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OPEN SOURCE ANALYSIS OF RECENT WEAPONIZED UNMANNED VEHICLE USAGE WORLDWIDE

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WEAPONIZED COMMERCIAL UAVS / DRONES - BACKGROUND

- Early reported (non-state) weaponized UAV attacks
  - July 14, 2006 - *Israel: Hezbollah Drone Attacks Warship* – AP
  - September 2013 – Militants in Pakistan caught with UAVs with intent to arm them
  - October 25, 2013 - *Hamas Cell Planned to Detonate Remote Controlled Aircraft Bomb in Israel* – Algemeiner
  - July 14, 2014 - *Hamas Sends Iranian-Made Drones Into Israel* – MEMRI/others
  - September 21, 2014 - *Hezbollah drones wreak havoc on Syrian rebel bases* – Times of Israel
  - December 16, 2015 - *ISIS Is Reportedly Packing Drones With Explosives Now* – Popular Mechanics
  - February 18, 2016 – [translation] Drones drop firebombs at ammunition dump, victims – Censor.Net
  - October 11, 2016 - *ISIS used an armed drone to kill two Kurdish fighters and wound French troops, report says* – Washington Post
    - Comment: This is general considered the start of the ISIS drone campaign in Iraq and Syria, however, there was one known attack in Syria by ISIS prior to this.
  - Note: Many of the Hezbollah and Hamas UAVs are not commercial models, but a Iranian designed and/or produced model.

COUNTRIES IN WHICH WEAPONIZED COMMERCIAL UAVS / DRONES USED

Countries that experienced a weaponized UAV 'terrorist' attack		Some countries that have not
Armenia (Republic of Artsakh)	Saudi Arabia	Colombia
Azerbaijan	**Syria**	Egypt
Iraq	Turkey	India
Israel	Ukraine	Pakistan
Japan	United Arab Emirates (?)	Philippines
Libya	Venezuela	Somalia
Mexico	**Yemen**	US

HOUTHI UAV CAMPAIGN IN YEMEN & SAUDI ARABIA

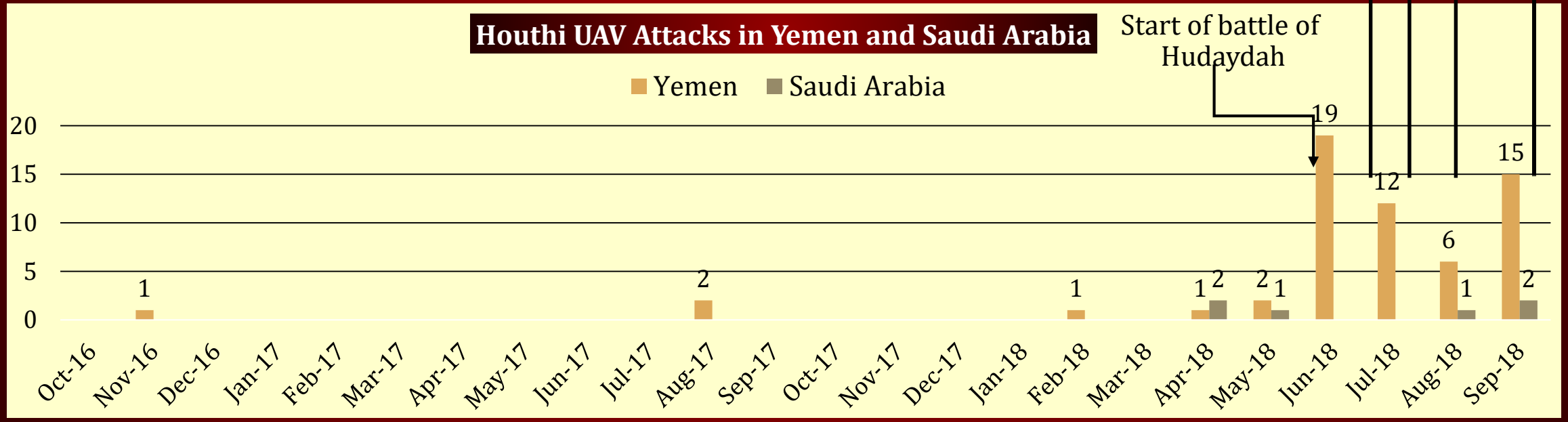
HOUTHI (IRANIAN) UAV ATTACKS IN YEMEN/SAUDI ARABIA

All attacks unless indicated otherwise are believed to have been conducted using the (Iranian) Houthi Qasef-1

In one incident a (reportedly) weaponized Houthi Walker X8 UAV was shot down. However, the attached device could be an extra battery to extend flight time.

Alleged Samad-2 attack Riyadh

Alleged Samad-3 attacks UAE airports discussed next slide



COMMENTS ON HOUTHI UAV EMPLOYMENT

- Alleged Sammad UAV attacks outside of Yemen
  - The Houthis provided no photos or video of alleged attacks
  - Two of the attacks occurred on days when twitter accounts for the facilities allegedly attacked reported accidents (did Houthis see accident on twitter and then claim the attack?)
  - For one attack the only evidence reported was some delayed flights
  - No 3rd party (e.g., travelers at airports) provided any photos or video
  - It appears that none of these attacks occurred and that the main thrust of the propaganda is to create uncertainty to hurt Saudi and UAE economies

YEMEN (HOUTHI) UAV INVENTORY

Rased

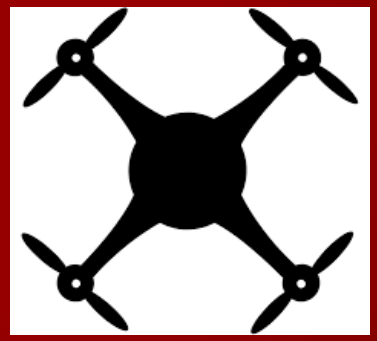
- 35 km range
- "geographical surveying and mapping"
- Walker X8?

Qasef-1

- 150 km range
- 30 kg payload
- "intelligent system to monitor, select, and strike target"

Hudhud-1

- 30 km range
- Advertised low radar, IR and acoustic signatures

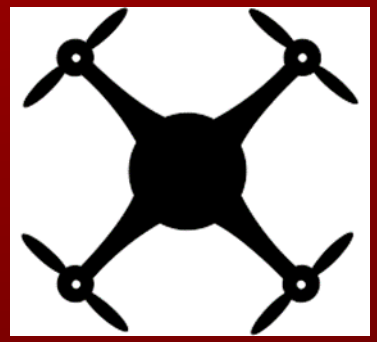


Sammad-2

- Allegedly used to attack Saudi ARAMCO facility in Riyadh on 18Jul2017
- ~ 900 km from Yemen

