DISPATCH FROM THE FIELD

EVOLUTION OF UAVs EMPLOYED BY HOUTHI FORCES IN YEMEN

February 2020

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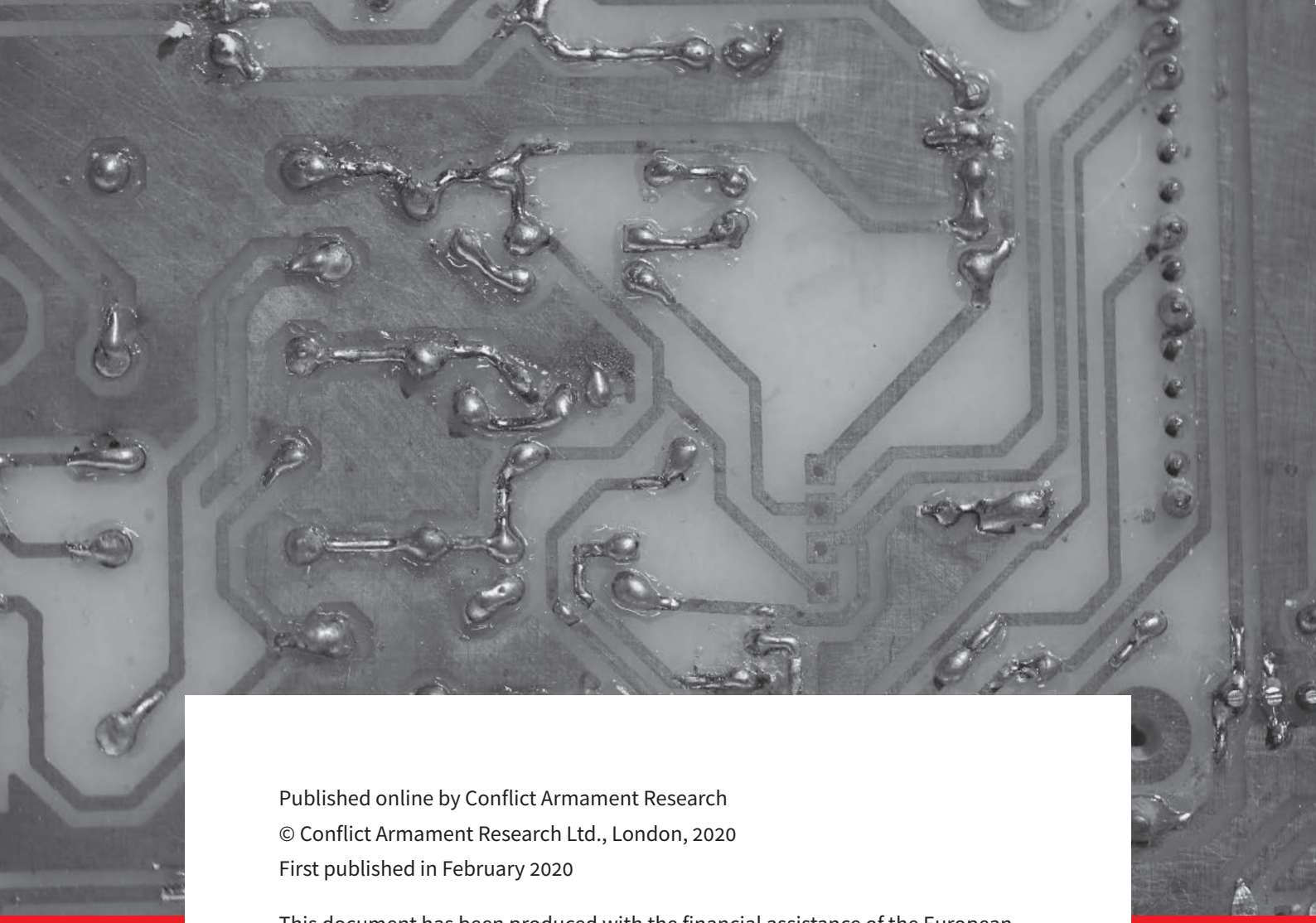

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Front cover image: A two-cylinder petrol model engine found in a Qasef-1, which UAE forces captured in Yemen.

Inside cover image: A circuit board found in a Qasef-1 UAV, which UAE forces captured in Yemen.

CONTENTS

BACKGROUND

Since 2016, Ansar Allah 'Houthi' forces have deployed unmanned aerial vehicles (UAVs) in an increasingly lethal fashion against Saudi-led Arab Coalition forces in Yemen and across its borders.

