating Net Defenses with Protective Cage

## CHICKEN WIRE FOR THE WIN

Chicken Wire Cage = ~$15

VS.

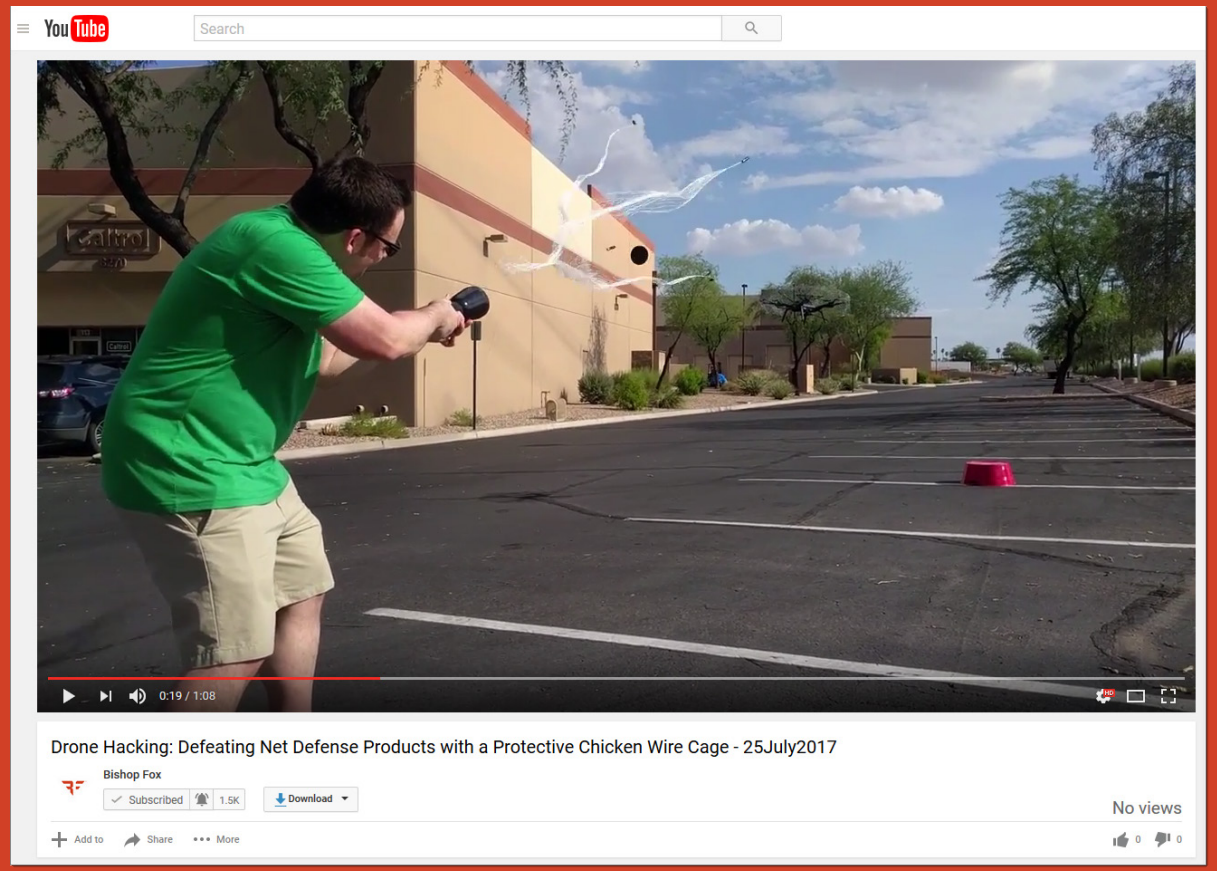

Flashlight Net Gun = ~$600-$700

Breaking Drone Defenses: Using Chicken Wire to Defeat Net Projectile-Based Products - Bishop Fox - Blog - 03Aug2017

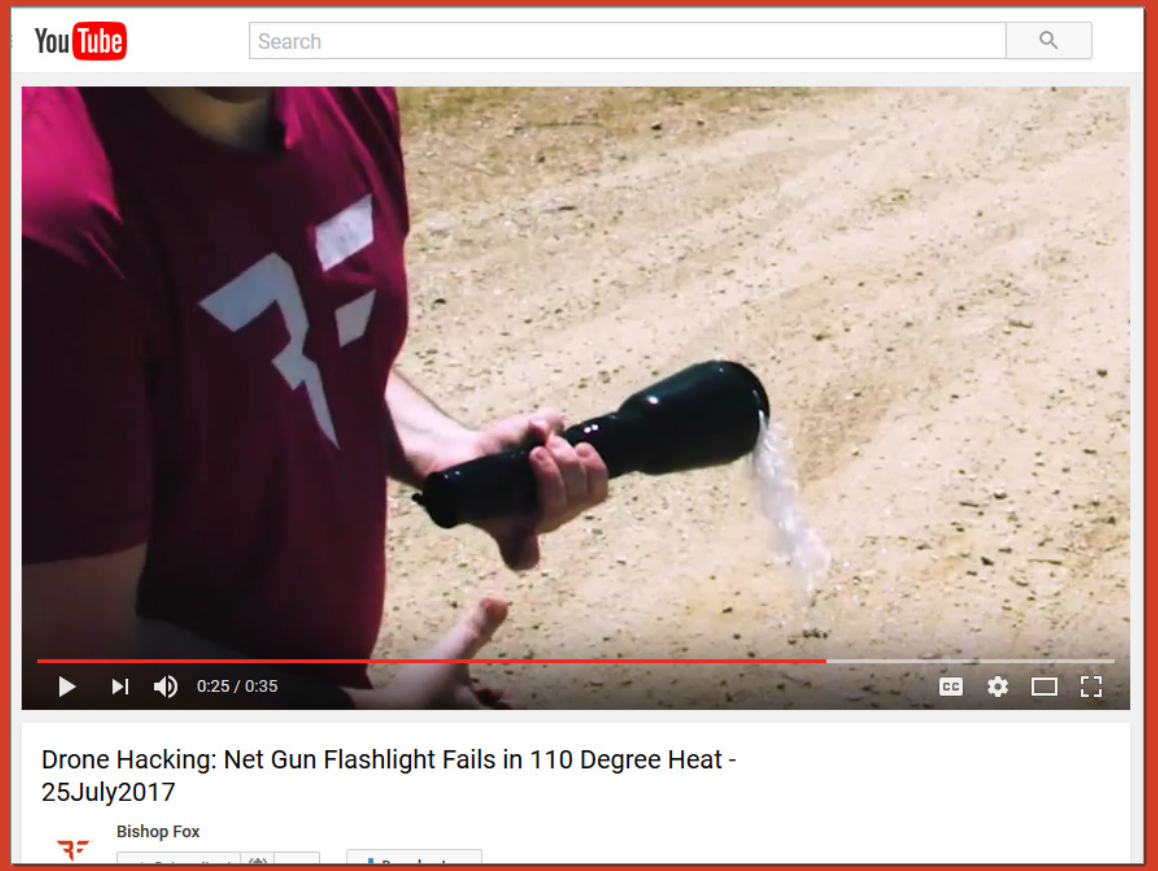
- https://www.bishopfox.com/blog/2017/08/breaking-drone-defenses-using-chicken-wire-defeat-net-projectile-based-products

# DEMO: Defeating Net Defenses with Protective Cage

## CHICKEN WIRE FOR THE WIN, ARIZONA HEAT FOR THE WIN TOO!




https://www.youtube.com/watch?v=m2qSQ5__agA



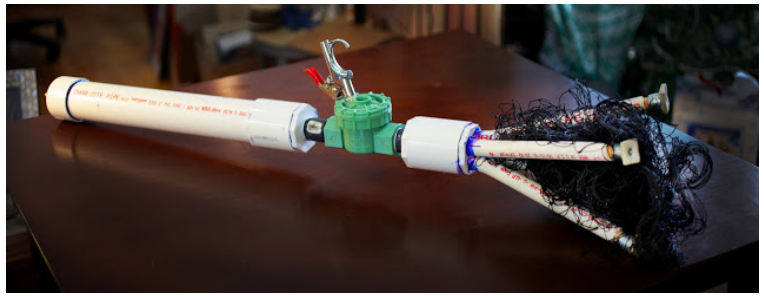

https://www.youtube.com/watch?v=jlGdPrhRvBA&t=99

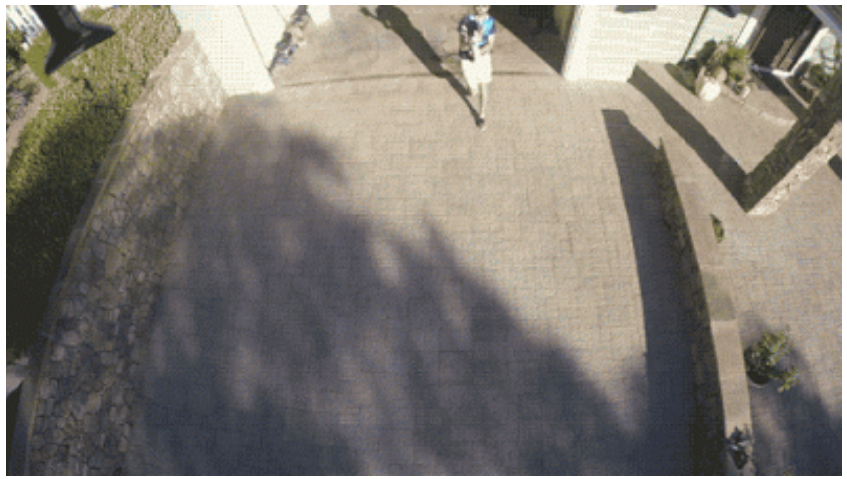
# Drone Defenses Gone Wild

## DIY DRONE NET GUN

~$40 - $75

[LifeHacker - Build a Drone-Catching Net Gun Out of Basic Plumbing Parts - 24Feb2017]



DIY Net Gun for Drones - William Osman

- http://www.williamosman.com/2016/12/diy-net-gun.html

# Drone Defenses Gone Wild

## DRONE NET GUN SHOTGUN SHELLS

~$20 for 3 shells

[Advanced Ballistics Concepts - Skynet™ Drone Defense]





SKYNET – Drone Defense – Shotgun Net Shells

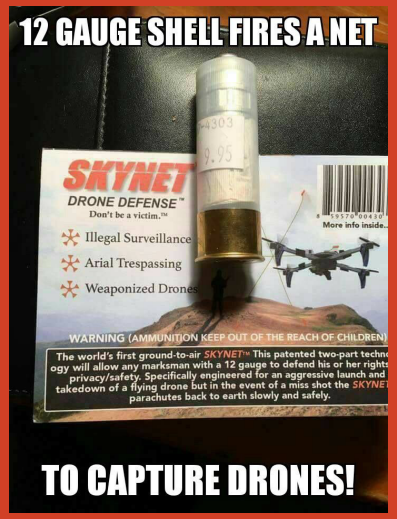
- http://store.mibullet.com/skynetdronedefense.aspx

# DEMO: Defeating Net Defenses with Protective Cage

## SHOTGUN SHELLS WIN

Chicken Wire Cage = ~$15

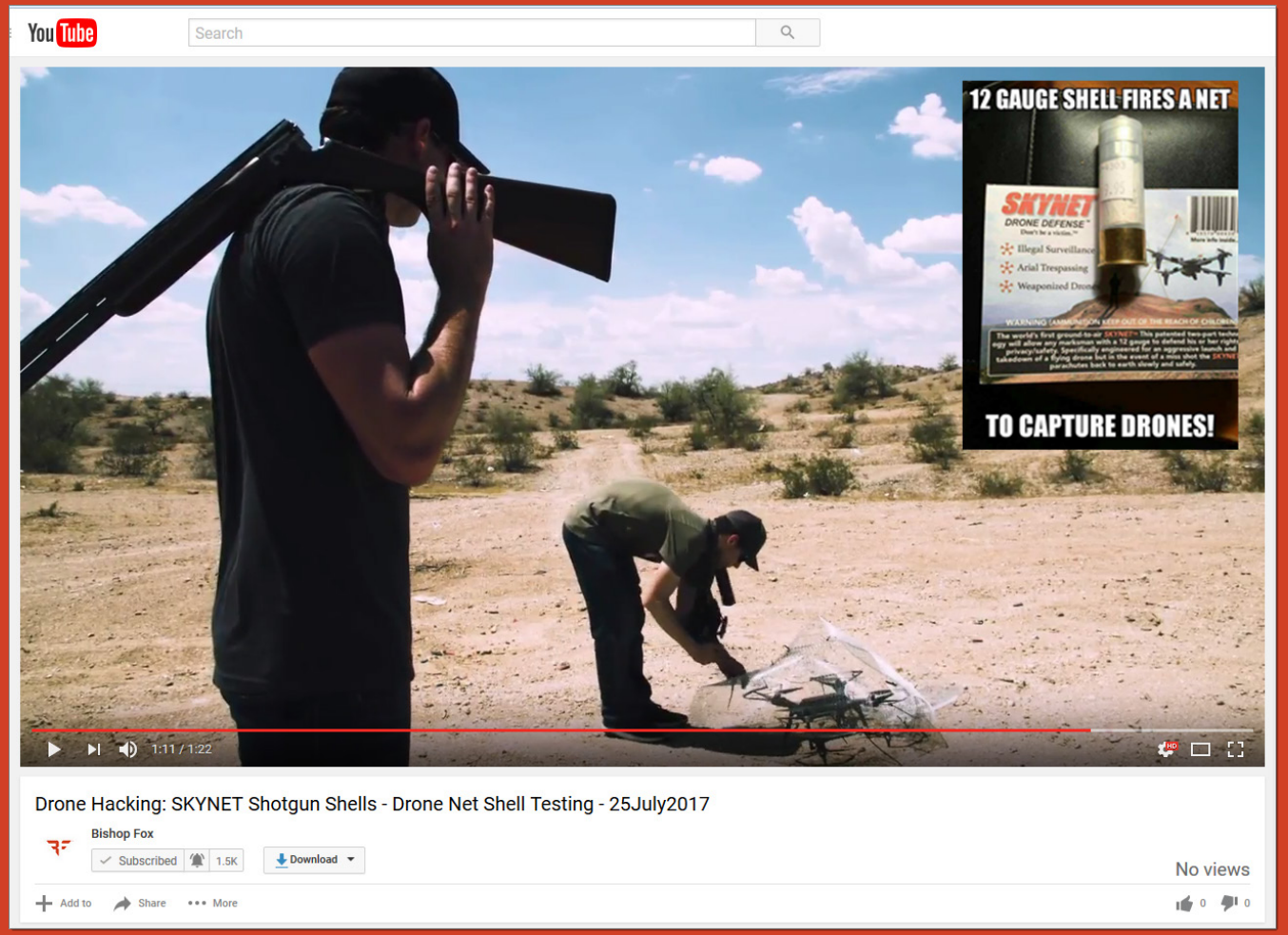
VS.