Raqeep

- 15 km range
- Laser for targeting



Sammad-3

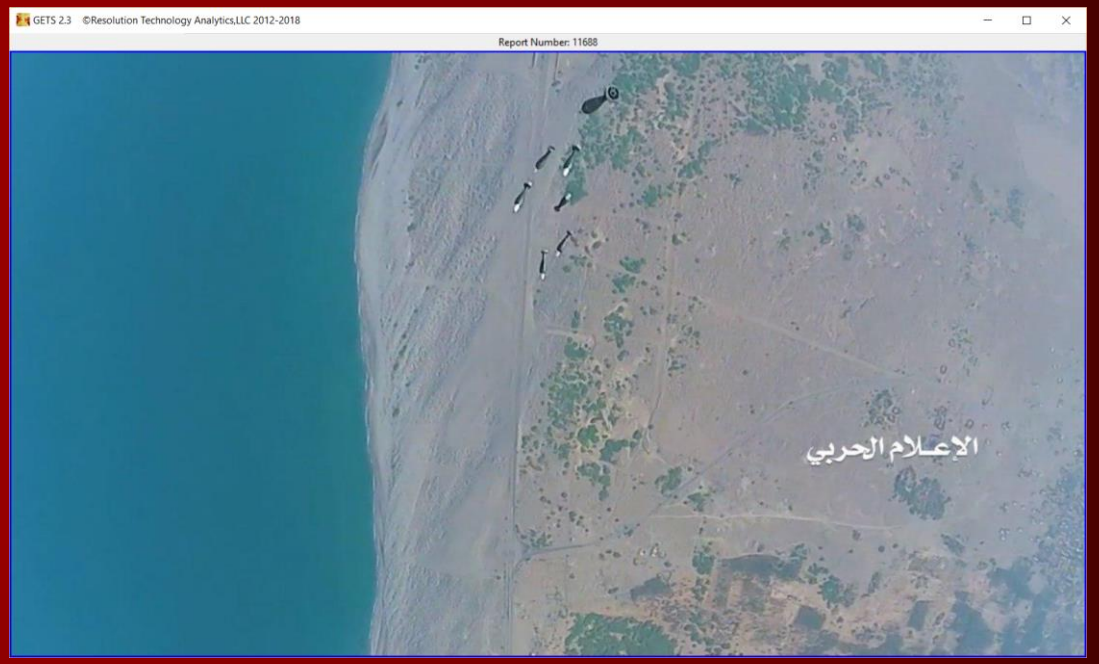
- Allegedly used to attack Abu Dhabi airport 1 time and Dubai airport 2 times
- ~1500 km from Yemen

HOUTHI UAV MISSIONS AND TACTICS

- The Houthis list the following missions for their UAVs:
  - Reconnaissance
  - Espionage
  - Observation of the battlefield
  - Jamming of missile and air defense stations
  - Surveying
  - Assessment and early warning
  - Execution of limited suicide and combat missions
- A tactic reportedly used by the Houthis at least 3 times is to simultaneously attack an air defense site with UAVs and missiles.

COMMENTS ON HOUTHI UAV EMPLOYMENT

- 17Aug2018 – Houthi UAV attack Al Hudaydah
  - Of 65 alleged Houthi UAV attacks, only in two cases were picture/video evidence provided. According to Houthi press the picture shows 7 bomblets being dropped from a Qasef-1.
  - All UAV attacks in Yemen in which a UAV type was specified by the Houthis were conducted by Qasef-1.



- Neither the Houthis, Al Qaeda, or other parties involved in conflict in Yemen have used 'ISIS-style' UAV attacks.

ASSESSMENT OF FUTURE HOUTHI UAV USAGE

- Assuming continued slow, but steady Saudi coalition progress in 'recovering' Yemeni territory, the Houthis would likely have limited UAV resources and no new types of UAVs. The Iranians could possibly covertly attack Saudi Arabia, UAE, or other areas with long-range UAVs from Iranian territory.

AIRBORNE INCENDIARY DEVICE DELIVERY – ISRAEL / GAZA STRIP

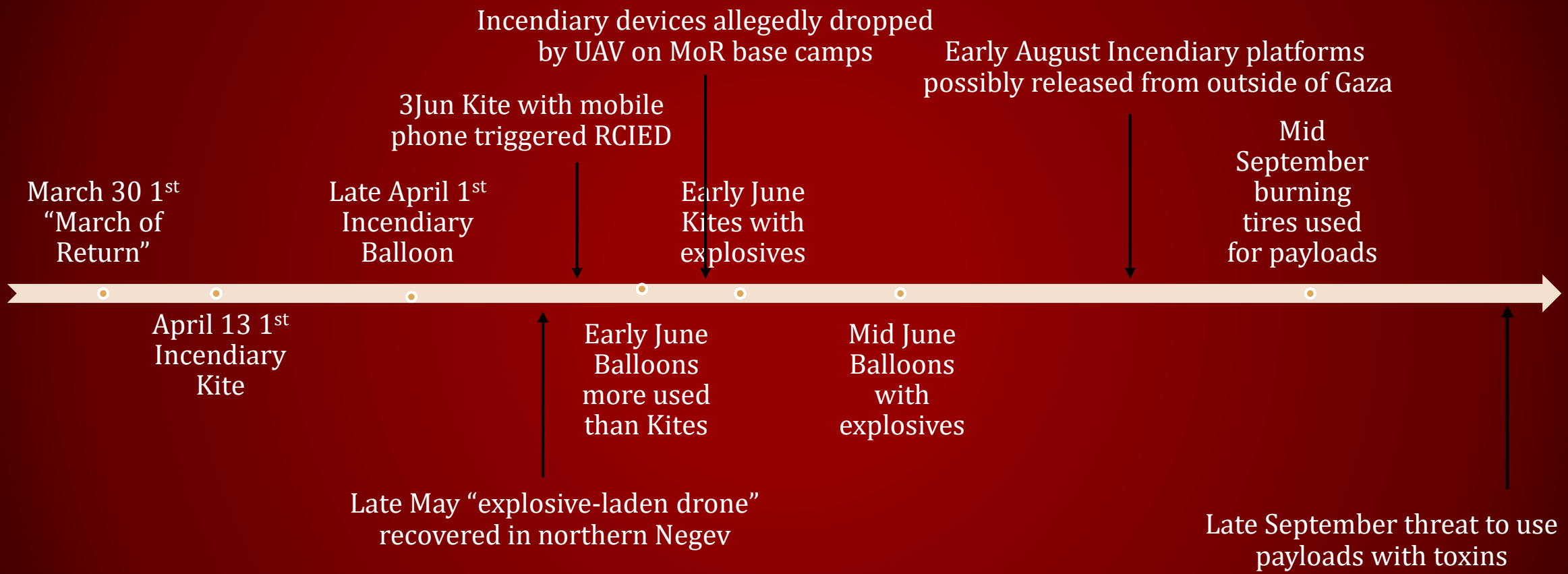
INCENDIARY KITES INTRODUCED IN ISRAEL

- April 16, 2018 – [translation] Kite terror continues: A wheat field surrounding the Gaza Strip caught fire – Ynet
  - Background:
    - On March 30, 2018 a 5 week period of protests began on the Gaza Strip/Israel border. The protests started out as mostly peaceful demonstrations of Palestinians wanting to "return" to Israel proper.
    - From the Gazan prospective the demonstrations appeared to have been effective and for this and other reasons have been continued.
  - Comments:
    - *Friday April 13, 2018 saw the first attempt by Gazans to use kites to ignite fires in Israel outside of the Gaza Strip. The attempt failed, but attempts on each of the next 3 days succeeded.*