Initially, and as Conflict Armament Research (CAR) first reported in 2017, Houthi forces crashed unarmed UAVs into the Coalition's Patriot surface-to-air missile defence systems (CAR, 2017). Since then, they have deployed UAVs with explosive payloads and over greater distances. In mid-2019, for example, the Houthis conducted a string of attacks using UAVs against installations in Saudi Arabia (UNSC, 2020, pp. 19-20).' In July 2019, Houthi forces unveiled a collection of UAVs, which they claimed to have manufactured domestically (Yemen Press, 2019). Shortly thereafter, the Iranian state-affiliated Press TV released a promotional video profiling the same UAV types (Press TV, 2019; see Table 1 and Figure 1).

Between October 2016 and September 2018, CAR documented nine UAVs and one UAV engine, which United Arab Emirates (UAE) Presidential Guard forces had seized in Yemen. In total, CAR has documented seven industrially manufactured Qasef-1 UAVs, one hybrid Qasef-1 UAV, and one Sammad-pattern UAV.[1]

This Dispatch compares the physical characteristics and internal components of three types of Houthi UAVs documented by CAR. In addition, it compares items used in the construction of Houthi UAVs with components of improvised explosive devices (IEDs) seized from non-state forces in Yemen and Bahrain, as well as two types of Iranian-made UAV. The Dispatch also highlights similarities between Houthi UAV components and those that Yemeni forces seized from the *Jihan 1* merchant vessel in 2013, when it was en route from Iran to Yemen.

▼ **Wire bundles inside a Qasef-1 UAV, which UAE forces seized in Yemen.**
© CAR

Table 1

Houthi-manufactured UAVs in media reports

UAV name	UAV type
Hudhud-1	Reconnaissance
Qasef-1	Combat
Qasef-2K	Combat
Raqib	Reconnaissance
Rased	Reconnaissance
Sammad-1*	Reconnaissance
Sammad-2	Combat
Sammad-3	Combat

Note: *Although the Sammad-1 is constructed as a reconnaissance UAV, it can be weaponised.
Sources: Press TV (2019); UNSC (2019, pp. 28–31)