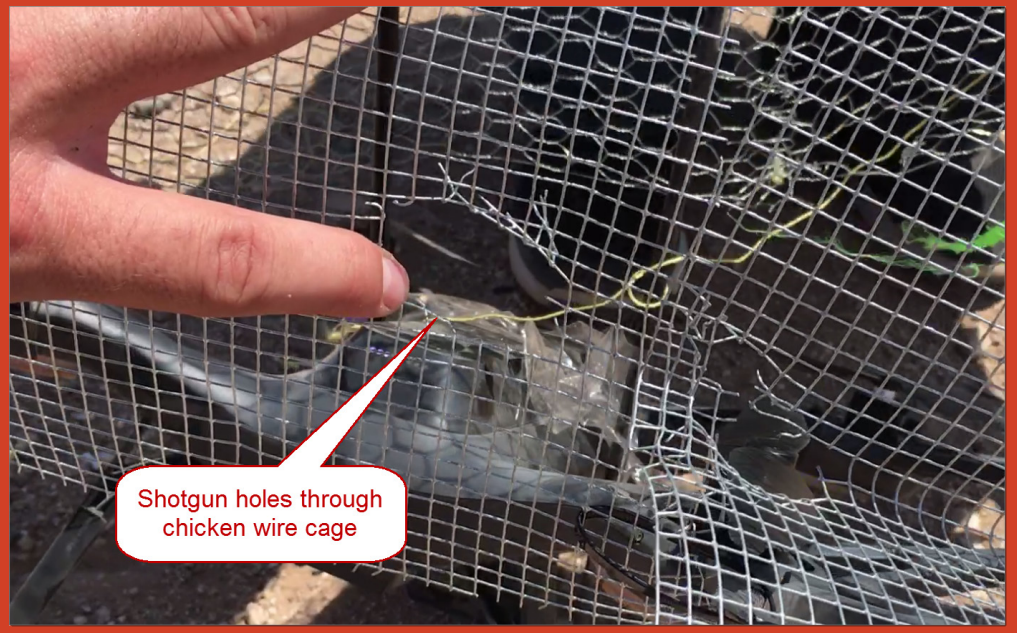



SkyNet Drone Net Shotgun Shells (3 pack) = ~$20

# DEMO: ~~Defeating~~ Net Defenses with Protective Cage

## SHOTGUN SHELLS WIN




https://www.youtube.com/watch?v=hRgAn9GJEbQ

DRONE SHOOTING

# DRONES SHOOTING NETS AT DRONES

# Drone Defenses Gone Wild

## DRONES SHOOTING NETS AT OTHER DRONES

~$30,000 Euro

*"Hoping to ship first units by the end of 2017"*

DroneCatcher - Catching a Drone with a Drone - 19Aug2016 -YouTube

Security Affairs - The DroneCatcher evolves featuring a new improvement - 04April2016



| Specifications | |
|---|---|
| DroneCatcher | Flying system |
| Dimensions | 775 x 755 x 350 mm |
| Speed | Currently up to 20 m/s<br>44.7 mph |
| Operating time | Up to 30 min. |
| Netgun range | Up to 20 meters<br>65.6 feet |
| Weight | < 6 kg |


DroneCatcher - DelftDynamics

- http://dronecatcher.nl/

# Drone Defenses Gone Wild

## DRONES SHOOTING NETS AT OTHER DRONES

Michigan Technological University

[Popular Mechanics - Drone-Mounted Net Cannon Snags Other Drones with Ease - 12Jan2016]

[TheNextWeb - Watch Michigan Tech's 'Robotic Falcon' snatch this drone out of mid-air - 13Jan2016]


Michigan Tech - Robotic Falconry

- http://me.sites.mtu.edu/rastgaar/hirolab/

# Drone Defenses Gone Wild

## DRONES SHOOTING NETS AT OTHER DRONES

*"Millions of dollars"* in cost –
according to them on phone

[WSJ - Its Drone vs. Drone as Airspace Systems Takes Flight - 09Mar2017]

[Gizmodo - Watch a Drone-Hunting Quadcopter Attack Its Prey - 13Oct2016]

[Airspace Systems Inc One Touch Interceptor TI - 22Oct2016 - YouTube]

AIRSPACE



Airspace Systems - One-Touch Interceptor

- http://airspace.co

# TREND: Defensive Drones Going Autonomous

## ONE-TOUCH 'CLEAN THE SKY' SOLUTIONS – AUTO-MAGICALLY FIND AND ELIMINATE 'ROGUE DRONES'

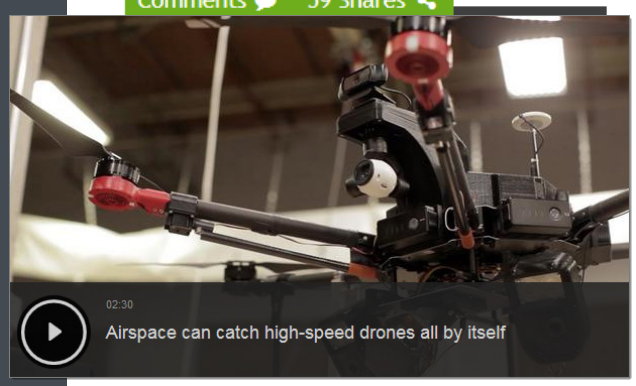
- Most air-to-air drone defenses starting to incorporate **A.I.** and **machine learning** to deploy **automated anti-drone** products
- **One-touch** search-and-destroy **autonomous** drones, i.e. no need to teach your employees how to be **Top Gun's** in order to defend against '*rogue drones*'


https://news.developer.nvidia.com/autonomous-drone-hunts-down-rogue-drones-from-the-sky/

NVIDIA DEVELOPER

NVIDIA Developer - Autonomous Drone Hunts Down Rogue Drones From the Sky - Powered by NVidia Jetson TX1 Board - 18Oct2016

Comments 59 Shares




## Autonomous Drone Hunts Down Rogue Drones From the Sky

October 18, 2016

Once it classifies the object, the Jetson-powered Airspace drone fires a tethered net to capture the other craft from the sky and safely returns it to its landing pad.

Airspace is the only drone security solution capable of identifying, tracking, and autonomously removing rogue drones from the sky.

The start-up is using GeForce GTX 1080 GPUs and DIGITS to train their deep learning model to detect anomalies in the sky and classify rogue drones. Once trained, the drone is equipped with an Jetson TX1 on-board, and uses VisionWorks, TensorRT and CUDA to classify and react to rogue drones in real-time.


NVIDIA Developer - Autonomous Drone Hunts Down Rogue Drones From the Sky – Powered by NVidia Jetson TX1 Board - 18Oct2016

# Drone Defenses Gone Wild

## DRONES SHOOTING NETS AT OTHER DRONES

~$3,500 in Nov 2016

~$47,500 in 2017 (Fortem)

[Net Gun Drone - Excipio | Flite Test - 11Jan2016 - YouTube]

- "*Excipio*" is Latin for "*capture*"
- Rebranded "Fortem – *Drone Hunter*" in 2017:
  - http://fortemtech.com/dronehunter/



Excipio - Net Gun Drone - thisisuav.com

- http://www.theissuav.com/researchanddevelopment/

# Drone Defenses Gone Wild

## DRONES SHOOTING NETS AT OTHER DRONES

[SPARROWHAWK PHASE ONE - Search Systems]

[SparrowHawkFinal_1_1.mp4 - 07Mar2016]



Search Systems - SparrowHawk Phase One (2016) - Counter UAV

- http://searchsystems.eu/sparrowhawk/

DRONE NETTING

# DRONES WITH NETS SWOOPING AT AND SNAGGING DRONES

# Drone Defenses Gone Wild

## DRONES WITH NETS SWOOPING IN AND SNAGGING DRONES

[Tokyo police drones use nets to catch illegally flown devices - 14Dec2015 - YouTube]

[Daily Mail Online - Tokyo police reveal bizarre 'UAV drone catcher' - 11Dec2015]

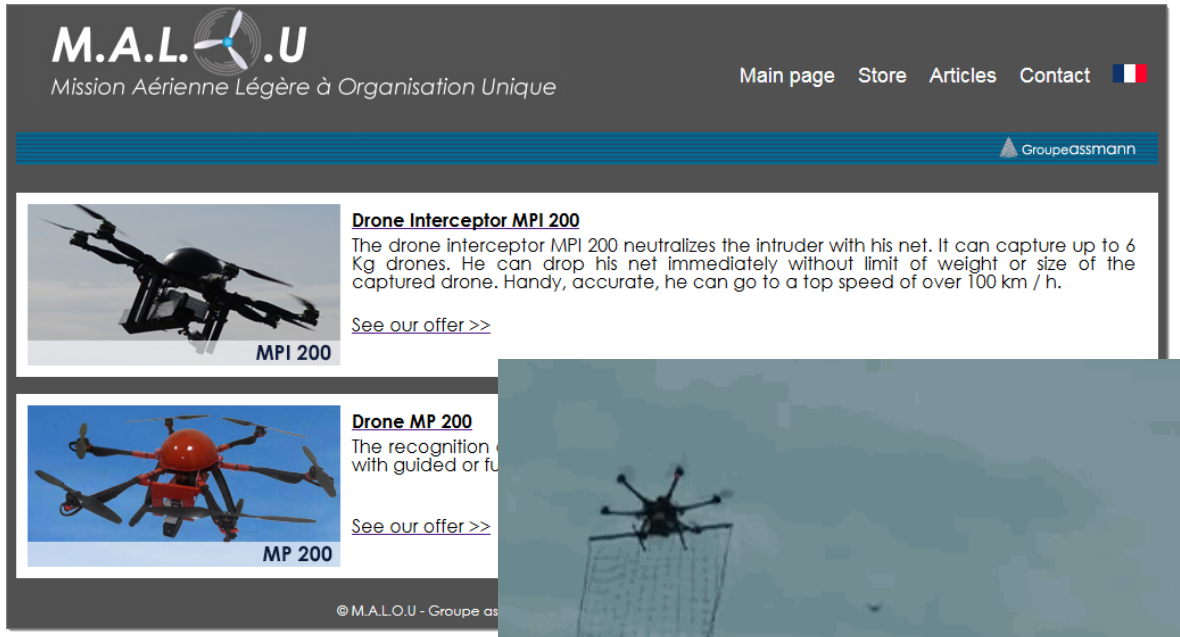

Tokyo Police - Drone Interceptor

# Drone Defenses Gone Wild

## DRONES WITH NETS SWOOPING IN AND SNAGGING DRONES

~$25,000 Euro

[Popular Mechanics - This Drone Interceptor Captures Your Pathetic Puny Drone With a Net - 11Feb2015]