"MARCH OF RETURN" USE OF INCENDIARY DEVICES

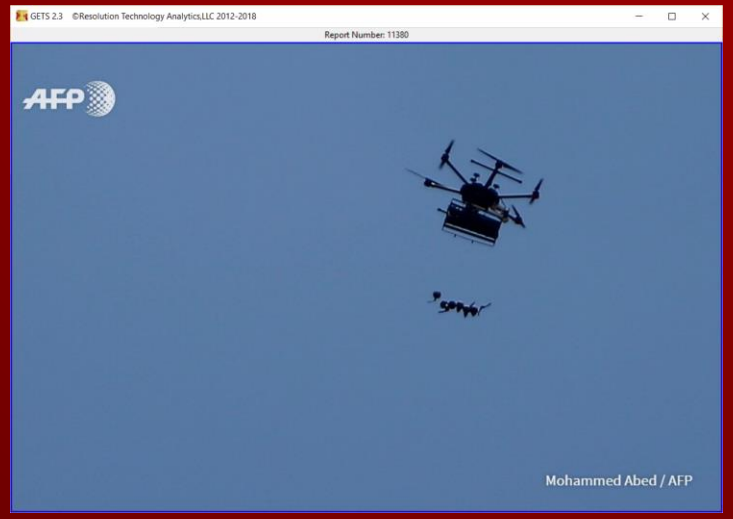
- Background:
  - The Gaza Strip is a territory encompassing 141 square miles (San Antonio is 465 square miles) along the Mediterranean Sea. It has a population of approximately 2 million people. Being along the sea, the weather is typically breezy and the sea breeze often blows from Gaza toward Israel.
  - Kite flying has always been somewhat popular in Gaza and it has been typical to see kites flying at demonstrations.
  - Shortly after the start of the "March of Return" demonstrations the idea came about to attach incendiary devices to the kites and release them to fly into Israel. In a relatively short period of time the incendiary kites were proved effective, starting many fires. Since April over 1,000 fires have been started in the arid land next to Gaza causing a large loss to vegetation.
  - The types of incendiary device delivery platforms used have evolved as will be discussed in the next slides.

GAZA STRIP AIRBORNE INCENDIARY DEVICE TIMELINE



MOBILE AIRBORNE DEVICE EXAMPLES

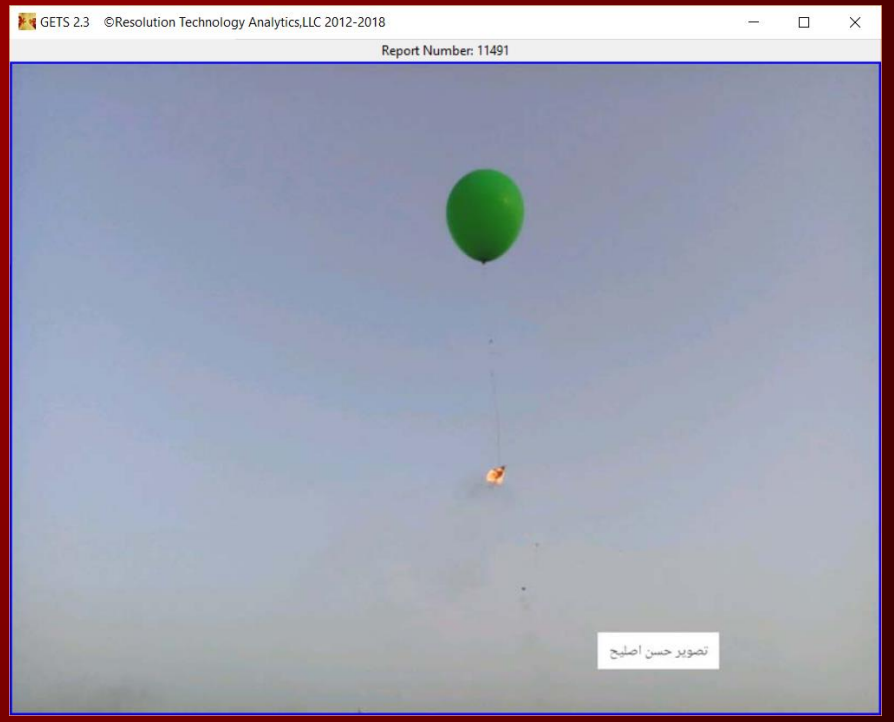
- June 8, 2018 – [translation] Demonstrators drop an Israeli 'teargas drone' east of Gaza – Hadf News
  - Comments: *The Israelis have been using DJI Matrice 600 multicopters to drop teargas canisters on "March of Return" demonstrators. At least two times kites carrying nets were able to down the multicopters.*



Israeli DJI Matrice 600 teargas dispensing platform

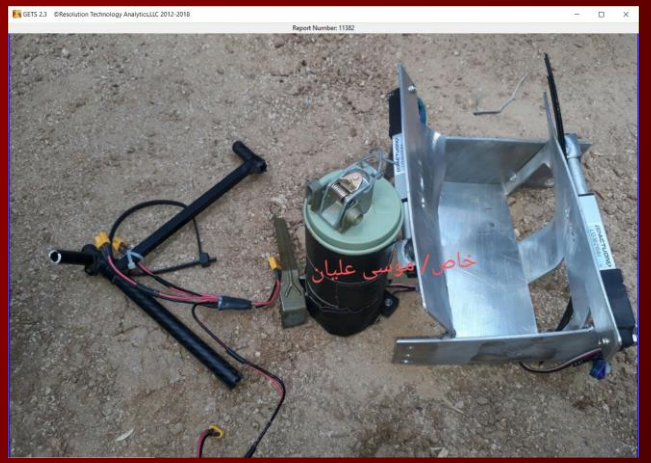
MOBILE AIRBORNE INCENDIARY DEVICE EXAMPLES

- June 4, 2018 – *Beyond kites: 'Fire balloons' increasingly used to set southern Israel ablaze* – Times of Israel
  - Comments: *Thousands of incendiary balloons have been released from the Gaza Strip into Israel proper. Most 'balloons' are groups of simple balloons, but sometimes variations, such as the sky lantern shown in the middle picture, are used. Being able to fly farther, balloons have become more popular than kites.*



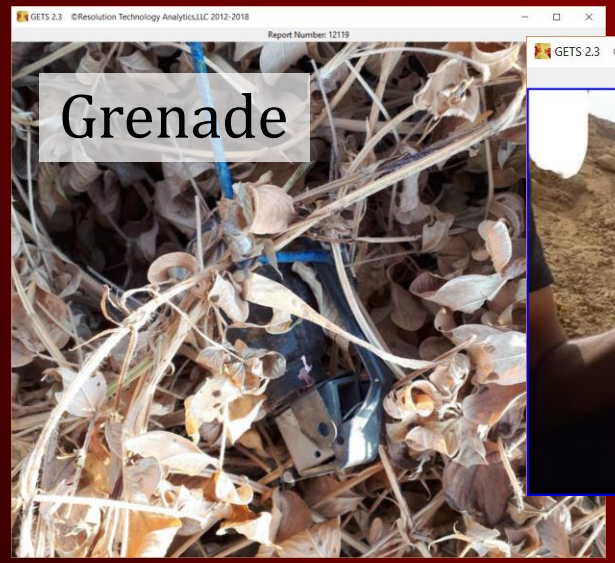
MOBILE AIRBORNE INCENDIARY DEVICE EXAMPLES

- May 14, 2018 - [translation] Israeli UAV shot down at al-Awda camp east of Jabaliya in the Gaza Strip - Hassan Ridha Twitter page
  - Comments: *Palestinian media reported that this DJI Matrice 600 was shot down inside the Gaza Strip. As can be seen the multicopter was carrying an incendiary device plus accelerant. The target for the UAV may have been supplies for the demonstrations including tires. The actuators used to release the incendiary devices are Actuonix L12-50-210-6-I Linear Servos.*