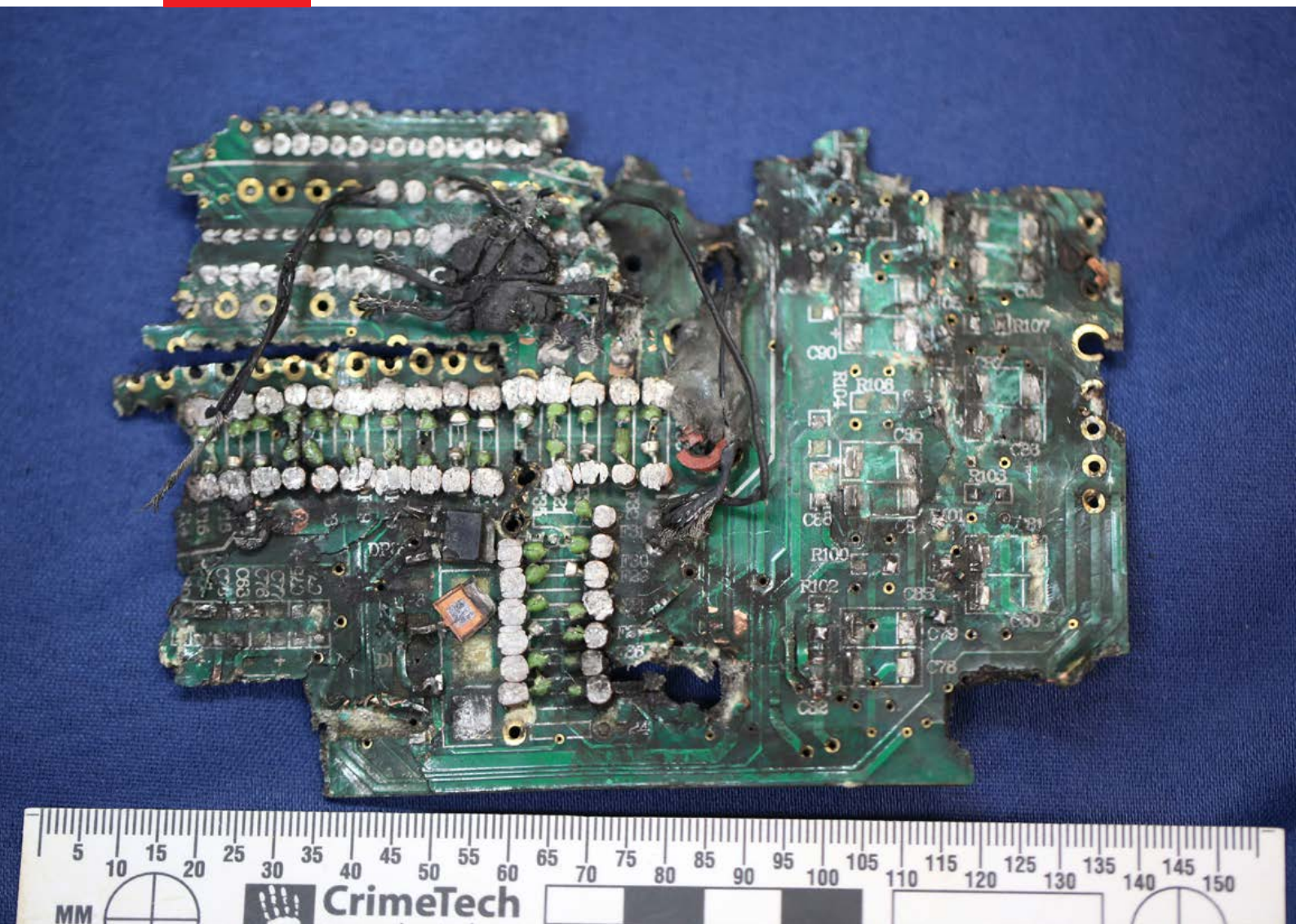
Figure 1

Houthi-produced UAVs on display at an exhibition in Sanaa, Yemen, 7 July 2019.

© Yemen Press

▼ **Damaged circuit board found inside an Iranian manufactured Shahed-141 UAV.**

© CAR



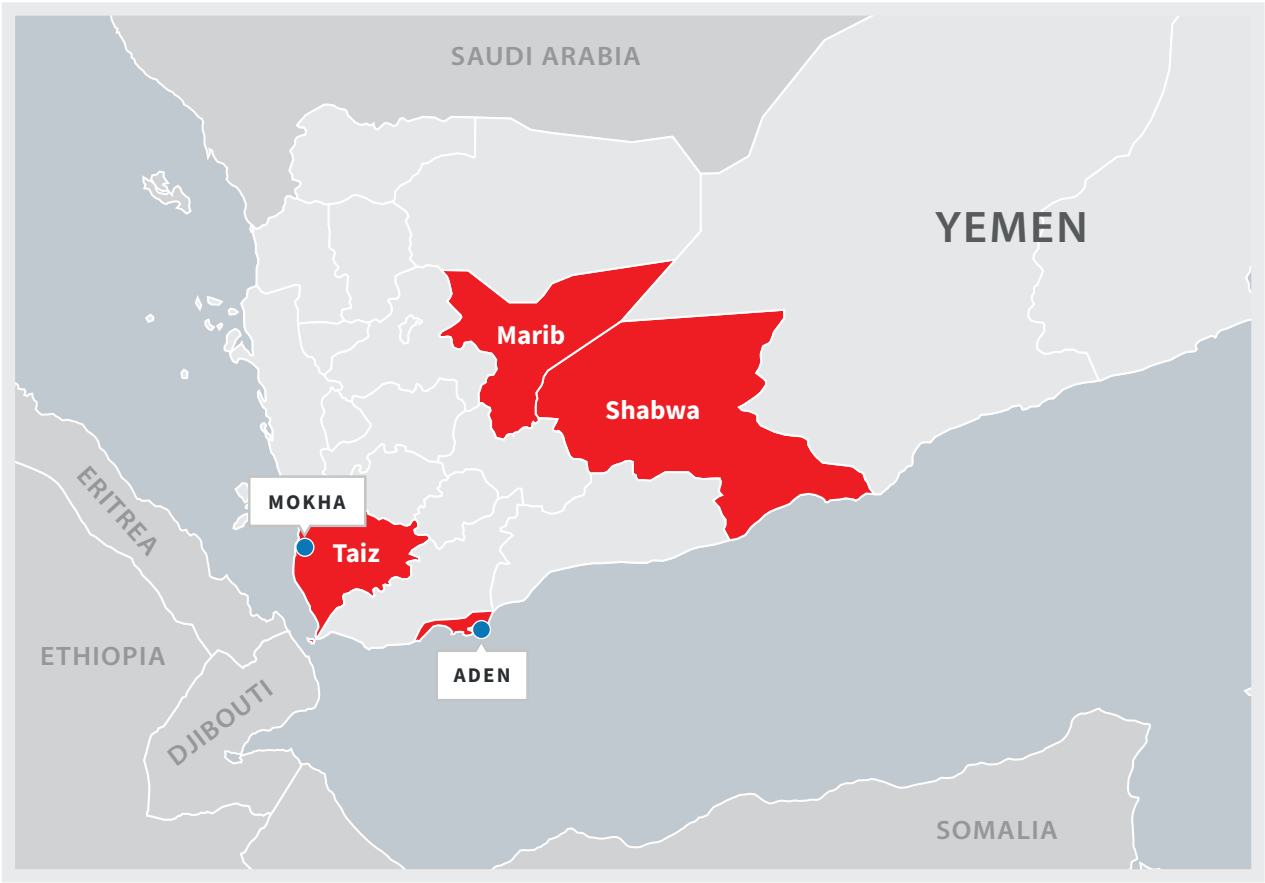
KEY FINDINGS

- Owing to the introduction of explosive payloads and more powerful engines, Houthi forces have deployed increasingly potent and lethal UAVs since 2016.
- A significant number of Houthi UAV components documented by CAR are identical or similar to IED components that CAR documented in Yemen, following their recovery from Houthi forces, and in Bahrain, following recovery from militant factions. These specific components were also present on the *Jihan 1* merchant vessel. In most cases, the components either originated in Iran, or match those used by factions in the region that are linked to Iran.
- While Houthi forces seem to procure most UAVs from external sources, they appear to have begun manufacturing some parts of at least one type of UAV domestically in 2018.