Malou Tech - Drone Interceptor MPI 200

- http://groupe-assmann.fr/malou-tech/

# Drone Defenses Gone Wild

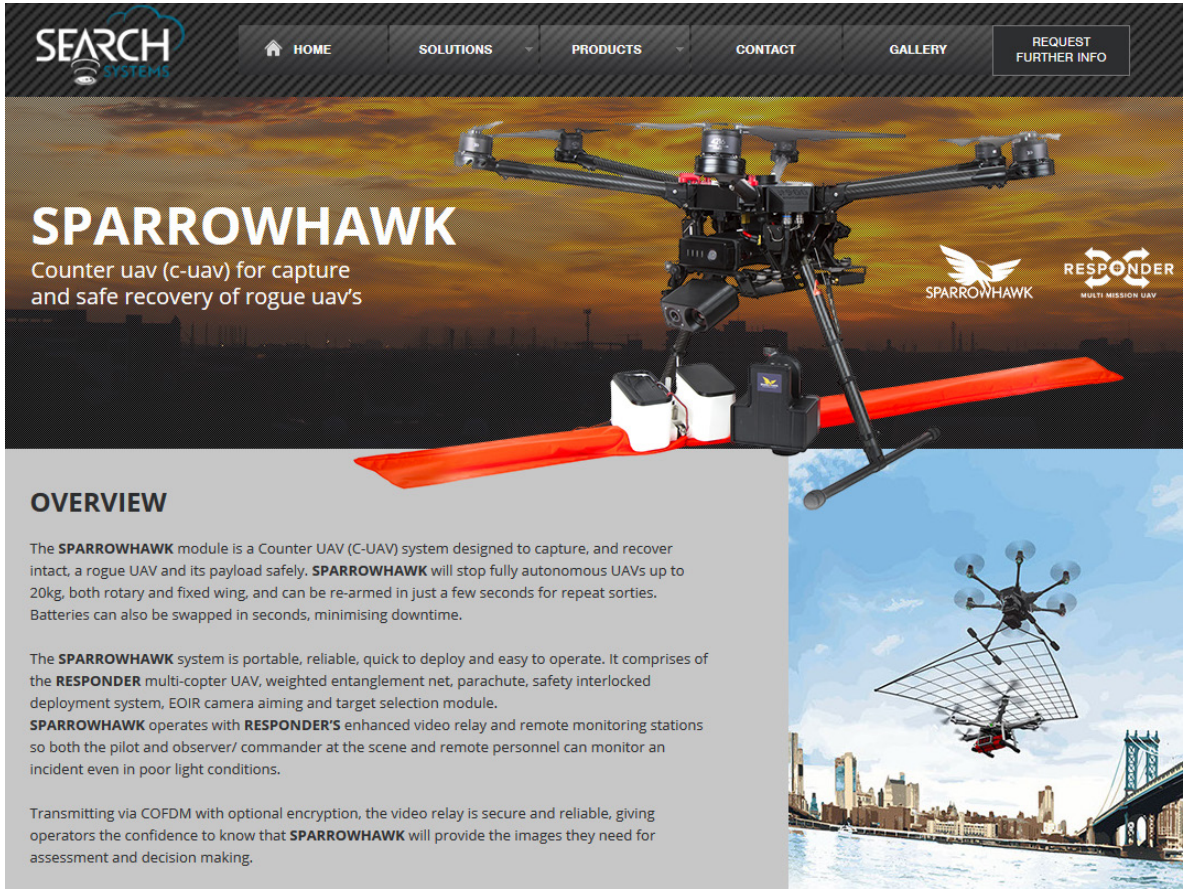
## DRONES WITH NETS SWOOPING IN AND SNAGGING DRONES

**~$11k** =
$5k drone (DJI M600) **+**
$6k attachment (£5k)

http://searchsystems.eu/gallery.html

sparrowhawk_2.mp4 - 07Mar2017

http://www.dji.com/matrice600

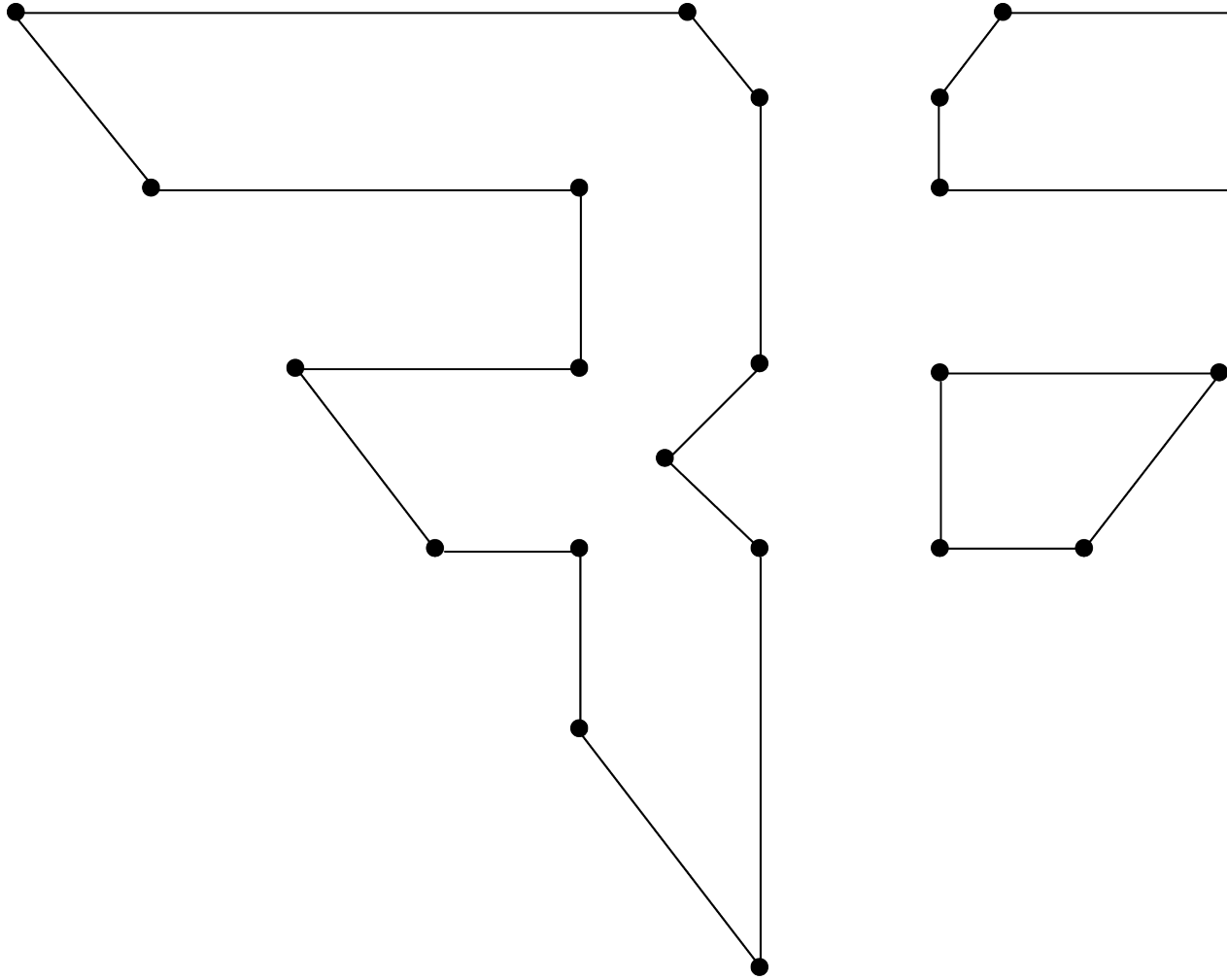



Search Systems - SparrowHawk v2 (2017) - Counter UAV

- http://searchsystems.eu/sparrowhawk.html

DRONE NETTING

# DEMO



# DEMO: Testing the SparrowHawk v2 Prototype

## AIR-TO-AIR COMBAT DRONE DEFENSE WITH LARGE NET FOR SWOOPING


https://www.youtube.com/watch?v=jlGdPrhRvBA&t=129


# CANNONS SHOOTING JAMMING SIGNALS OR EMPS TO KNOCK DRONES OUT OF SKY

# Drone Defenses Gone Wild

## CANNONS SHOOTING JAMMING OR EMP SIGNALS TO KNOCK DRONES OUT OF SKY

*"10's of thousands of dollars"*

DRONESHIELD


[Mashable - DroneShield - DroneGun - Here is the anti-drone gun of your Rambo fantasies - 27Nov2016]

- *DroneGun may **not** be used or offered for sale in the U.S., other than to the government and its agencies. That's because the FCC "prohibits the operation, marketing, or sale of any type of **jamming** equipment."*

**Exhibit 2: DroneShield Key Products** https://www.droneshield.com/sites/default/files/JAW_Drop_V27_04-25-17.pdf

| Product | Function | Available To: | Pricing | Quick Details |
|---|---|---|---|---|
| WideAlert Sensor | Passive Detection | Consumers and Up | ~$6k/yr (*base*) | 180° detection coverage, up to 200m distance |
| FarAlert Sensor | Passive Detection | Consumers and Up | ~$6k/yr (*base*) | 30° detection coverage, up to 1000m distance |
| DroneGun | Active Counter | Militaries International Federal Agencies | 10s of thousands (*outright purchase*) | 2km range; jams 2.4/5.8 GHz, with optional GPS, GLONASS capabilities |
| DroneShield UI | Management Software | Consumers and Up | Free (*included*) | browser-based monitoring and control application |
| DroneSentry (*in development*) | Detection + Counter | Militaries International Federal Agencies | N/A | all-in-one solution comprised of mutliple sensors and integrated jamming for manual or automatic activation on detection |

Source: Company reports; Oppenheimer & Co. Inc.

We detail late-2016/2017 DroneShield announcements below in Exhibit 3; the recent elevated level of significant news flow was reflected in the financials as 72% of the company's 2016 revenue came in the 4th quarter.

DroneGun – by DroneShield

- https://www.droneshield.com/dronegun

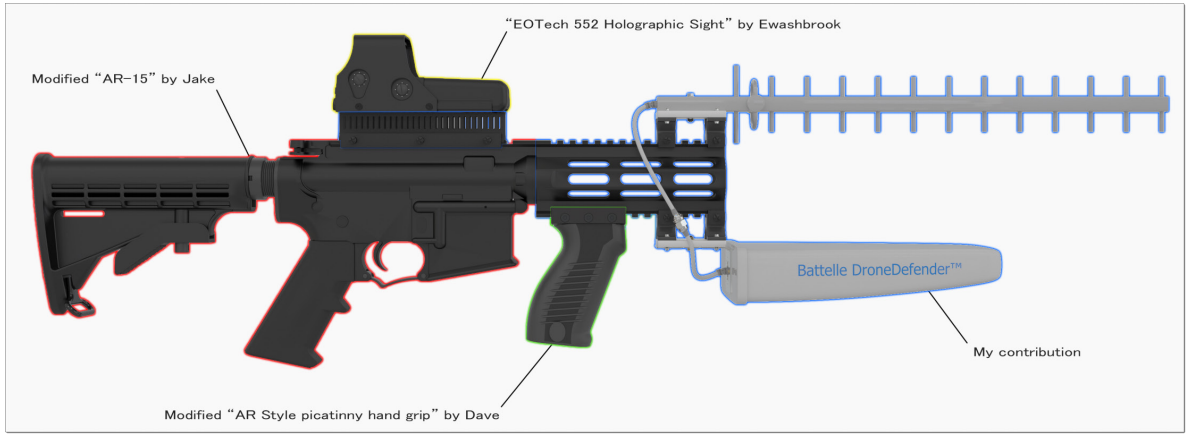
# Drone Defenses Gone Wild

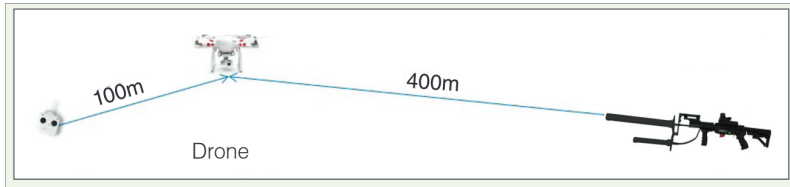
## CANNONS SHOOTING JAMMING OR EMP SIGNALS TO KNOCK DRONES OUT OF SKY

[Security Affairs - DroneDefender, electromagnetic gun that shoot down drones - 16Oct2015]

- Only really work against Wi-Fi controlled drones, ineffective against those like the Danger Drone (i.e. cellular/GPS control)

BATTELLE
DroneDefender™


Effective range of 400 meters, with the adversary at 100 meters.

Antennas can mount to many platforms, including a Picatinny rail as in the nominal form factor shown above.

DroneDefender – by Battelle

- https://www.battelle.org/government-offerings/national-security/aerospace-systems/counter-UAS-technologies/dronedefender

# Drone Defenses Gone Wild

CANNONS SHOOTING JAMMING OR EMP SIGNALS TO KNOCK DRONES OUT OF SKY

$35k

[Popular Science - Skynet Anti-Drone Rifle Can Jam Signals In The Air - 15Sept2016]



HiGH + MiGHTY – SKYNET - Anti-Drones.net - Anti-Drone Rifle - Jamming

- http://anti-drones.net/

# Drone Defenses Gone Wild

## CANNONS SHOOTING JAMMING OR EMP SIGNALS TO KNOCK DRONES OUT OF SKY

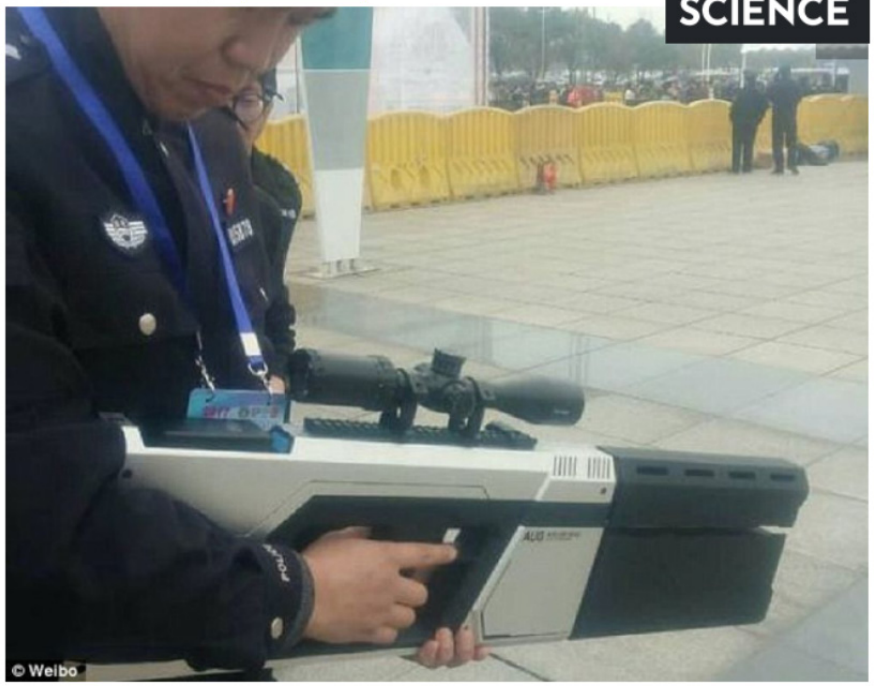
$19k

# Here's how China is battling drones

THERE'S NO SHORTAGE OF TARGETS.