BALLOONS WITH EXPLOSIVES

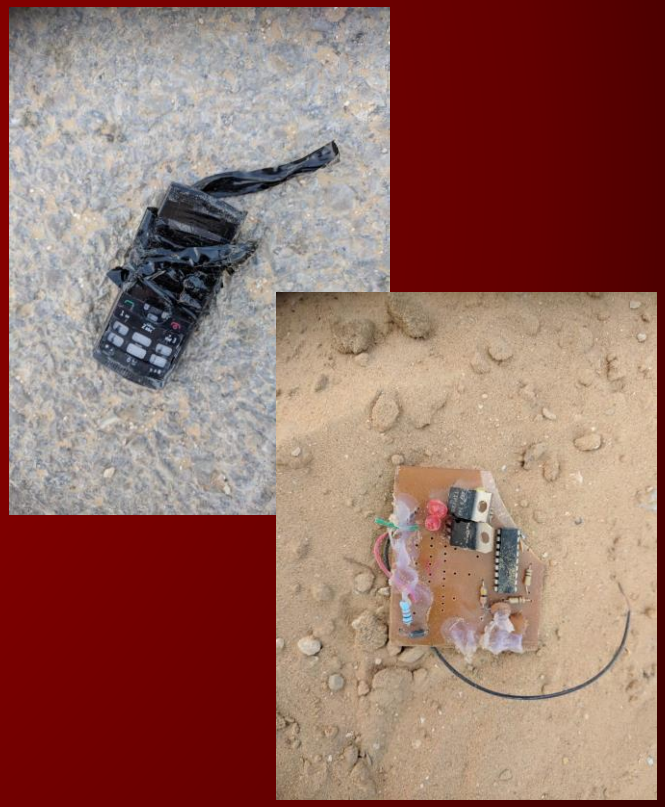
- June 14, 2018 – Ignis Fatum Twitter page
  - "For the first time , a balloon with explosives attached to it was launched from #Gaza and landed in a Israeli community on the Gaza border. Police remotely detonated the explosives"
  - Comments: *The attached explosive devices appear to typically be "large firecrackers" that are likely intended to create a noise nuisance and/or start fires. Occasionally, more serious devices are carried, such as the grenade shown in the far left picture.*



KITE WITH RCIED

- June 3, 2018 - AmichaiStein1 Twitter page
  - "Palestinian terror kite with explosive sent from Gaza to southern Israel"
  - Comments: *This is the only report of a kite or balloon carrying an RCIED the I have seen. This could be a hoax, but it appears to have all the necessary components for an RCIED.*

Phone and circuit board?

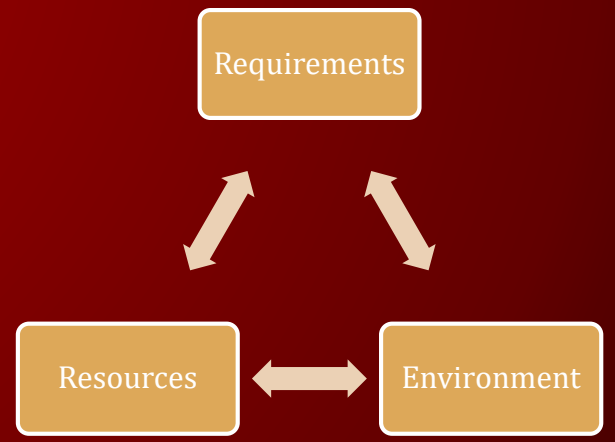


BURNING TIRE PAYLOADS

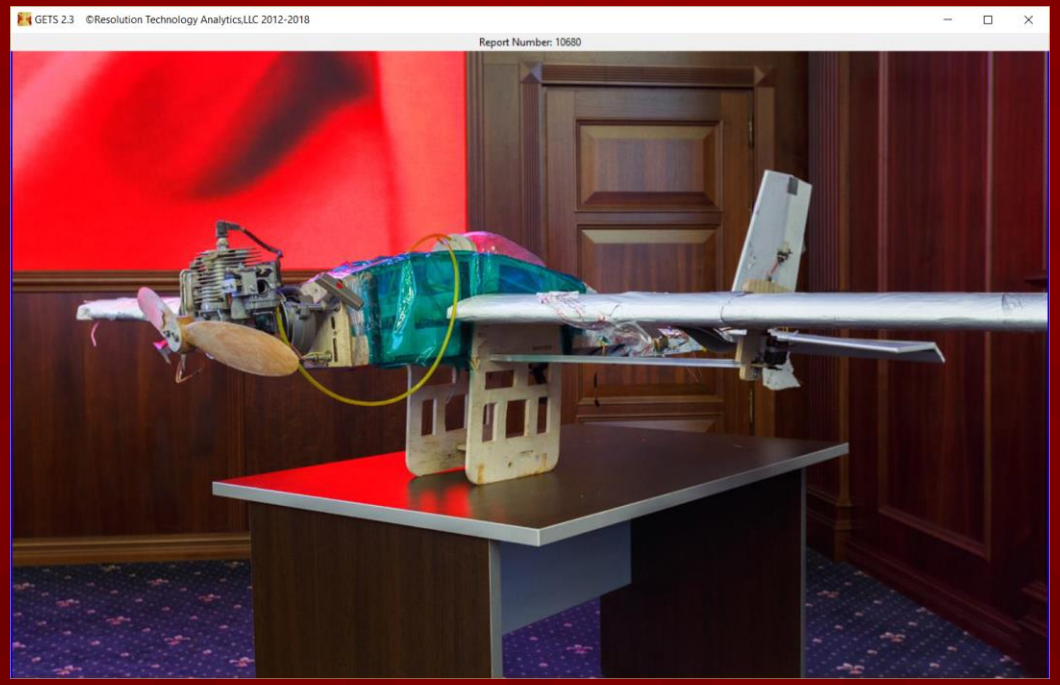
- September 30, 2018 – Ignis Fatum Twitter page
  - "Burning tires attached to balloons/kites are now being launched from the #Gaza strip."
  - "The ropes that are tying them are usually being torn apart by the weight of the tires so the tires are impacting the ground with scary speed and could potentially hurt people."