MANY COMPONENTS EITHER ORIGINATED IN IRAN OR ARE USED BY IRANIAN-BACKED GROUPS IN THE REGION.

Map 1

Locations of seizures referenced in this Dispatch



METHODOLOGY

CAR field investigation teams document illicit weapons, ammunition, and related materiel in conflict-affected locations and trace their supply sources.

The teams inspect weapons in a variety of situations—whether recovered by state security forces, surrendered at the cessation of hostilities, cached, or held by insurgent forces. They document all items photographically, date and geo-reference the documentation sites, and incorporate contextual interview data gathered from the forces in control of the items at the time of documentation.

CAR occasionally uses information and photographs from social media as background information but does not base its investigations on them, since the provenance of such data is often difficult to verify. Moreover, open-source information does not always provide the detailed physical elements—notably external and internal markings required to trace weapons and ammunition.

CAR traces only a portion of the items it documents in the field. This traced materiel is usually of particular significance to CAR investigations. If numerous individual items were to be traced, an excessive burden would need to be placed on the national governments and manufacturing companies concerned. Furthermore, some of the documented items are untraceable. For example, most loose small-calibre ammunition lacks the lot numbers required to identify it in production, sales, and export records. Similarly, records pertaining to the production, sale, and export of many older weapons are no longer available. CAR supplements formal weapon tracing by analysing physical evidence gathered from the weapons themselves and from related materiel; obtaining government, commercial, transport, and other documents; and interviewing individuals with knowledge of the equipment transfers under scrutiny.

CAR retains all documents, interview notes, emails, recordings, photographs, and other data obtained from third parties in a secure, encrypted format. Wherever relevant, CAR publications refer to these items as being 'on file'. To protect its sources, CAR is unable to publish all details about them or the circumstances under which it acquired certain items. CAR's sources provide all such items willingly and with full knowledge of their use by CAR. CAR does not undertake undercover work or use other clandestine investigation methods. For privacy reasons, CAR publications do not refer to private individuals by name, except in the case of well-known public officials.

▲ CAR supplements formal weapon tracing with analysis of physical evidence gathered from the weapons themselves and that of related materiel.
© CAR

CAR has contacted all governments and companies referenced in this report. Unless specified, no reference to the names of countries of manufacture, manufacturing companies, intermediary parties, distributors, or intended end users implies illegality or wrongdoing on the part of the named entity. CAR would like to acknowledge the cooperation of the governments, companies and individuals whose responses to CAR's trace requests and provision of other information have been critical in its ongoing investigations.

DOCUMENTATION

QASEF-1 UAVS

The Qasef-1 is a first-generation, rudimentary UAV in service with Houthi forces in Yemen. It is virtually identical in design, dimensions, and capability to the Iranian-manufactured Ababil-T UAV (CAR, 2017). The Qasef-1 has an estimated maximum range of 200 km; when operated from the western part of the country, its targets are thus restricted to those on Yemeni territory (UNSC, 2019, p. 29).[2] Houthi forces initially used the Qasef-1 to target the Saudi-led Coalition's MIM-104 Patriot surface-to-air missile defence systems (CAR, 2017). More recently, however, Houthi forces have fitted the Qasef-1 with improvised fragmentation charges (including nuts and bolts), which are initiated in flight and directed at soft targets, including exposed personnel located below. The most notable use of such charges occurred on 10 January 2019, when a Qasef-1 (or Qasef-2K[3]) detonated in the sky above the Al Anad Airbase during a military parade, killing six people and wounding many others (Bellingcat, 2019; FPRI, 2019).

In March 2017, CAR published a Frontline Perspective entitled *Iranian Technology Transfers to Yemen: 'Kamikaze' Drones Used by Houthi Forces to Attack Coalition Missile Defence Systems.* The report concludes that the Qasef-1 UAV is not of indigenous design and construction, but rather manufactured in Iran and supplied in batches to Houthi forces in Yemen (CAR, 2017, p. 3).[4]

In October 2016, February 2017, and July 2018, CAR documented eight Qasef-1s and one engine recovered from a Qasef-1, which UAE Presidential Guard forces seized in Yemen. Seven of the Qasef-1s, which CAR documented in 2016–17, were manufactured on a production line, were identical in construction, and had matching internal components (see Figures 2–10). In contrast, the eighth Qasef-1, which CAR documented in July 2018, had a frame and attachments whose construction was relatively rudimentary.