By *Jeffrey Lin and P.W. Singer* *March 28, 2017*

POPULAR SCIENCE




**THE $19,000 GUN**

This drone-jamming gun, one of several owned by the Wuhan police, can shut off drones up to a kilometer away.

Weibo

At a March 11 soccer game in Wuhan, China, police faced a new kind of threat: drones trespassing near the stadium. Their response was to use a new kind of weapon: an anti-drone gun that jammed the control signals, forcing the trespassing drones to land automatically.


Chinese police test out their $19,000 drone guns. Spending a fortune on drone jamming equipment shows how seriously Chinese police take the unmanned aircraft systems threat.

Hubei Government

Popular Science - Heres how China is battling drones - 28Mar2017

- http://www.popsci.com/chinas-new-anti-drone-weapons-jammers-and-lasers

# Drone Defenses Gone Wild

## DRONE PORTABLE JAMMERS

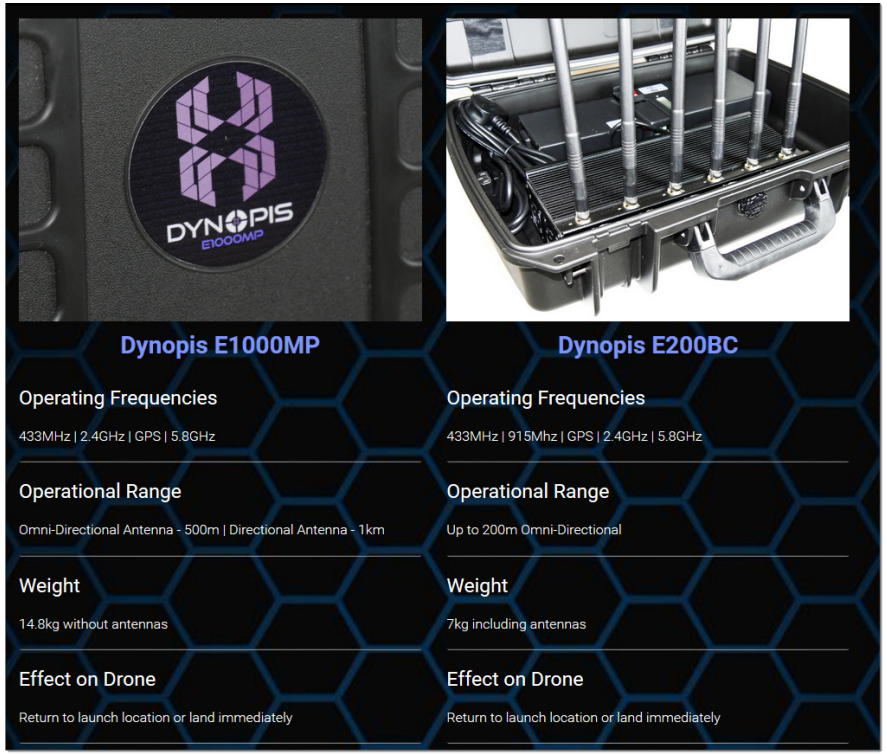
[DroneDefence.co.uk - Dynopis Electronic Counter Measures (ECM)]

DRONEDEFENCE

### Dynopis E1000MP Operation

The E1000MP is the ultimate man portable anti-drone solution. It is a safe, simple to operate and can be carried effortlessly by law enforcement and security officers. The device uses focused electronic counter measures to block the drone's control, GPS and video signals while minimizing the impact on other local devices. With a range of up to 1km if you can see the drone then you can stop it.


*Depending on power settings and environmental conditions.




Drone Defense - Dynopis E1000MP - Man Portable Drone Jammer

- http://www.dronedefence.co.uk/dynopis-ECM

# Drone Defenses Gone Wild

## DRONE PORTABLE JAMMERS

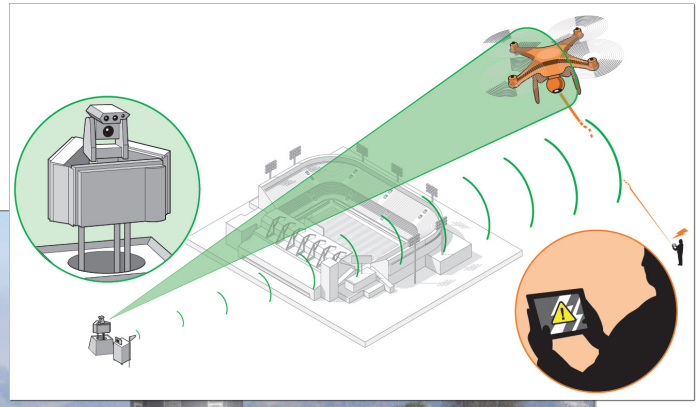
~$500k

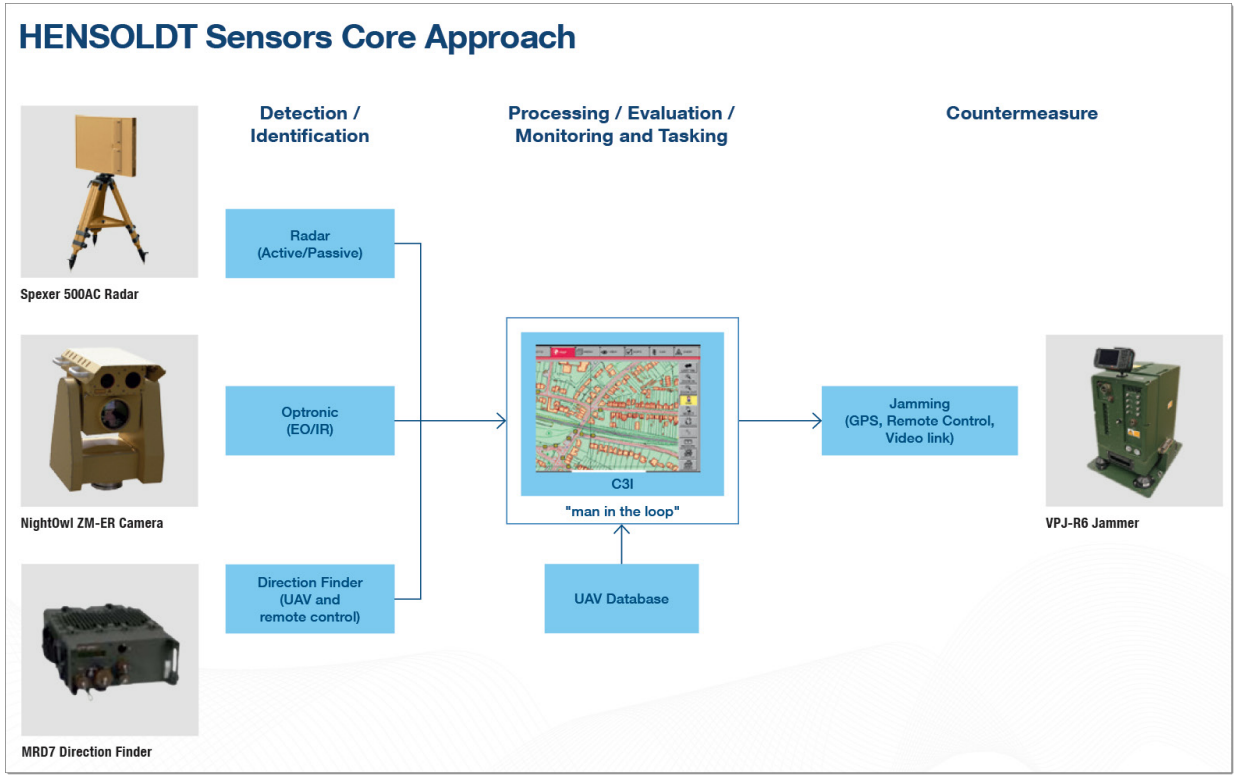
[Hensoldt.net - Xpeller - Counter UAV System Specsheet.pdf]

[c4isrnet.com - Airbus expands counter-drone line (acquired by Hensoldt - rebranded Xpeller) - 17Jan2017]

[Airbus DS EBS Adds Portable Jammer to Its Innovative "Xpeller" Counter-UAV Product Family - 03Jan2017]

HENSOLDT
Detect and Protect.




Hensoldt.net - Xpeller - Counter UAV System (formerly Airbus - Defense and Space - EBS)

- https://www.hensoldt.net/solutions/land/electronic-warfare/xpeller-counter-uav-system/

# Drone Defenses Gone Wild

## CANNONS SHOOTING JAMMING OR EMP SIGNALS TO KNOCK DRONES OUT OF SKY

~£800k (~ $1,037,656.00 USD)

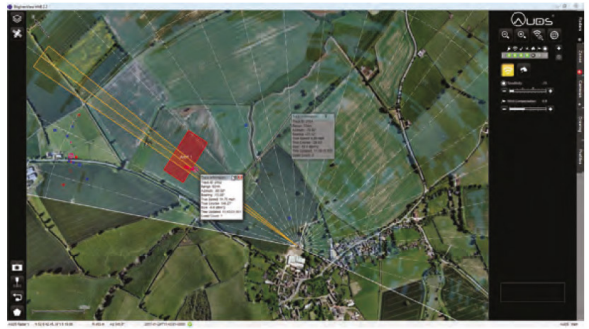
## The Register - FAA to test Brit drone-busting kit (Blighter) - 01Jun2016

- "The Blighter AUDS counter-UAV system can detect a drone six miles (10km) away using electronic scanning radar, track it using precision infrared and daylight cameras and specialist video tracking software before disrupting the flight using an inhibitor to block the radio signals that control it. This detect, track, disrupt, defeat process is very quick and typically takes 8-15 secs."

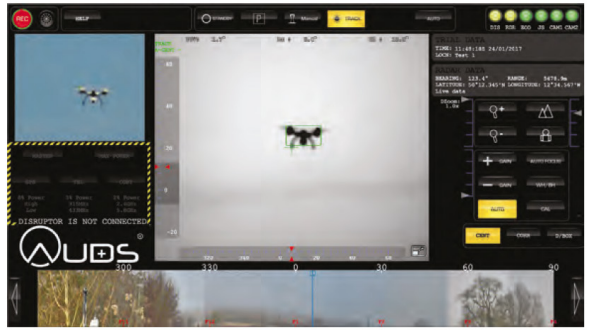
Blighter® Surveillance Systems


LITEYE


**Blighter AUDS** *(shown with Blighter A422 radar with W20S antennas)*




AUDS Radar GUI




AUDS EO/Inhibitor GUI

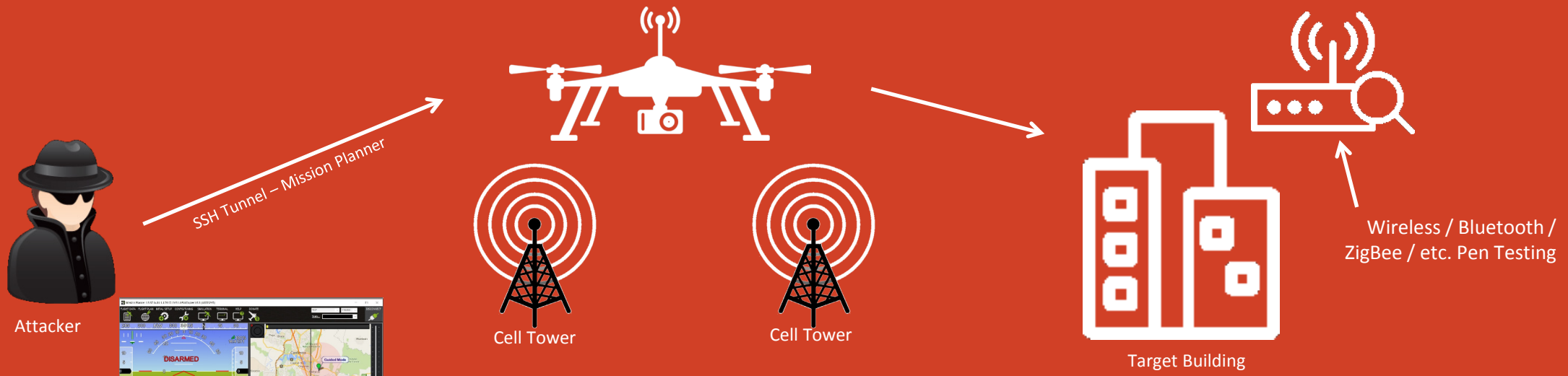
Blighter - AUDS (Anti-UAV Defence System) – Detect, Track, Disrupt, Defeat