ASSESSMENT OF FUTURE MOBILE AIRBORNE DEVICE USAGE IN GAZA STRIP

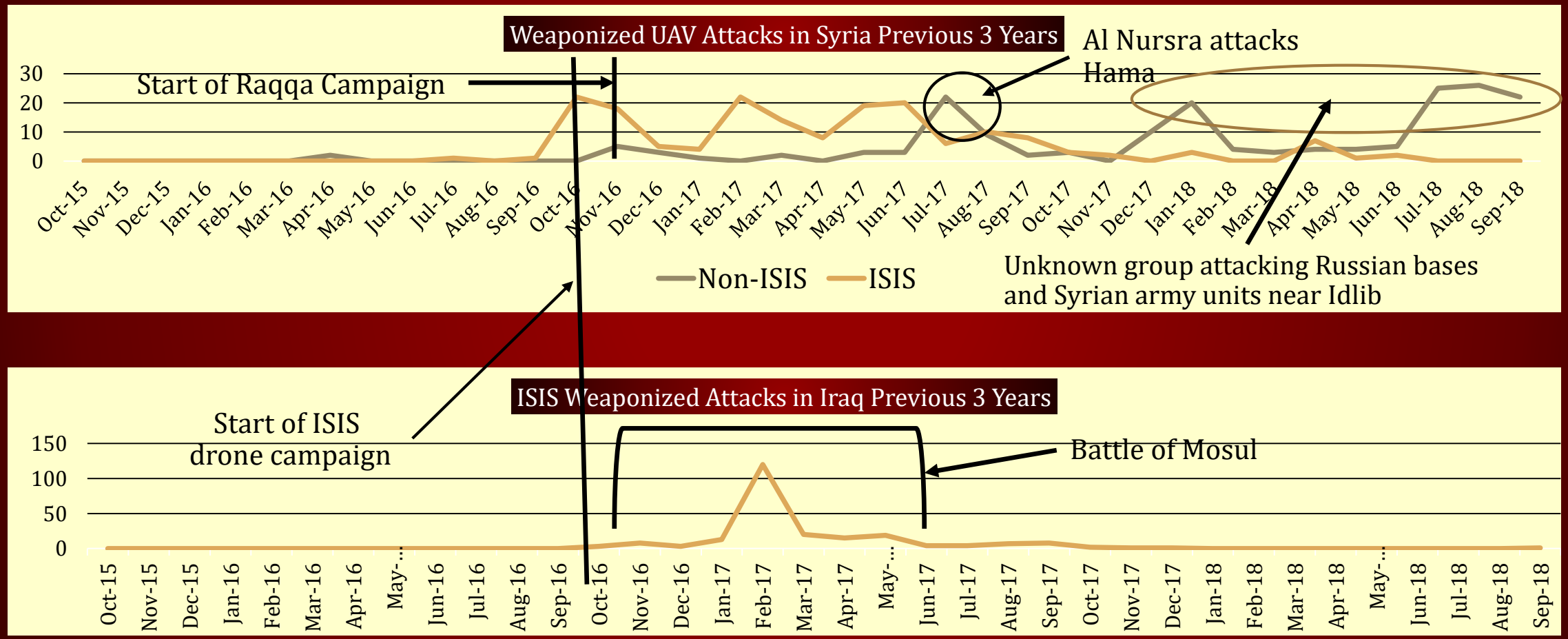
- To some degree there seems to be an understanding that if the destruction resulting from the "March of Return" is low-level that the Israeli government will not retaliate too significantly.
- The precise goals of the mobile airborne incendiary device campaign are not known, but in general it appears they want to create anxiety in Israeli society and bring world attention to their plight.
- The campaign future could follow two paths:
  - 1) continue down the current path – devices would not advance much in technology and capability level, but could assume a more mass produced quality.
  - 2) pursue a path to obtain greater effectiveness for the devices
    - Possibilities - weaponized UAVs, balloons with some sort of control capability, sensors to determine when to do actions, controlled delivery