Figure 2

A Qasef-1 UAV.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

The fuselage and wings of the Qasef-1 UAVs bear printed and written serial numbers, which correspond to handwritten serial numbers applied to various internal components. The serial numbers, some of which are consecutive, indicate that the UAVs were manufactured on the same production line and that an external source supplied them to Houthi forces for further assembly (CAR, 2017). The components display a relatively high degree of precision in their fabrication; they are well assembled and markings on the electronic components point to industrial production and quality control processes. Some internal components match those found in Iranian-made UAVs, as discussed below.

The eight Qasef-1 UAVs feature the components and parts shown in Figures 3–10.[5]

Figure 3

A two-cylinder petrol model engine bearing the label DLE, possibly manufactured by the Chinese company Mile Hao Xiang Technology Co. Ltd.[6]

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

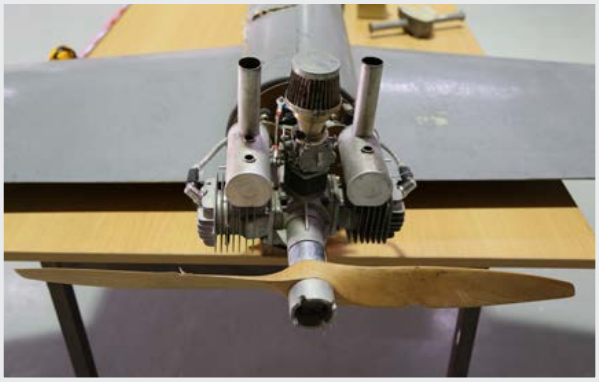


Figure 4

Sail propeller blades.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 5

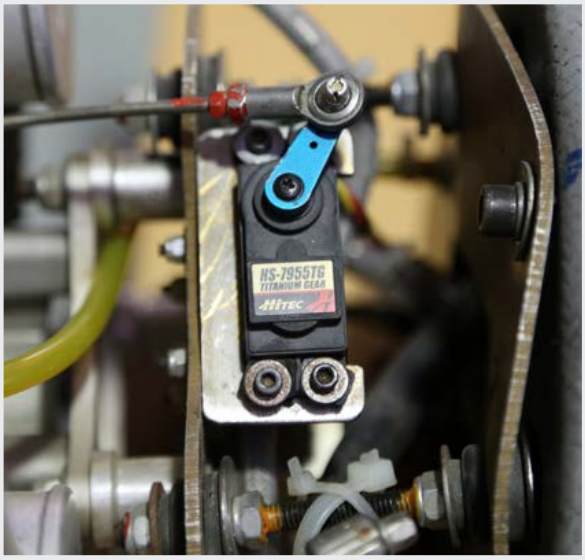
A model V10 vertical gyroscope.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 6

A Hitec HS-7955TG Titanium Gear servomotor.[7]

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.



WHILE MANY OF THE COMMERCIALLY PRODUCED INTERNAL COMPONENTS ARE SMALL AND EASY TO SMUGGLE, THE UAV FRAME IS MUCH LARGER AND WOULD BE MORE DIFFICULT TO TRANSPORT DISCRETELY.

Figure 7

A full-duplex multi-frequency data link.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 8

A Bahar box containing a Navior satellite compass with a MINMAX DC output converter. CAR traced three MINMAX DC output converters with MINMAX Technology Co. Ltd., which delivered them to Arman Optimized Systems in Iran in 2011 and 2012.[8] Arman Optimized Systems informed CAR that it does not retain sales records and therefore cannot trace the exact chain of supply of the items that CAR documented, but that the company only sells its products on the Iranian domestic market.[9] According to the UN Panel of Experts on Yemen, in August 2015, Arman Optimized Systems switched from directly paying for components via an Iranian bank to using a logistics company in Hong Kong, Turn Key International Logistics Company Ltd., with payments made through the Industrial and Commercial Bank of China (Asia) Limited—a bank that is also based in Hong Kong (UNSC, 2018, pp. 154–56).

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 9

Labels attached to wire bundles.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 10

Serial number 22-122-39 and batch number A5 on various Qasef-1 UAV components.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

In July 2018, a CAR field investigation team documented a Qasef-1 UAV that UAE forces reportedly captured in an unidentified location on the western coast of Yemen on 18 April 2018 (see Figure 11). While the UAV's engine and internal components are mostly identical to those of the industrially manufactured Qasef-1s, the frame is poorly constructed and comprises both industrially produced parts and crudely moulded fibreglass parts. CAR suspects that Houthi forces may have produced this hybrid frame domestically. While many of the commercially produced internal components are small and easy to smuggle, the UAV frame is much larger and would be more difficult to transport discretely. As CAR reported in 2018, Houthi forces have the ability to manufacture IEDs on a semi-industrial scale, which suggests that they may also possess the tools and expertise to produce parts for UAVs (CAR, 2018).