- http://www.blighter.com/products/auds-anti-uav-defence-system.html

# Defeating Jammers

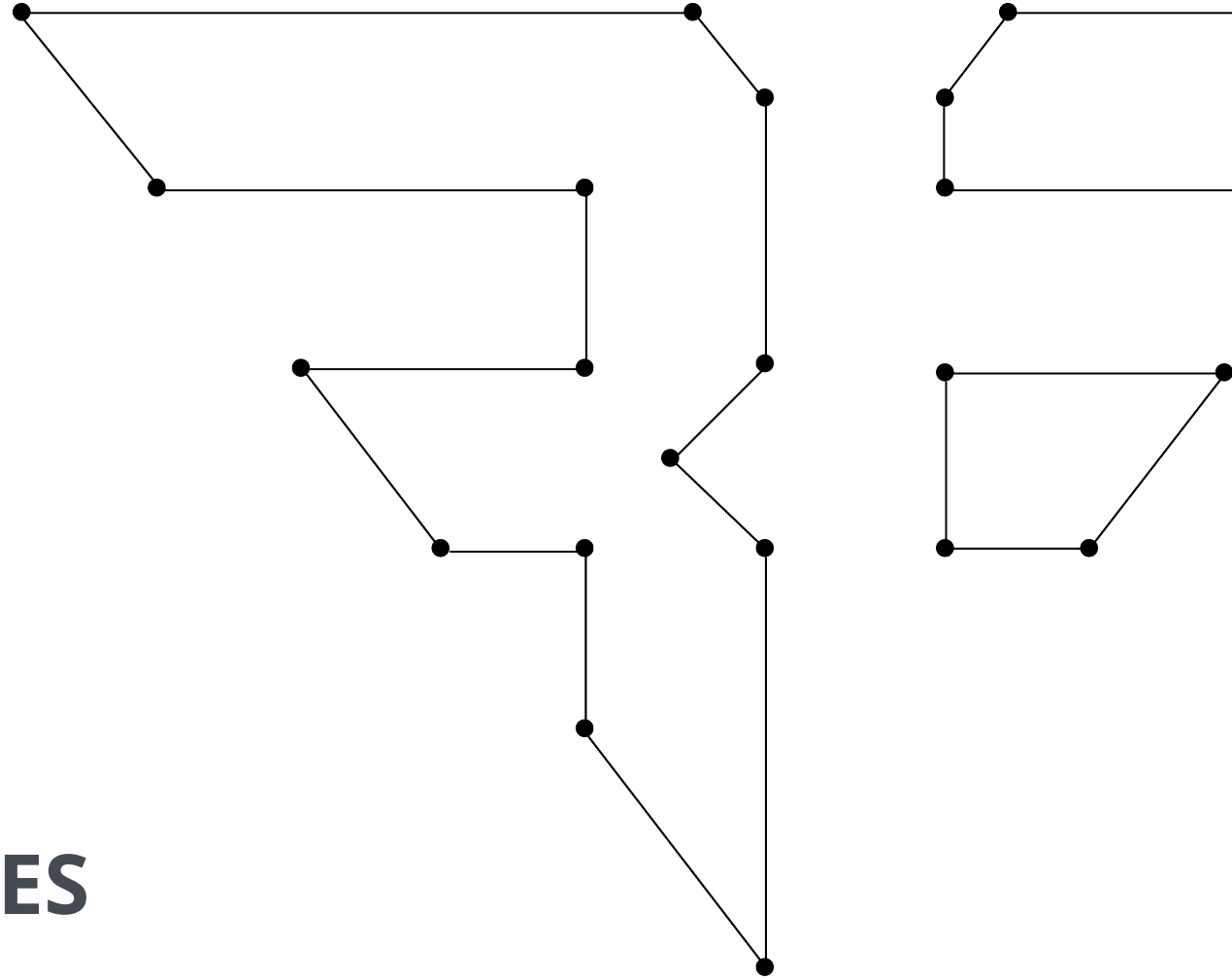
## HACKING PERIPHERALS – CELLULAR 3G USB & GPS – SECURE COMMAND & CONTROL


- Remote control over SSH tunnel via 3G USB cell connection. GPS & Cellular signals are illegal to jam (see FCC regulations), making it hard to defend against this type of drone.
  - https://transition.fcc.gov/eb/jammerenforcement/jamfaq.pdf





* **Note**: be sure to check upcoming FCC regulations about needing to keep drone within line of sight while flying.

# REMOTELY HACKING DRONES TO DISABLE THEM

# Drone Defenses Gone Wild

## REMOTELY HACKING DRONES TO DEFEND AGAINST THEM

~$311k

[Popular Science - Defense Company Unveils Anti-Drone System - 17Sept2015]

[Falcon Shield - 01Oct2015 - YouTube]

- "The material is vague on how exactly it stops small drones, but a video of the system shows the hypothetical threat: a quadcopter dropping a bomb in a stadium. The video then rewinds to show the same attack, foiled by Falcon Shield after mysterious beams take over the drone."

LEONARDO
INGENUITY AT YOUR SERVICE




Leonardo-Finmeccanica - Selex ES - Falcon Shield

- http://www.leonardocompany.com/en/-/falcon-shield-launch

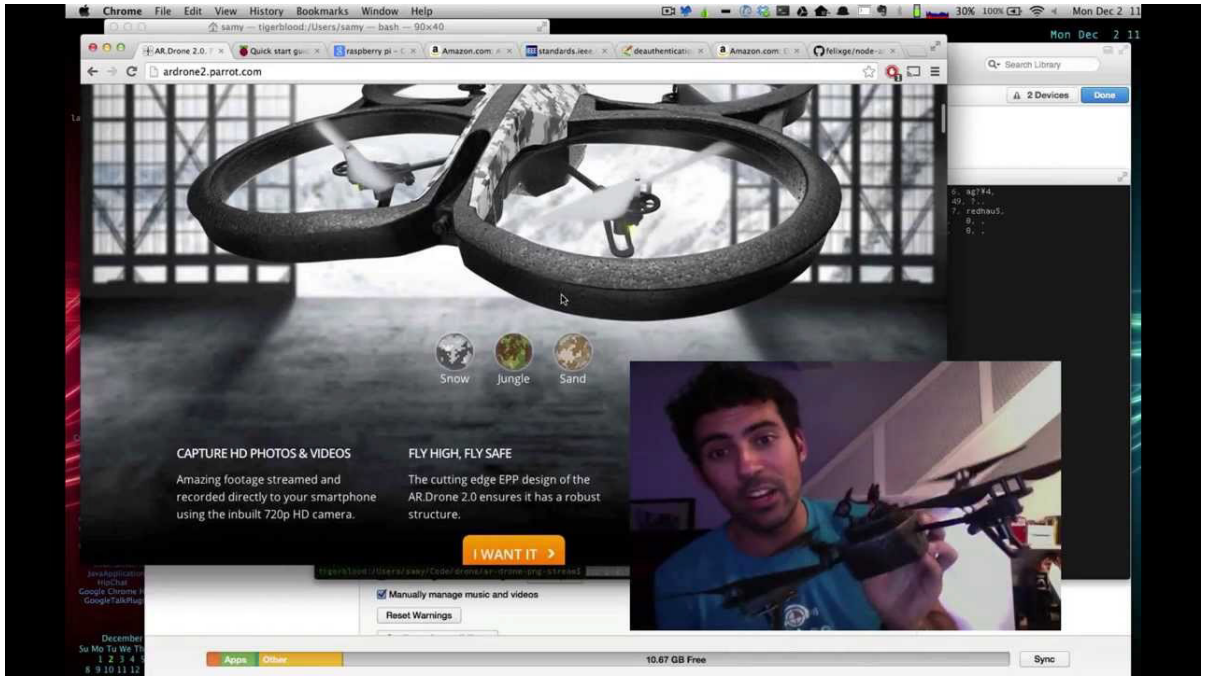
# Drone Defenses Gone Wild

## REMOTELY HACKING DRONES TO DEFEND AGAINST THEM

[Threatpost - How to Skyjack Drones for $400 - 03Dec2013]

[SkyJack - autonomous drone hacking w/Raspberry Pi, aircrack & Javascript - 03Dec2013 - YouTube]

- Raspberry Pi drone that autonomously seeks outs, hacks, and takes remote control of other drones





SkyJack - Samy.pl - Raspberry Pi hacking

- http://samy.pl/skyjack/

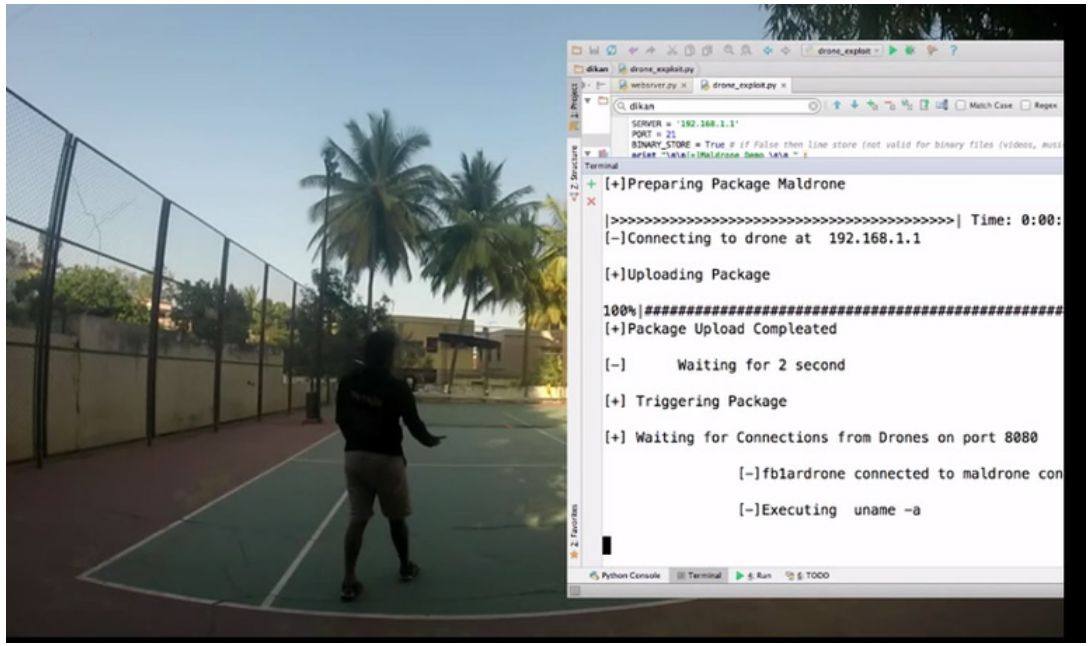
# Drone Defenses Gone Wild

## REMOTELY HACKING DRONES TO DEFEND AGAINST THEM

[SecurityAffairs.co - A hacker developed Maldrone, the first malware for drones - 27Jan2015]

[First Backdoor for Drones. Maldrone aka Malware for Drones - 26Jan2015- YouTube]

- *"Security expert Rahul Sasi has discovered and exploited a backdoor in Parrot AR Drones that allows him to remotely hijack the UAV with the malware Maldrone."*




Maldrone – the First Backdoor for Drones

- http://garage4hackers.com/entry.php?b=3105

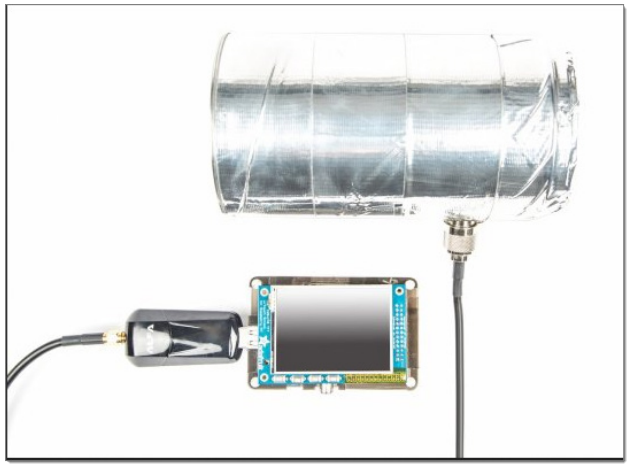
# Drone Defenses Gone Wild

## CANNONS SHOOTING JAMMING OR EMP SIGNALS TO KNOCK DRONES OUT OF SKY

[DRONELIFE - Anti-Drone Gun Uses Raspberry Pi - 11May2016]

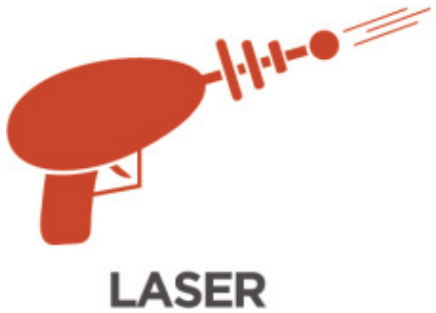
- Only really work against Wi-Fi controlled drones, ineffective against those like the Danger Drone (i.e. cellular/GPS control)