“DIY UAV” CAMPAIGN IN SYRIA

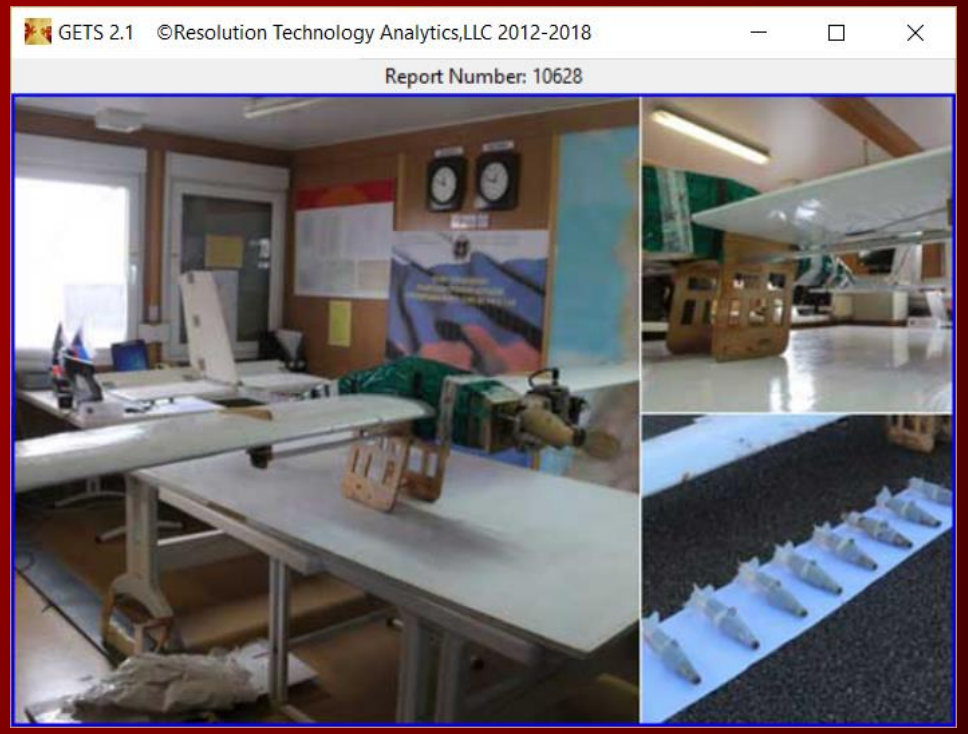


UAV ATTACK TIMELINES IN IRAQ / SYRIA

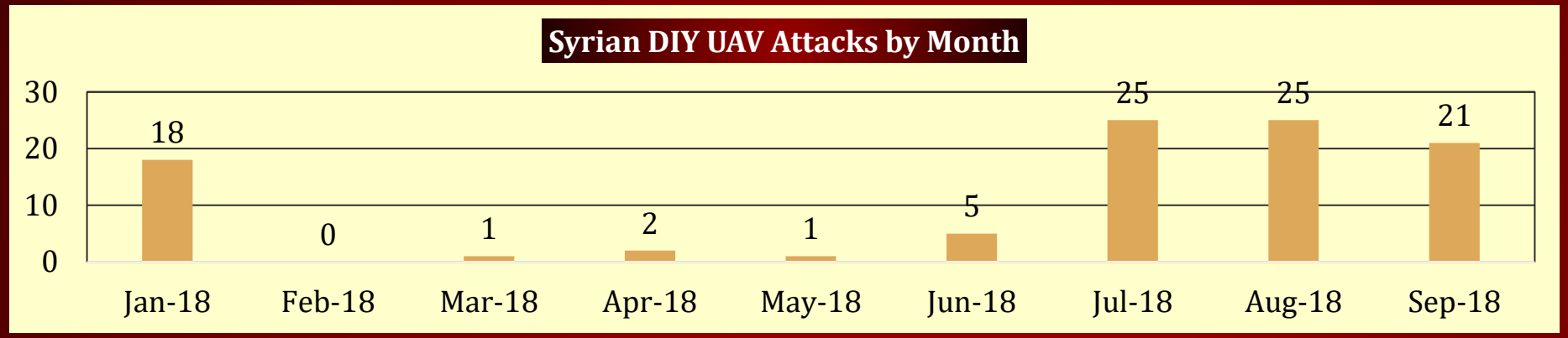


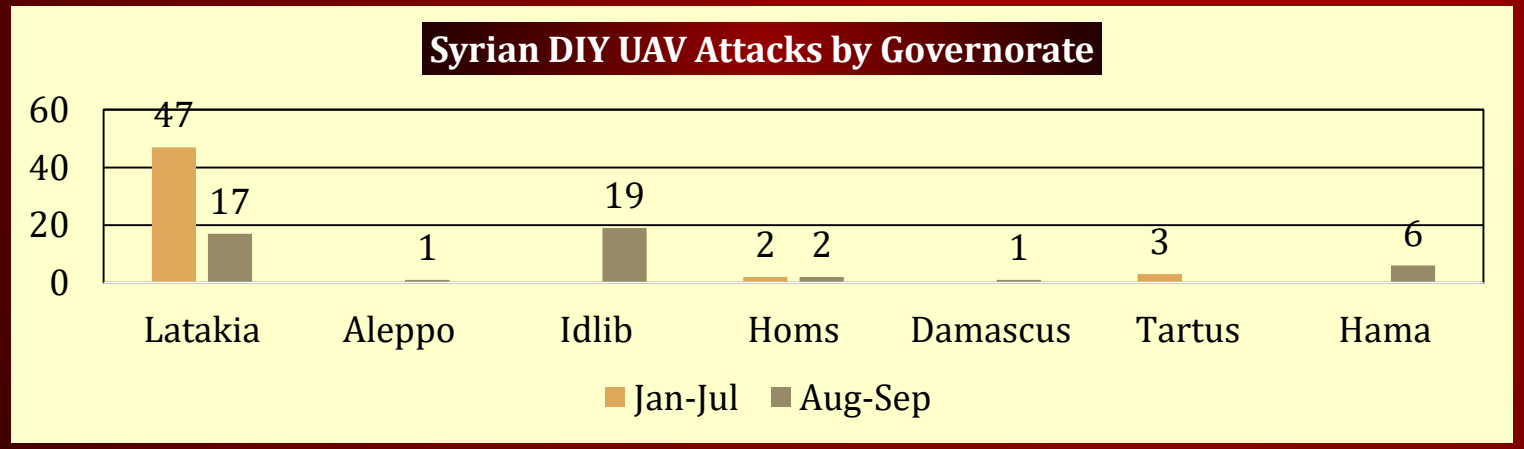
UAV ATTACK ON RUSSIAN SYRIAN BASES – 5/6JAN

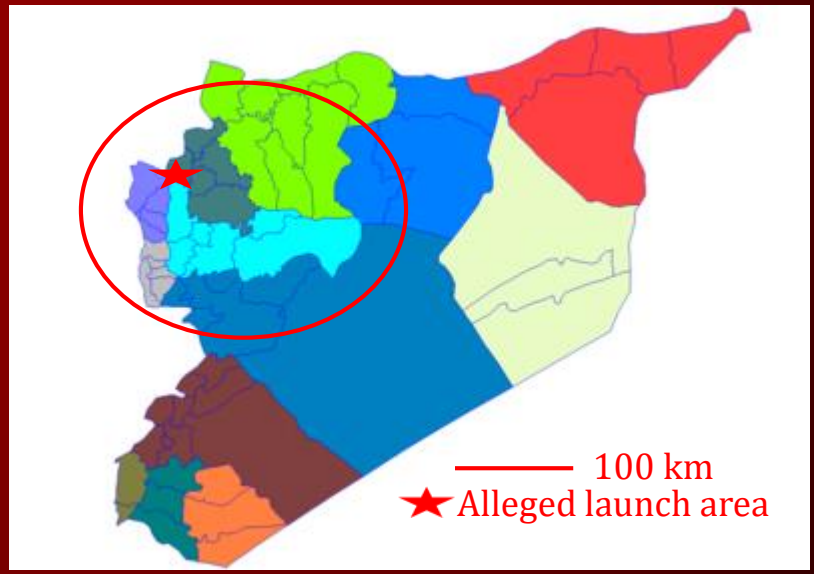
- January 8, 2018 – [translation] Russian air defenses intercept 10 UAVs at Khmeimim Air Base and 3 at Tartous Naval Base in one night! – Syria Now
  - [summary of translation] The Russian Defense Ministry announced that Russian air defenses at the Hameimim and Tartous bases had repulsed the attack of 13 UAVs; 10 targeting Humaimim and 3 targeted Tartous.
  - The ministry confirmed in a tweet on Twitter, accompanied by pictures of the wreckage of the attacking drones, that the attack repelled by the Russian air defenses had been completely foiled. The Terrorists planned it to be an intensive attack on the Russian positions in Syria.
  - Comment: *The picture shows one of the downed UAVs.*



DIY UAVS ATTACK RUSSIAN FORCES IN SYRIA

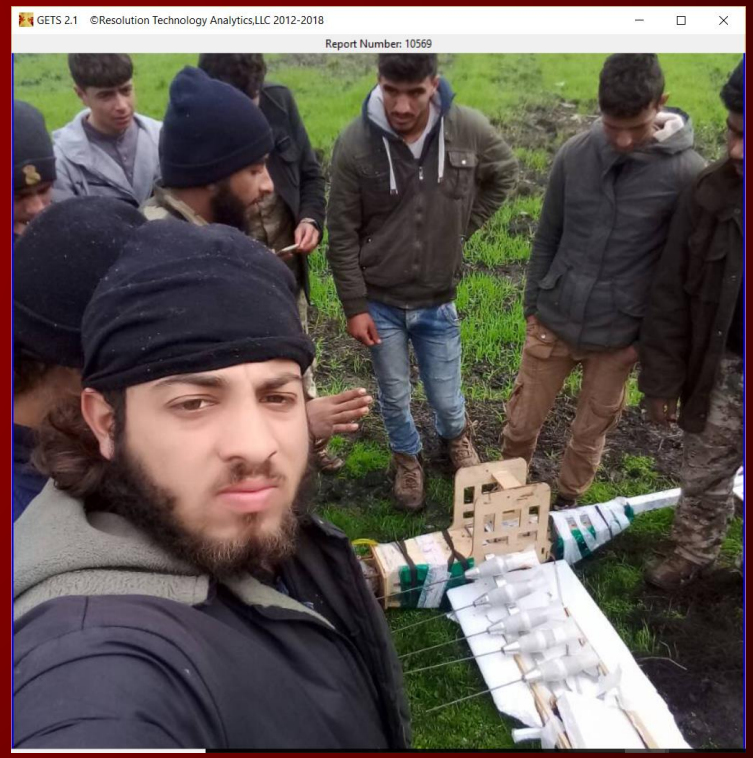






UAV ATTACK ON RUSSIAN SYRIAN BASES – 31DEC/1JAN

- January 1, 2018 - fredabo222 Twitter page
  - [translation] Ahrar al-Sham dropped a Assad regime UAV
  - Comments:
    - *The tweet is timestamped 0838L on 1Jan, so the UAV was likely downed early 1Jan or on 31Dec2017. One of the responses to the tweet says the picture was taken in eastern Hama Governate, which would put them east of the Russian bases.*
    - *Note that the UAV is homemade and not from a mass produced kit. [could be from a hobby design] Also, up to this incident, none of the non-government UAVs/drones used in Iraq or Syria dropped ordnance from bar pylons in this manner. ISIS UAVs of somewhat similar construction were suicide UAVs.*
    - *Because the ordnance is still attached, the UAV was likely headed to the target. Are the rods in the front of the bomblets to cause them to detonate above ground level?*
    - *Even though the tweet says the UAV was regime, this seems doubtful. It is unknown if the UAV was shot down or failed airborne.*



UAV ATTACK ON RUSSIAN SYRIAN BASES – 31DEC/1JAN

- January 4, 2018 - *Russia Confirms Syria Attack But Denies Seven Aircraft Got Destroyed As Photos Emerge* – The Drive
  - "The Russian Ministry of Defense has acknowledged an attack on its Khmeimim air base in Syria [31Dec2017], but has disputed key details from an initial report, denying that seven aircraft had been destroyed in the incident. At the same time, unconfirmed pictures have begun emerging on social media showing significant damage to at least one Su-24 Fencer attack plane."
  - "To launch an attack with a mortar, the type of weapon that both *Kommersant* and TASS said militants used in the incident, would require the enemy force to get deep into a regime area, and near the highly patrolled air base itself, without detection."
  - "Aside from the primary narrative that this was an indirect fire attack, another possibility is that rebels or terrorists used a small quad- or hex-copter style drone with an improvised payload to launch the attack remotely."
  - Comments: *According to unsubstantiated rumors and claims, this incident was a UAV attack. Was the downed drone from the previous slide part of this attack? There have been no credible claims to this attack and the Russians have offered no evidence as to the type of attack or responses from air defense.*

UAV ATTACK ON RUSSIAN SYRIAN BASES – 31DEC

- January 12, 2018 - *The Poor Man's Air Force? Rebel Drones Attack Russia's Airbase in Syria* – Nick Waters (Bellingcat)
  - "Drone for sale on Telegram, timestamped on the evening of 31 December 2017"
  - "An investigation by XXX and YYY for *The Daily Beast* discovered this kind of drone for sale on Telegram, a popular messaging app which they and ZZZ had previously shown was being used as an online arms bazaar. The seller also offered drone bombs for sale. The UAV is very similar to those used in attacks against Russian forces. The fact that this drone is damaged raises questions about how it was obtained, and whether the seller was actually party to its construction or happened to find one that had crashed."