While the two makes of the Qasef-1 exhibit many similarities, CAR also identified several differences in design and manufacture. For instance, the hybrid Qasef-1's body parts bear matching hand-written numbers, which suggest a basic level of workshop production (see Figure 12); in contrast, the industrially manufactured version features plated, serialised lot numbers (see Figure 10).

Figure 11

A hybrid Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.

Figure 12

A handwritten number (28) inscribed on the tail wing (left) and fuselage (right) of a hybrid Qasef-1.

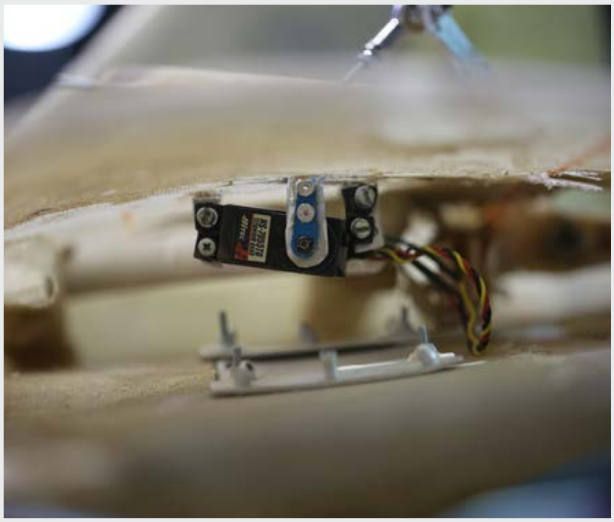
Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.

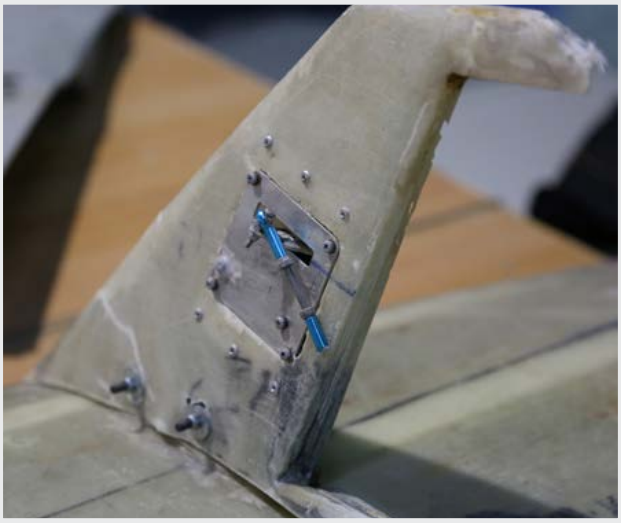
Although all of the Qasef-1s documented by CAR use Hitec HS-7955TG titanium-gear servomotors, they are connected to the UAVs' flight control surfaces in different ways (see Figure 13). On the hybrid Qasef-1, the servomotor gears, and the method of linkage to the UAV's ailerons and rudders, are relatively rudimentary.

Figure 13

Servomotor gears on the tail fin of a hybrid Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.





In addition, circuit boards in the hybrid Qasef-1 are crudely assembled in comparison to those in the industrially manufactured Qasef-1s (see Figure 14).

The hybrid Qasef-1's microprocessor is different from microprocessors that CAR previously documented in the industrially manufactured Qasef-1s (see Figure 15). CAR traced the hybrid Qasef-1's microprocessor with Digi, its manufacturer, which stated that it had produced the item in May 2017 and exported it to Schmidt & Co., (Hong Kong) Ltd. as part of a consignment of 500 units on 26 May 2017—less than one year prior to its recovery in Yemen.[10] On 8 August 2018, CAR issued a trace request regarding the onward transfer of the microprocessor to Schmidt & Co., (HK) Ltd.; it has yet to receive a response.

The hybrid version contains a general-voltage regulator (see Figure 16), which was not present in the industrially manufactured version. CAR traced the item with its manufacturer, STMicroelectronics (STM), which confirmed that the item was genuine and that it had been shipped between October and November 2009, although no records were kept of the recipient.[11]

Figure 14

Circuit board found in a hybrid Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.