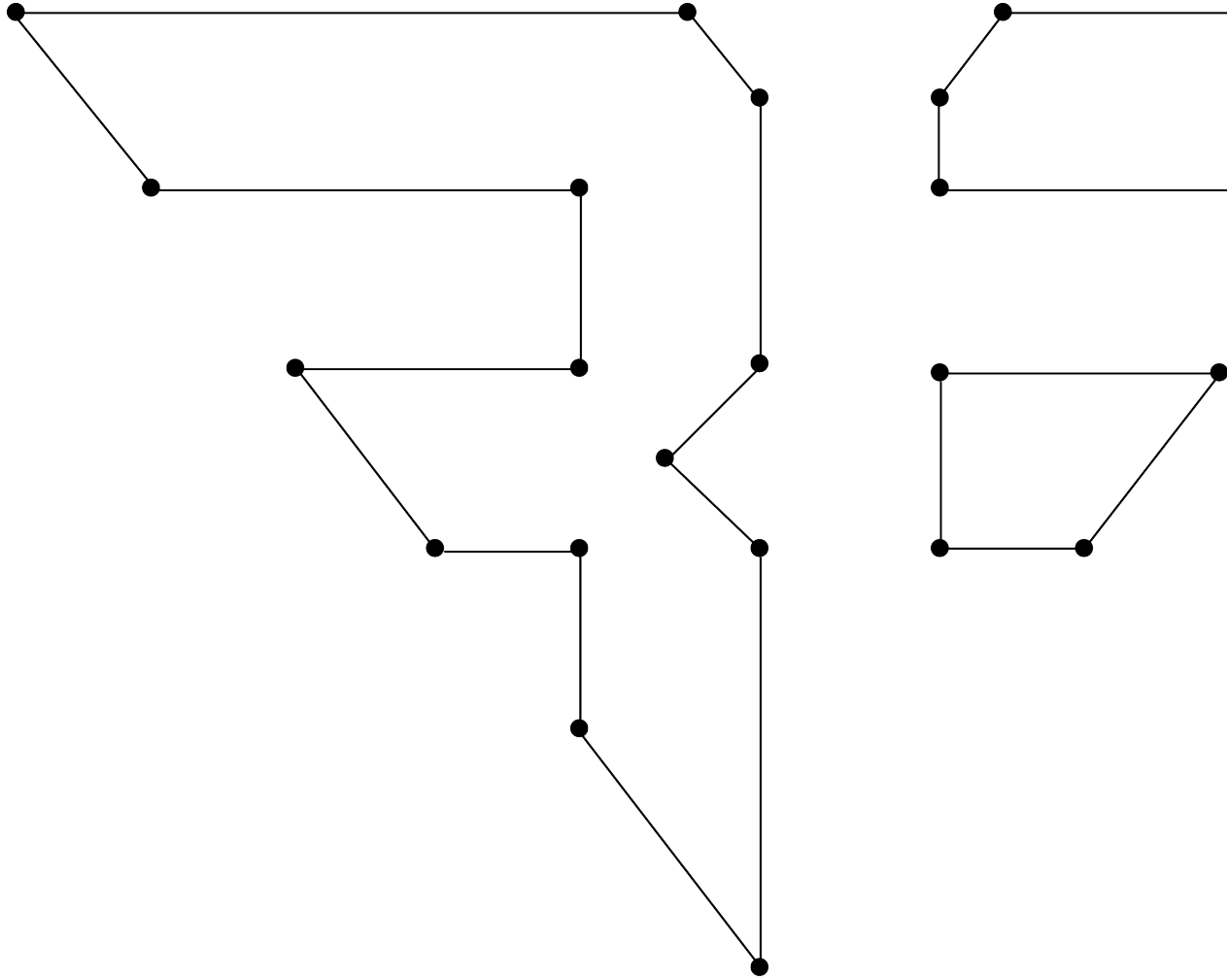
Make:



MAKE: Build a Wi-Fi Drone Disable with a Raspberry Pi – May2016

- http://makezine.com/projects/build-wi-fi-drone-disabler-with-raspberry-pi/



# SHOOTING DRONES WITH FRICKIN LASER BEAMS

# Drone Defenses Gone Wild

## SHOOTING DRONES WITH FRICKIN LASER BEAMS

~$11 million

BOEING

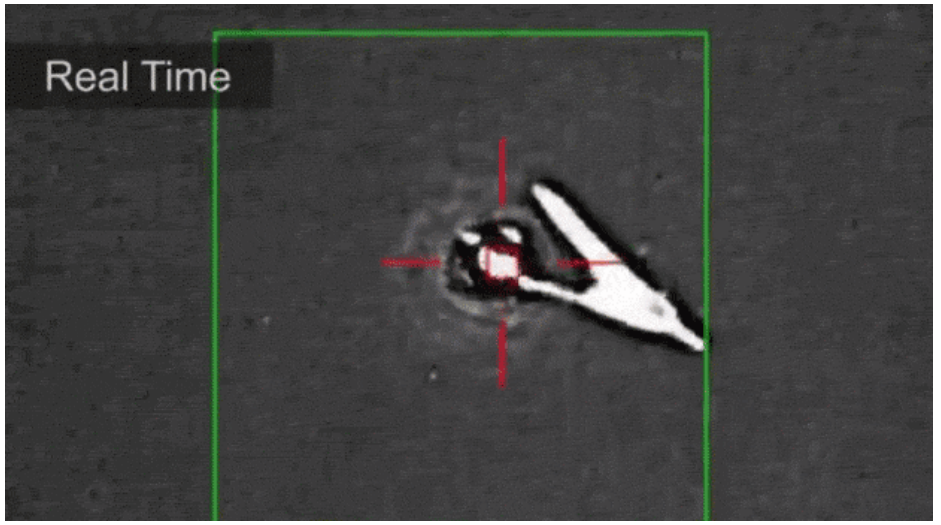
[LA Times - To keep drones out of high-risk areas, companies try hijacking them and shooting them down - 07Oct2016]

- "Last year, Boeing unveiled its compact laser weapons system, which ignites targeted drones. At a demonstration in California, Boeing said it took only about 15 seconds for its 2-kilowatt laser to disable the drone."

[Wired.com - Welcome to the World, Drone-Killing Laser Cannon - 27Aug2015]

- "The laser can take the 220 volts of power it needs from a generator or mobile battery pack and is controlled with nothing more than a laptop and an Xbox 360 controller, and the system will take over to track and fire on a drone itself once it's in range.

[Boeing's Compact Laser Weapons System: Sets Up in Minutes, Directs Energy in Seconds - 27Aug2015 - YouTube]



Boeing - Compact Laser Weapons System – "Directed Energy"

- http://www.boeing.com/features/2015/08/bds-compact-laser-08-15.page

# Drone Defenses Gone Wild

## SHOOTING DRONES WITH FRICKIN LASER BEAMS

POPULAR SCIENCE

### The Navy Is Going To Test A Big Laser Soon

150 kilowatts of directed energy, pointed at an unknown date on a calendar.

By **Kelsey D. Atherton** June 24, 2016

US Naval Research, YouTube Screenshot

Laser Weapon System On The USS Ponce

Damage done by laser weapons is a function of power and time. The longer a laser can stay on a target, like a drone or an incoming missile, the more damage it can do. The more powerful that laser is, the less time it needs to spend burning its target. The U.S. Navy already has a 30-kilowatt laser mounted on a ship. Yesterday, at a summit on directed energy weapons in Washington, D.C., the Navy announced it plans to go bigger: 150 kilowatts.

Not yet lethal ? 11 December 2014, Atlantic Ocean. Senior Chief Master-at-Arms Shannan Richardson receives training in the use of an LA-9/P laser aboard the amphibious transport dock ship USS Arlington. Seen here mounted on a rifle stock, this hand-held GLARE/LA 9/P laser from B.E. Meyers, is used by individual Sailors out to 4 km at night and 1.5 km during daylight for hail and warning across linguistic and cultural boundaries. U.S. Navy photo by Mass Communications Specialist 2nd Class Stevie Tate

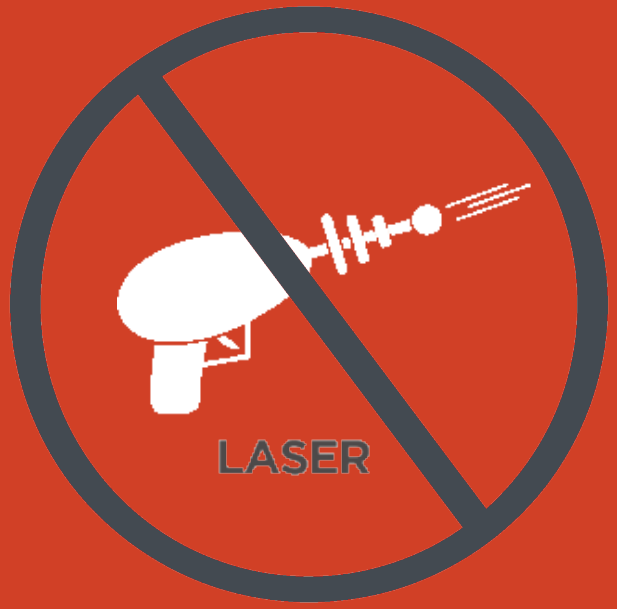

U.S. Navy LaWS - AN/SEQ-3 Laser Weapon System or XN-1 LaWS

- https://en.wikipedia.org/wiki/Laser_Weapon_System

# Defeating Laser Weapons

## SHOOTING DRONES WITH FRICKIN LASER BEAMS

1. **Mirrors (Dielectric or Bragg)**
2. **Smoke, Dust, Obscurants**
3. **Thermal Transport Delay**
4. **Ablative Materials (heat -> gas)**
5. **Metamaterials (bend light like Predator)**
6. **Adsys Controls – Helios**
   - **Detects laser and fights back**

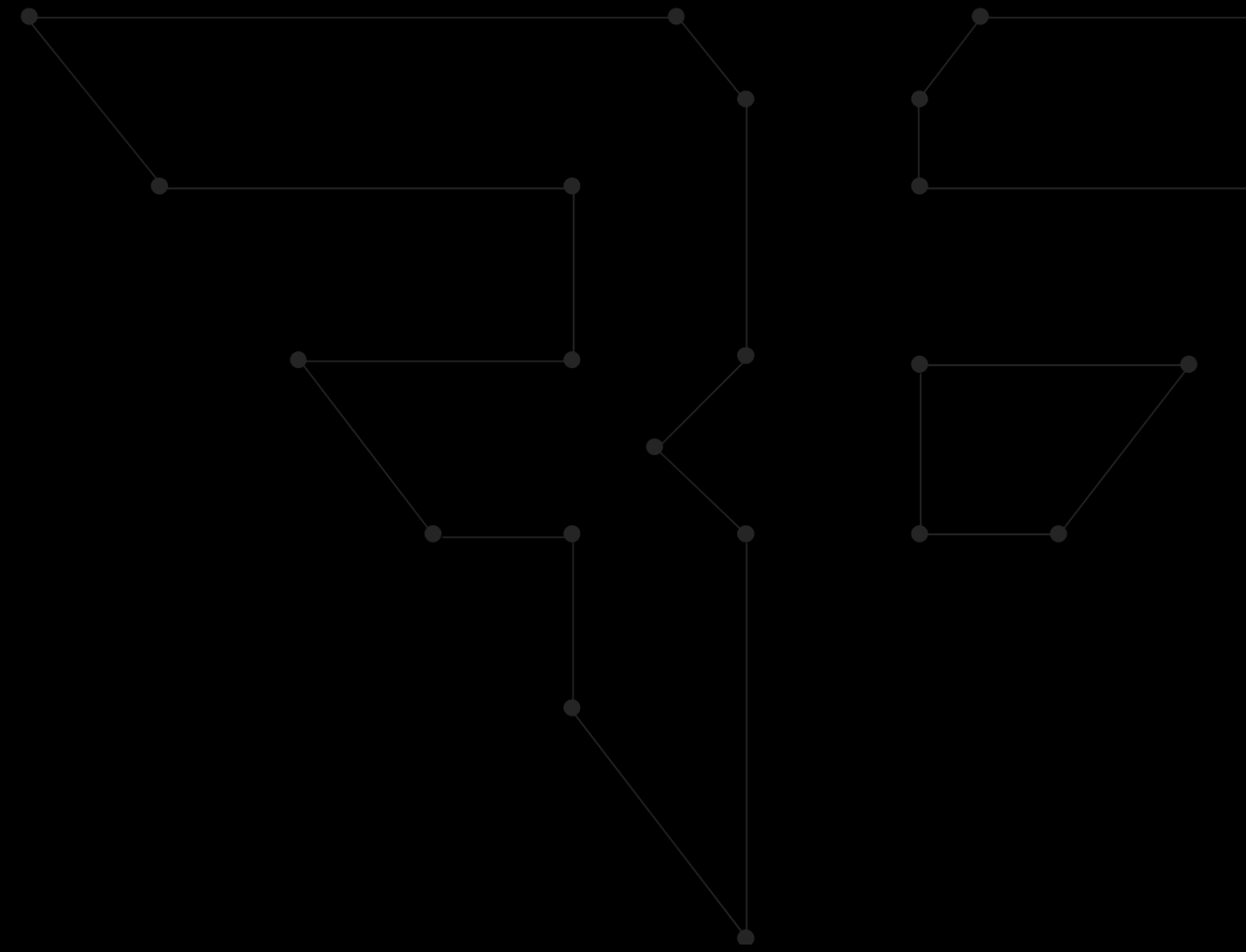



Popular Science – Defeating Anti-Drone Laser Weapons

- http://www.popsci.com/laser-guns-are-targeting-uavs-but-drones-are-fighting-back
- http://www.popsci.com/china-plans-to-defeat-american-lasers-with-smoke

Counter Directed Energy Weapons - Office of Naval Research

- https://www.onr.navy.mil/en/Media-Center/Fact-Sheets/Counter-Directed-Energy-Weapons.aspx