UAV ATTACK ON RUSSIAN SYRIAN BASES IN JANUARY 2018

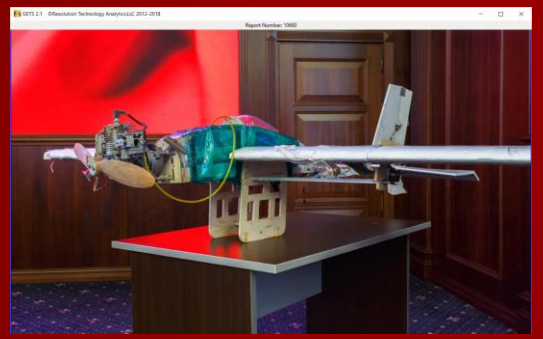
THE UAV

AIRFRAME / ENGINE

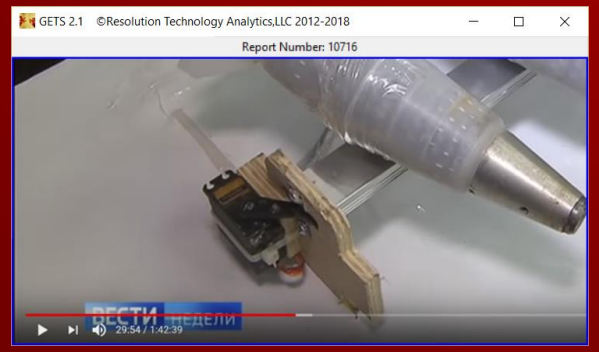
- Comments:
  - As can be seen in the pictures below the airframe structural support is a combination of metal rods and wood framing. The wings are shaped with Styrofoam and covered with a plastic material. The fuselage is shaped with wood and wrapped with plastic and taped.
  - It is highly unlikely the vehicle is a commercial kit, but it could be a (modified) hobbyist design.
  - The engine is a small lawn mower type and the means of throttle control is unknown.

FLIGHT / ORDNANCE ACTUATORS

- Servos are used to control the flight surfaces and to release ordnance.
  - The pictures below show servos for the control surfaces.
  - Separate wires run from the control module to each servo.



  - The pictures below show servos to used to release the bomblets on the wings.
  - It appears one servo is used for bomblet release on each wing.



SENSORS

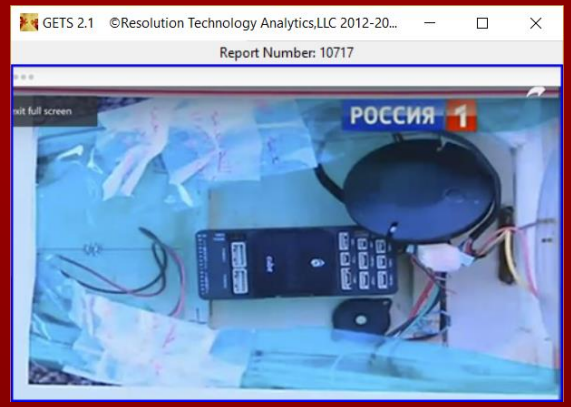
- In all the pictures and videos in general, sensors were not seen. Pictures and screen grabs possibly showing sensors are shown below.
- The first picture shows a CMOS or CCD camera present on one of the UAVs as seen in a video presented by *Russia24*. The second shows a possible camera (on top?) of fuselage of one of the UAVs taken down by EW during the base attack.

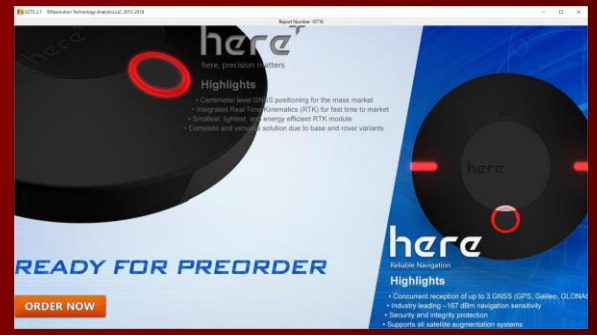
- The picture on the side shows a CCD camera for sale on Alibaba that appears to be the same model.
- It is unknown if the cameras were actually placed on top of the fuselage in the design or by whoever handled the UAVs after they were downed.

FLIGHT COMPUTER / NAVIGATION

- The flight computer and Global Navigation Satellite System (GNSS) were installed in the fuselage behind the 'fuel tank' as shown in the picture.

- The flight computer, shown in a Russian video, is a Pixhawk 2.1 autopilot with Cube Inertial Measurement Unit (IMU)
- The GNSS is the Here module that can concurrently use 3 of the GPS, Galileo, GLONASS, and BeiDou systems.



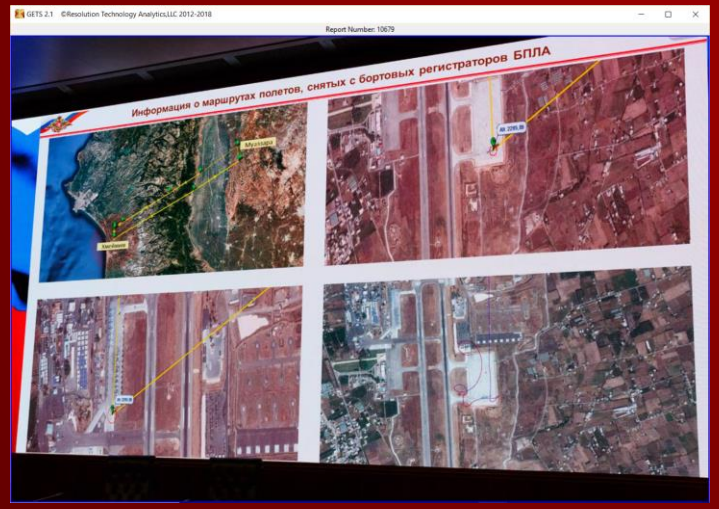


- The flight computer takes inputs from the IMU on vehicle movement, integrated barometric sensors for altitude, and GNSS for position, altitude and movement. From these inputs it then decides what control surface movements are needed to match the actual vehicle position to the flight plan. This is how the vehicle can fly a preprogrammed flight autonomously.

MISSION PLANNING

- The mission planning software was likely the ArduPilot Mission Planner shown below.
- The mission planner allows the user to click points on a map or type in a Lat/Long
- After the route is planned, it is loaded into the flight controller/autopilot.
- As can be seen, this is a relatively easy process.