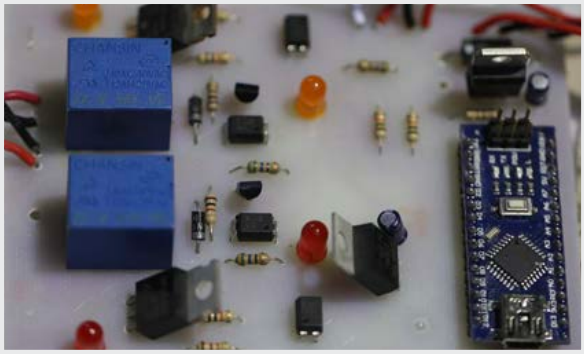


Figure 15

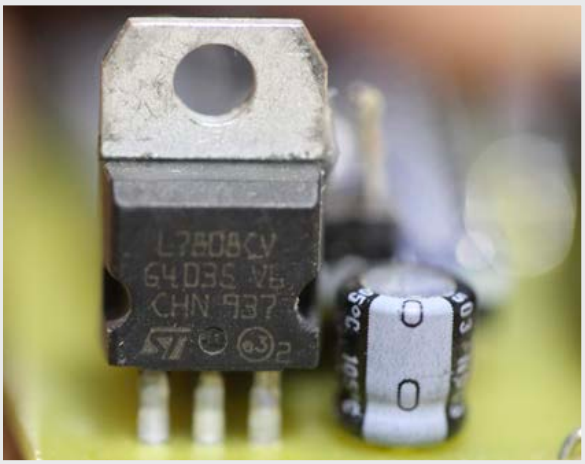
A Digi microprocessor found in a hybrid Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.

Figure 16

An STMicroelectronic general-voltage regulator found in a hybrid Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.



HOUTHI FORCES HAVE DEMONSTRATED AN INCREASING ABILITY TO INFLICT DAMAGE THROUGH THE USE OF UAVS.

THE SAMMAD-PATTERN UAV

In an effort to expand the reach and impact of their UAV capabilities, Houthi forces began deploying a new, more advanced UAV—the Sammad—in mid-2018. According to various media releases, the UAV comes in three variants (Press TV, 2019; Yemen Press, 2019). In addition to its distinct design, the Sammad features a larger warhead than the Qasef-1, and it has a more powerful engine, which provides it with a longer effective range. The Sammad has an estimated maximum range of 1,500 km, which supports claims by Houthi forces that they maintain the capability to strike targets outside of Yemen (UNSC, 2019, p. 30). The Sammad has the same exterior cast and paint colour as the imported Qasef-1.

In September 2018, CAR documented a Sammad-pattern UAV, which UAE forces reportedly had captured on Yemen's west coast on 21 June 2018 (see Figure 17). Several of the components resemble those of the Qasef-1, but with a few notable differences.

Figure 17

A Sammad-pattern UAV.

Documented by a CAR field investigation team in Abu Dhabi, UAE, September 2018.

The most significant distinctive features of the Sammad-pattern UAV are its shape and its engine. It uses a 3W-110i B2 engine, manufactured by 3W-Modellmotoren Weinhold GmbH (3W) in Hanau, Germany (see Figure 18). CAR contacted 3W, which stated that due to insufficient information, the company was unable to confirm the engine's supply chain.[12] The engine bears markings that have been deliberately obliterated by grinding (see Figure 19).

Although the engine's serial number has been removed, the UN Panel of Experts on Yemen recovered the number and traced it. According to the Panel, the engine derives from a shipment of 21 such engines that 3W exported to Eurowings Aviation and Consultancy of Athens, Greece, in June 2015 (UNSC, 2019, p. 89). The Panel further identified that the engines were resupplied to a company based in Iran, in violation of German law (UNSC, 2020, pp. 110-113).

Figure 18

A 3W engine found in a Sammad-pattern UAV.

Documented by a CAR field investigation team in Abu Dhabi, UAE, September 2018.

Figure 19

Obliterated marking on a 3W engine found in a Sammad-pattern UAV.

Documented by a CAR field investigation team in Abu Dhabi, UAE, September 2018.

▼ **V-shaped tail of a Sammad-pattern UAV.**
© CAR

ELSEWHERE IN THE REGION: COMPONENTS IDENTICAL TO THOSE IN HOUTHI UAVS

While Houthi forces appear to have developed some domestic UAV production capacity, the bulk of evidence gathered from Houthi UAVs recovered by UAE forces, and documented by CAR, reveals that a number of UAV components are identical to components and parts that proliferate elsewhere in the region. For instance, some items contained in Houthi UAVs match ones that CAR identified in Iranian-made UAVs, in IEDs employed by non-state forces in Yemen, and in IEDs that Bahraini forces captured from militant factions in Bahrain (see Table 2); these components are also identical to some of the ones recovered from the *Jihan 1* merchant vessel, whose cargo originated in Iran (CAR, 2019, pp. 9–13). The following sections compare components found in Houthi UAVs documented by CAR with corresponding items in the region.