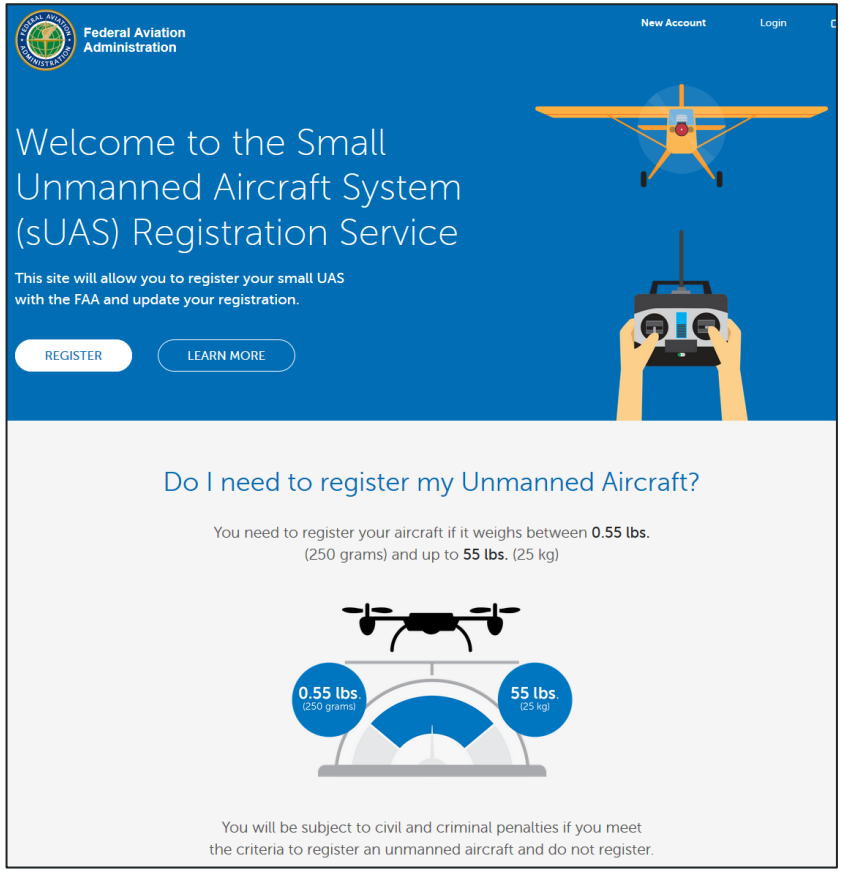
# LEGAL ISSUES

## YOU HAVE THE RIGHT TO REMAIN FRUSTRATED

# FAA Rule on Small Drones

## CHANGING LEGAL LANDSCAPE

- https://registermyuas.faa.gov/




The rules for operating an unmanned aircraft depend on why you want to fly.

| | Fly for Fun | Fly for Work |
|---|---|---|
| **Pilot Requirements** | No pilot requirements | Must have Remote Pilot Airman Certificate<br>Must be 16 years old<br>Must pass TSA vetting |
| **Aircraft Requirements** | Must be registered if over 0.55 lbs. | Must be less than 55 lbs.<br>Must be registered if over 0.55 lbs. (online)<br>Must undergo pre-flight check to ensure UAS is in condition for safe operation |
| **Location Requirements** | 5 miles from airports without prior notification to airport and air traffic control | Class G airspace* |
| **Operating Rules** | Must ALWAYS yield right of way to manned aircraft<br>Must keep the aircraft in sight (visual line-of-sight)<br>UAS must be under 55 lbs.<br>Must follow community-based safety guidelines<br>Must notify airport and air traffic control tower before flying within 5 miles of an airport | Must keep the aircraft in sight (visual line-of-sight)*<br>Must fly under 400 feet*<br>Must fly during the day*<br>Must fly at or below 100 mph*<br>Must yield right of way to manned aircraft*<br>Must NOT fly over people*<br>Must NOT fly from a moving vehicle* |
| **Example Applications** | Educational or recreational flying only | Flying for commercial use (e.g. providing aerial surveying or photography services)<br>Flying incidental to a business (e.g. doing roof inspections or real estate photography) |
| **Legal or Regulatory Basis** | Public Law 112-95, Section 336 – *Special Rule for Model Aircraft*<br>FAA Interpretation of the Special Rule for Model Aircraft | Title 14 of the Code of Federal Regulation (14 CFR) Part 107 |

Effective: 29 Aug 2016

The **NEW** Small UAS Rule (Part 107), including all pilot and operating rules, will be effective on **August 29, 2016**. For more detailed information, please see:

- Summary of the Small UAS Rule (PDF)
- Small UAS Advisory Circular – How to Use the Rule (PDF)
- Complete Text of the Small UAS Rule
- Sample Aeronautical Knowledge Test Questions (PDF)

Need more information? Read about how to fly a UAS for your work or business.

***Update: 19 May 2017:***

*Law thrown out after lawsuit. No longer required to register drones with the FAA and $$$ refunds for those that already did.*

# Taylor vs. FAA - Lawsuit Against Drone Rule

CHANGING LEGAL LANDSCAPE

19 May 2017

[RC Groups - Taylor v. FAA Update - 04Mar2017]

[DRONELIFE - The Lawsuit Over Drone Registration: Taylor vs. Huerta & FAA - 14Jun2016]

[Hackaday - Don't Like the FAA's Drone Registration? Sue Them! - 26Sept2016]

- "My case challenging the FAA's model aircraft registration regulation, and the application of DC-area flight zones to model aircraft is scheduled for **oral argument** in the U.S. Court of Appeals for the D.C. Circuit on **March 14, 2017**."

How a little-known insurance lawyer became a symbol of (drone) liberty

*When the Federal Aviation Administration started enforcing new rules around model aircraft pilots, John Taylor went from drone hobbyist to crusader.*

*John Taylor and one of the drones he custom built.*

Slashdot | Stories | Firehose | All | Popular | Polls | Deals | Submit

**Americans No Longer Have To Register Non-Commercial Drones With the FAA** (recode.net) 113

Posted by msmash on Friday May 19, 2017 @03:20PM from the go-and-be-happy dept.

A federal appeals court on Friday struck down a federal rule that required owners of recreational drones and other model aircraft to register the devices with the Federal Aviation Administration. The FAA had announced the rule in 2015 in response to growing reports of drones flying near manned aircraft and airports. Drones have become increasingly popular with hobbyists and more than 550,000 unmanned aircraft were registered within the first year it was required. From a report:

> The court ruled that the FAA's drone registration rules, which have been in place since 2015, were in violation of a law passed by Congress in 2012. That law, the FAA Modernization and Reform Act, prohibited the FAA from passing any rules on the operation of model aircraft -- in other words, rules that restrict how non-commercial hobbyist drone operators fly. Now, if a person buys a new drone to fly for fun, they no longer have to register that aircraft with the FAA. But if flying for commercial purposes, drone buyers still need to register. The lawsuit was won by John Taylor, a model aircraft enthusiast, who brought the case against the FAA in January 2016. Since first opening the FAA's registration system in December 2015, more than 820,000 people have registered to fly drones.

# Hard to Legally Defend Against Drones

IF YOU CAN'T JAM THE SIGNAL, AND YOU CAN'T BLAST WITH A SHOTGUN... THEN WHAT?

[The Register - Bloke cuffed for blowing low-flying camera drone to bits with shotgun - 20July2015]

[Digital Trends - Drone Shooting is a Federal Crime - 17Apr2016]

The Register®
Biting the hand that feeds IT

**Bloke cuffed for blowing low-flying camera drone to bits with shotgun**

Sharpshooter exercises Second Amendment rights

Drone pwner ... William Merideth

30 Jul 2015 at 05:02, Iain Thomson

A father of two girls didn't take too kindly to a camera-equipped quadrocopter hovering over his house and snooping on his kids – so he blasted it out of the sky.

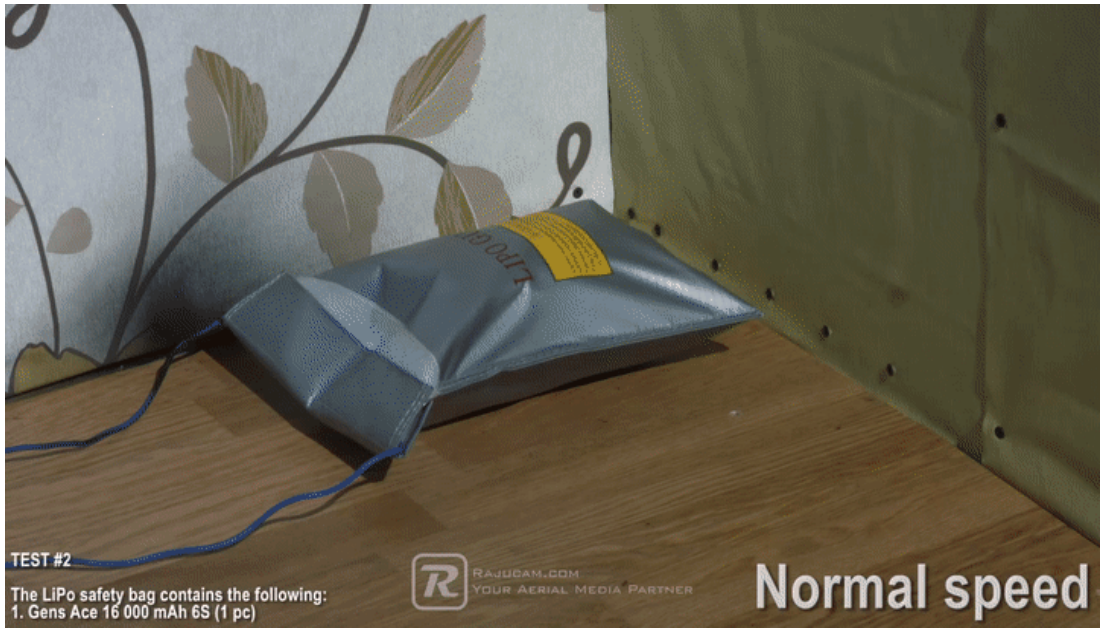
Now he's facing charges of first-degree criminal mischief and wanton endangerment.

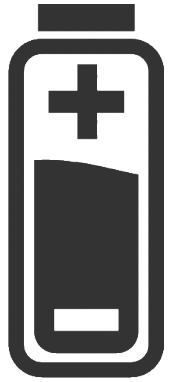
*"What the h*** are we supposed to use, man, harsh language?" –*

**Aliens (1986)**

# WARNING: Shooting LiPo Batteries Is Dangerous

BASICALLY AN UNSTABLE BOMB – POKE AND IT BLOWS UP, SPITTING FIRE



[YouTube - What happens when you puncture a LiPo battery - July2014]

[YouTube - How to store LiPo battery safely - In depth LiPo fire tests - 15May2016]

# Hard to Legally Defend Against Drones

IF YOU CAN'T JAM THE SIGNAL, AND YOU CAN'T BLAST WITH A SHOTGUN... THEN WHAT?

[Digital Trends - Drone Shooting is a Federal Crime - 17Apr2016]

**Aircraft Sabotage Law:**

*"Conviction for violating the FAA statute could result in a 5-year prison term."*

[Justice.gov - 2. Aircraft Sabotage - Law Statute 18 U.S.C. 32]

You can't shoot drones, it's a federal crime

EVEN IF YOU'RE BOTHERED BY THAT DRONE OVER YOUR HOUSE, YOU CAN'T SHOOT IT DOWN

By **Bruce Brown** — April 17, 2016 7:26 AM

DIGITAL TRENDS

The FAA wants people to stop shooting drones. At least 12 drones have been shot out of the sky in five U.S. states and the Federal Aviation Authority says it's a federal crime, according to a report in Forbes. Even if they're over your house. Even if they're carrying running chainsaws.

The FAA says you can't shoot them down and you can't disturb or interfere with someone flying a drone. Apparently drone pilot harassment is a bit less of an issue than, say, banging on the flight deck door on a passenger aircraft, but it's still against the law. Enforcement, however, seems sketchy — as in, no one's been arrested yet under the federal statute.

In response to a question from a Forbes reporter, the FAA cited statute 18 USC 32. The aircraft sabotage law authorizes prosecution of anyone who damages an aircraft or commits a violent act against persons operating the aircraft, or even in the aircraft, should that act endanger the safety of the aircraft. Exactly what constitutes an "act of violence" is not defined in the statute, but clearly shooting a drone or its pilot would qualify.

# More Drone Legal Guidance

## CHANGING LEGAL LANDSCAPE

https://jrupprechtlaw.com/drone-law-blog

JRupprechtLaw.com - US Drone Laws (2017) - Drone Laws by State

JRupprechtLaw.com - 7 Big Problems with Counter Drone Technology (Drone Jammer, Anti Drone Gun, Etc.) - 16Feb2017

### 7 BIG PROBLEMS WITH COUNTER DRONE TECHNOLOGY (DRONE JAMMERS, ANTI DRONE GUNS, ETC.)

#### A Brief Background on the Brewing Drone Problem


As the drone industry is taking off, some individuals and groups have started using drones for malicious purposes around the globe. Many companies are watching the trend and are trying to get into the counter drone industry. They have introduced all sorts of drone guns, anti-UAS shotgun shells, attack birds, net cannons, lasers, missiles, radio signal jammers, radio spoofers, etc.

#### Types of Counter Drone Technology

The counter drone technology is getting lumped all into one bucket but I think it is best broken up into two categories: (1) detectors and (2) defenders. Keep in mind that these terms are my own.

R Rupprecht Law P. A.