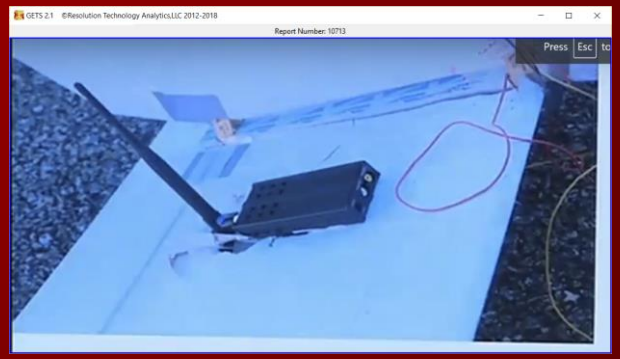
- The picture below shows the flight plan downloaded for forensic analysis from 1 or more downed UAVs.



COMMUNICATIONS

- Apparently communications between the UAVs and ground were minimal and were not required if autonomous satellite navigation was used.
- None of pictures of the downed UAVs show antennas on the airframe. The picture below shows an antenna that was included with the wreckage of one of the UAVs that allegedly attack one of the Russian bases.

- A video from Russia24 shows a picture of a communications device found with one of the UAVs. The image is likely from a UAV downed during the attack on the Russian bases. The device appears to be a 1.3 GHz video transmitter, like the RMRC - 1.3GHz 2500mW Transmitter - INTL VERSION shown to the right.

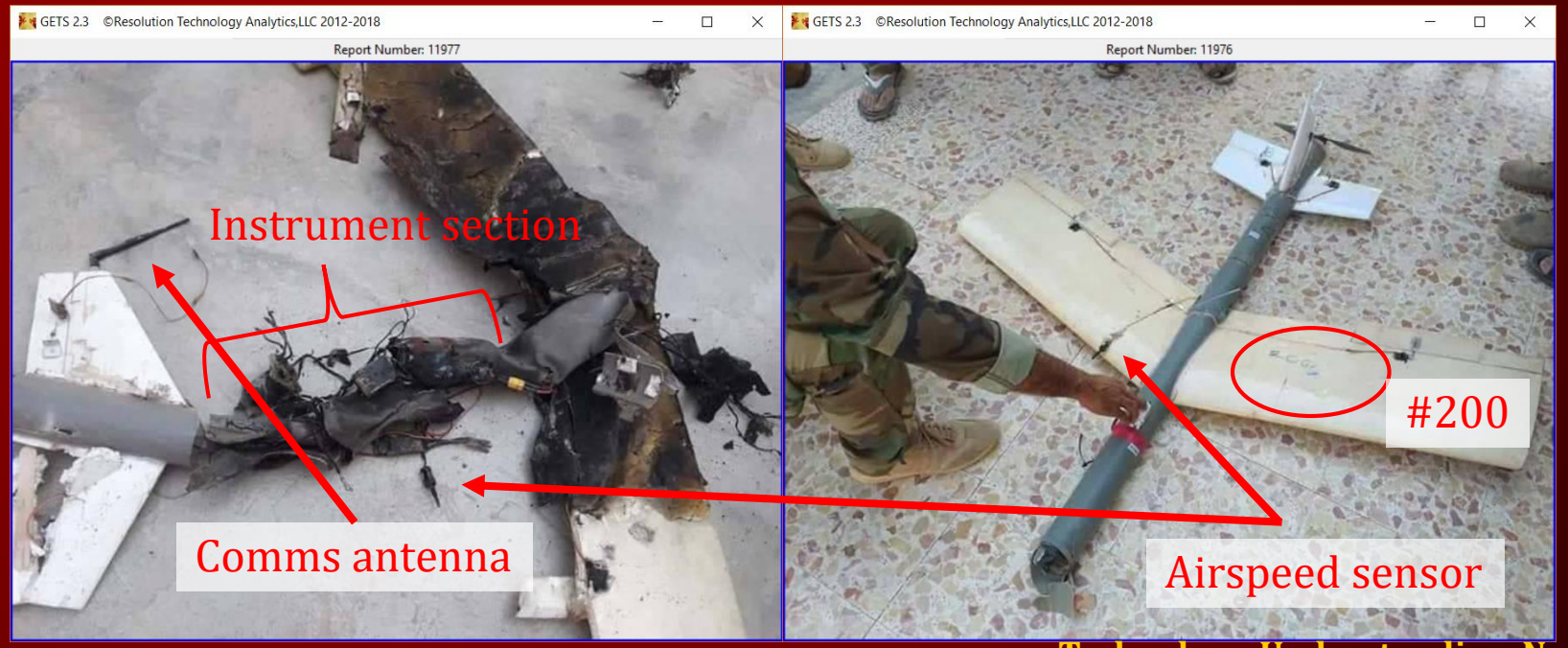


HOMEMADE UAVS FROM MORE RECENT ATTACKS

- September 3, 2018 – [translation] Weaponized drones from militants intercepted – Akdat.com
  - [summary of translation] [allegedly] On September 2nd 15 homemade UAVs loaded with explosives were launched from the Jisr al-Shugur area of Idlib to attack Syria army soldiers on Idlib-Hama-Latakia border. Of the 15, 13 were shot down and control was taken over 1 and it was forced to land. One successful attack was completed of a Syrian army observation post.
  - Comments: *The UAV forced down is shown below. Notice it has a Pixhawk 1 autopilot, which is an older Pixhawk version then that used earlier in the year. Also, the GNSS is a Ublox NEO-M8N GPS with compass. Unlike, the UAVs from January this UAV has a communication system prominently included. The communication system may be a RFD900+ telemetry radio. One reason that this UAV may have a communication system is that, unlikely the UAVs seen in January, this was to attack targets in a general area in which pre-defined coordinates could not be assured.*

HOMEMADE UAVS FROM RECENT ATTACKS

- August 22, 2018 – *Syrian Military Shoots Down Suicide Drones in Northern Hama* – SouthFront
  - "On August 21, the Syrian Arab Army (SAA) shot down three DIY suicide unmanned aerial vehicles (UAVs) over the town of Abu Dali in the northern Hama countryside. According to local sources, two other UAVs landed in an empty area near the town without exploding."
  - "The UAVs are made of plastic, wood and use an electrical motor for propulsion. This type of UAVs have been never seen in Syria before. However, the technology used in these UAVs is very similar to the one used in the armed UAVs that have been repeatedly shot down near Hmeimim airbase."
  - Comment: *This is the only reported incident before or since that this type of UAV was used. Based on all the material I've seen, I think it is the same group that uses the other DIY UAVs.*



ASSESSMENT OF "DIY UAV" CAMPAIGN IN SYRIA

- The DIY UAV campaign had a number of "firsts":
  - These weaponized UAVs were the first documented to use satellite navigation for autonomous navigation, control and targeting.
    - There is one alleged case in Ukraine of a DIY UAV attempting to attack based on pre-programmed coordinates.
  - These attacks, using non-military UAVs, were the longest range on record at over 80 km.
    - One UAV was found near Mersin, Turkey over 150 km from Syria.
  - This has been the largest armed UAV campaign using homemade platforms.
    - ISIS relied mainly on commercial and mass produced kit platforms.
- The two main questions that remain to be answered about this campaign are: who is behind it and what are their objectives?
  - Other than possibly damaging 7 aircraft on December 31, 2017 the UAVs have been militarily ineffective.
  - Without knowing these answers it is difficult to speculate how this campaign will move forward.

Questions?

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