# FUTURE IS AWESOME

1980’S SCI-FI... FINALLY HAPPENING

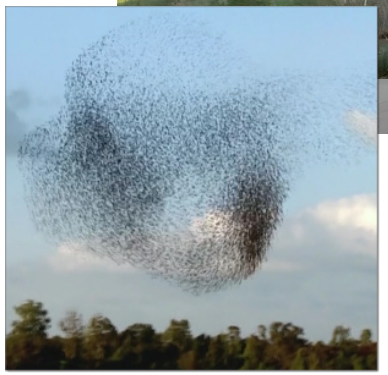
# The Future was on TV in the Past

GADGETS – SMALLER **FLYING DEVICES** & DROPPING OFF **GROUND DEVICES**

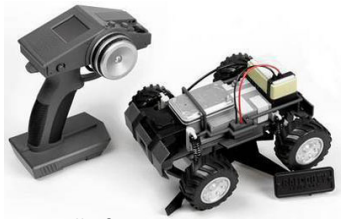
AS SEEN ON TV

1. Drone Swarms
2. Hybrid Approaches
3. Under-water Drone
4. Micro / Bug-sized Drones


24 (TV) – Spy Bot

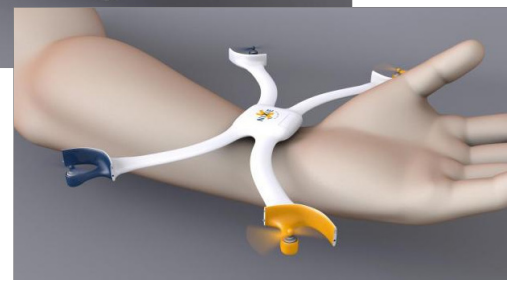


Drone Swarms

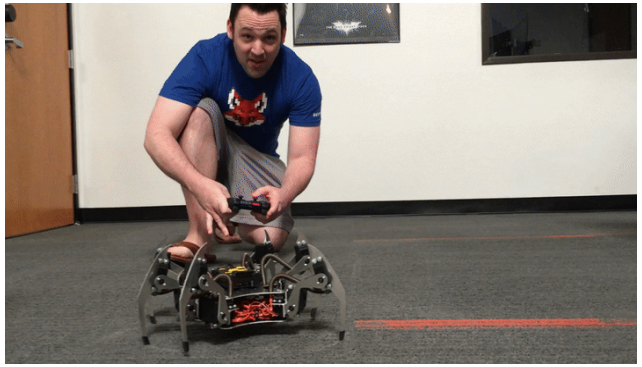


Call of Duty - RC-XD Remote Control Car (w Camera/Mic)

Wearable drones



Transformers – Laserbeak


Sand Flea - Jumping Infiltrating Robot

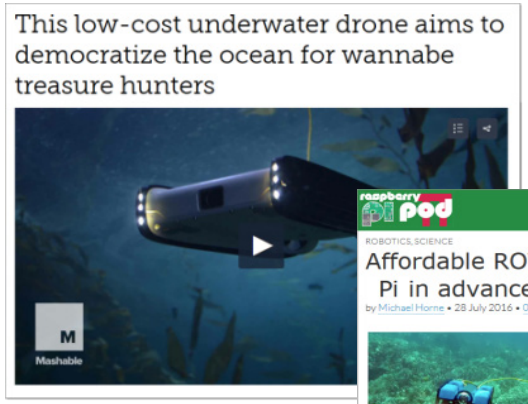
# The Future was on TV in the Past

GADGETS – SMALLER **FLYING DEVICES** & DROPPING OFF **GROUND DEVICES**

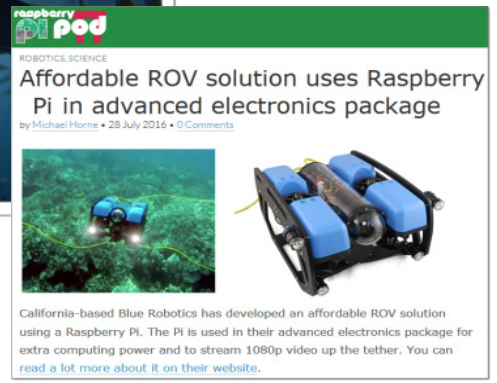
AS SEEN ON TV

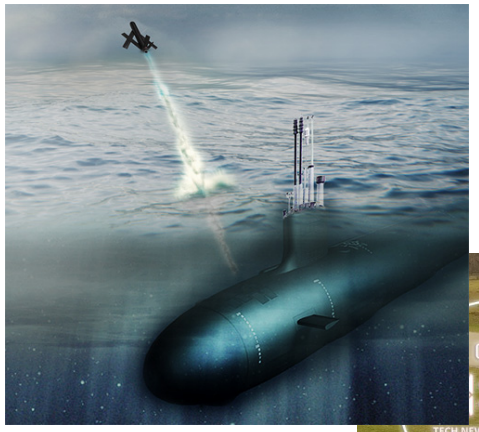
1. Drone Swarms
2. Hybrid Approaches
3. Under-water Drone
4. Micro / Bug-sized Drones

US Army – Micro Copters

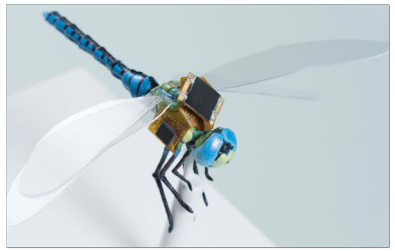


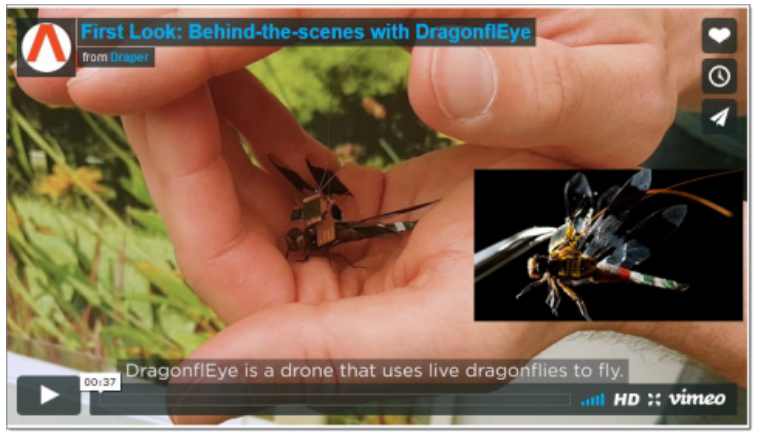

RaspPi Submarine Drones



Hybrid Approaches




DragonFly Cyborgs

Pollinating Drone Bees

# The Future was on TV in the Past

GADGETS – SMALLER **FLYING DEVICES** & DROPPING OFF **GROUND DEVICES**

*3D mapping the insides of target buildings,*

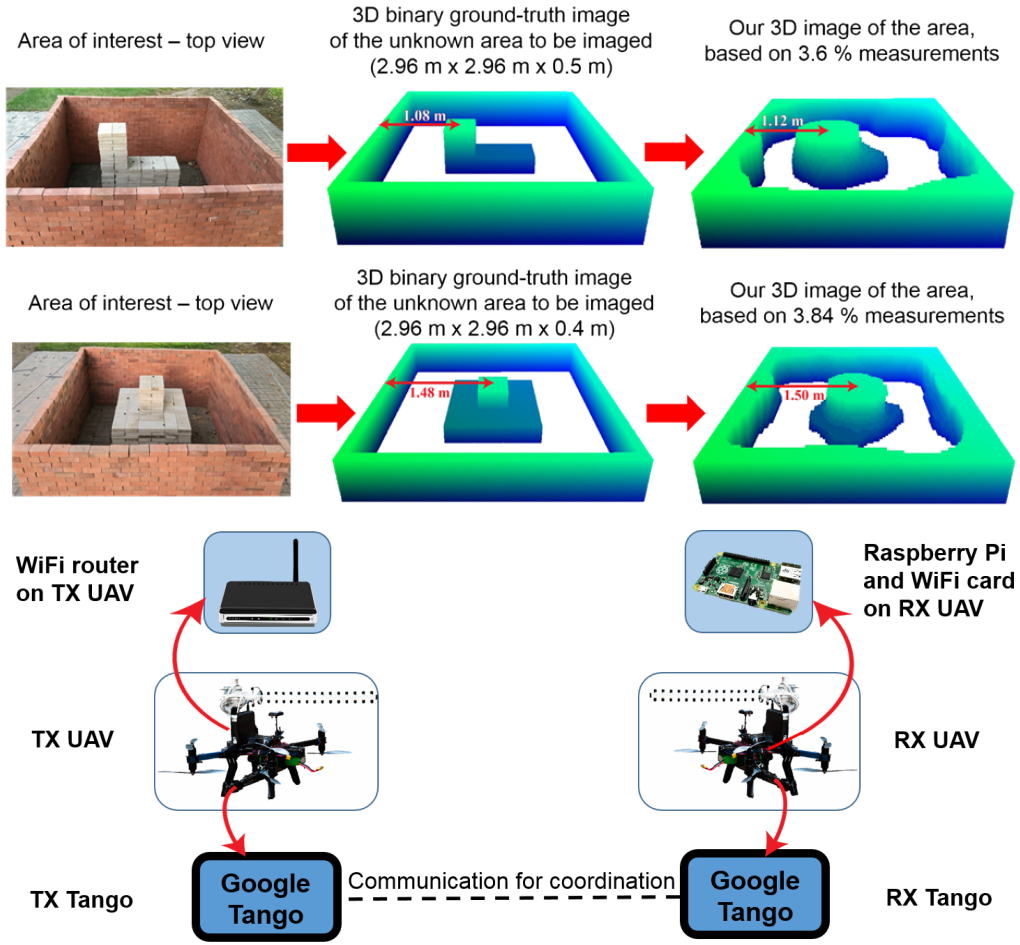
*kinda like **Batman** in '**The Dark Knight**'*


Drones can now see through walls — sort of.

Researchers at the University of California, Santa Barbara, just figured out how to use Wi-Fi signals and drones to create 3D maps of the inside of buildings. The video above demonstrates their process, which is also detailed in a paper published online.

For the experiment the team used two drones. One sent Wi-Fi signals from one side of the structure, while the other picked up what was left of the signal (the received signal strength or RSSI) on the other side of the walls. The result is a pretty decent image of what's inside the building.

Instead of Superman and X-ray vision, we have drones and Wi-Fi. But like Superman, the drones might be able to take some 3D measurements of the inside of collapsed buildings and so on before emergency rescue arrives.



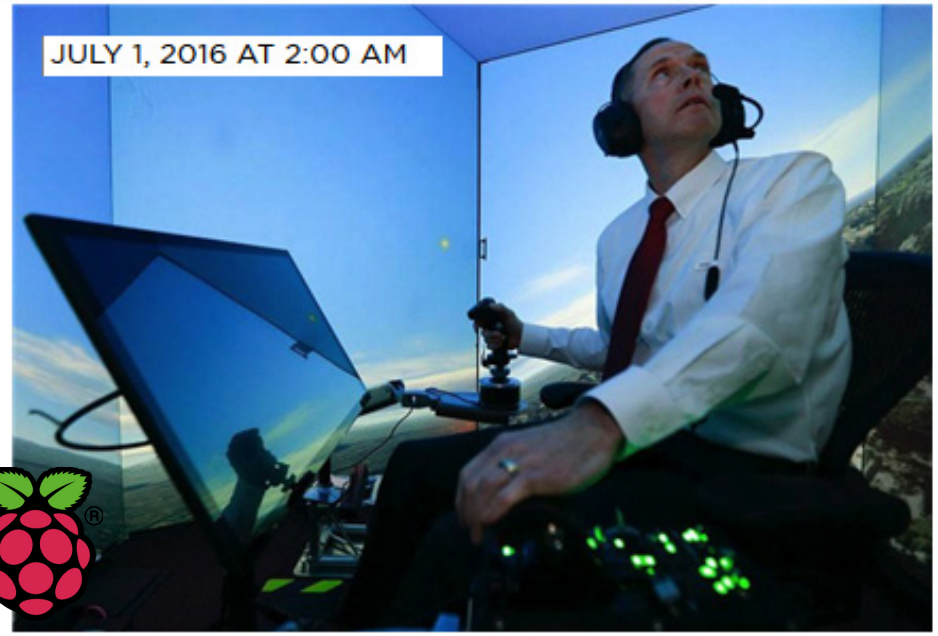

Mashable - These drones use wifi to make 3D images - 20Jun2017

- http://mashable.com/2017/06/20/drones-3d-wifi-map/

# The Future was on TV in the Past

GADGETS – SMALLER **FLYING DEVICES** & DROPPING OFF **GROUND DEVICES**

## Raspberry Pi-Powered AI Beats Human Pilot in Dogfight




**An AI that runs on Raspberry Pi made headlines in Newsweek this past week.**

When the Raspberry Pi computer was first launched in 2012 to promote the teaching of computer science, its creators probably didn't imagine the $35 device would one day take on a professional fighter pilot in a dogfight—and win.

But that is exactly what a doctoral graduate at the University of Cincinnati set out to do when he built a Pi-powered artificial intelligence pilot. The AI, dubbed ALPHA, went up against retired United States Air Force Colonel Gene Lee in a series of simulated battles, beating Lee in every single engagement.

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## Aerial Informatics and Robotics Platform

Established: February 15, 2017

### Bridging the simulator-to-reality gap with Aerial Informatics and Robotics platform

Machine learning is becoming an increasingly important artificial intelligence approach to building autonomous and robotic systems. One of the key challenges with machine learning is the need for many samples — the amount of data needed to learn useful behaviors is prohibitively high. In addition, the robotic system is often non-operational during the training phase. This requires debugging to occur in real-world experiments with an unpredictable robot.

## Autonomous robot security guard has a built-in drone to stop intruders


Rise of **A.I.** and **Auto-pilot** Software

# Possible Future from Bishop Fox??

## HACKING DRONES: STAY TUNED FOR FUN RESEARCH TO COME

Check our project page for continued updates to our drone defense and penetration testing research:

- http://DangerDrone.io


Danger Blimps

Danger Subs


Bishop Fox – Danger Drone Research:

- http://dangerdrone.io

BISHOP FOX

# Attributions (Images in Slides)

Wi-Spy image

Adapter image

ASUS USB image

Wi-Fi Antenna image

Blue-Tooth USB adapter image

Roving Networks image

BlueSMiRF image

Arduino BlueTooth image

Raspberry Pi BlueTooth image

O'Reilly BlueTooth Book image

SENA Adapter image

Wi-Fi Pineapple image

Raspberry Pi image

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BlueTooth Bee image

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