Table 2

Corresponding UAV and IED components recovered in the region

Components[a]	Documented items							
	Qasef-1 (industrial)	Qasef-1 (hybrid)	Sammad-pattern UAV	Ababil-3[b]	Shahed-141[c]	Houthi IEDs	IEDs in Bahrain[d]	Islamic State in Yemen/ AQAP RCIEDs
Bahar enclosure box	×						×	
Chansin power relay		×						×
Hitec servomotors	× (HS-7955TG)	× (HS-7955TG)	× (HS-7955TG)		× (HS-M7990TH)			
Microchip microcontrollers	×	×					×	
Quality control stickers	×					×	×	
STM general-voltage regulator[e]	×	×	×			×	×	×
Tillotson-labelled engine carburettor			×	×				
V10 gyroscope	×			×				
Woer-branded heat-shrink sleeving	×	×	×			×	×	

Notes: AQAP stands for Al-Qaeda in the Arabian Peninsula; RCIEDS are radio-controlled IEDs.

[a] *The use of these components in the documented UAVs and IEDs does not imply any wrongdoing on the part of the manufacturers.*

[b] *See Lost Weapons (2017) and HSBA (2012) for documentation of Ababil-3 components.*

[c] *Documented by CAR in Tel Aviv, Israel, 30 May 2018.*

[d] *The IED components seized in Bahrain that match those contained in Houthi UAVs were mixed with other components that match items found in Houthi IEDs.*

[e] *In correspondence with CAR, STM confirmed that some of these devices were counterfeit.*

Woer-branded heat-shrink sleeving

CAR has identified Woer-branded heat-shrink sleeving in all of the Houthi UAVs that it documented (see Figure 20), as well as in IEDs seized from Houthi forces and from militants in Bahrain (see Figures 21–22).

Furthermore, the *Jihan 1* merchant vessel included radio-controlled IED (RCIED) electronic components with Woer-branded heat-shrink sleeving (CAR, 2019; see Figure 23).

Figure 20

Woer-branded heat-shrink sleeving in an industrially manufactured Qasef-1 UAV (top), hybrid Qasef-1 (middle), and Sammad-pattern UAV (bottom).

Documented by a CAR field investigation team in Abu Dhabi, February 2017, July 2018, and September 2018, respectively.

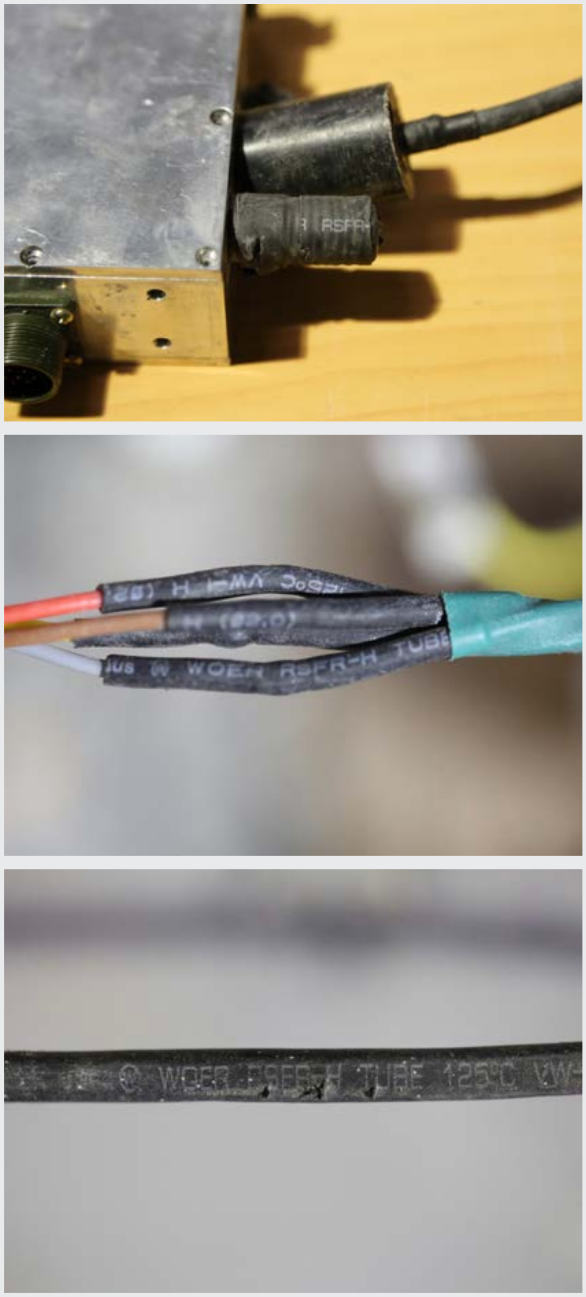


Figure 21

Woer-branded heat-shrink sleeving on RCIED components, seized from Houthi forces in Yemen.

Documented by a CAR field investigation team in Mokha, Yemen, July 2018.

Figure 22

Woer-branded heat-shrink sleeving used in the manufacture of an RCIED, seized from militant factions in Bahrain between August 2017 and February 2018.

Documented by a CAR field investigation team in Manama, Bahrain, April 2018.

Figure 23

Woer-branded heat-shrink sleeving on RCIED components seized from the *Jihan 1*.

Documented by UN investigators in Aden, Yemen, on 24 February 2013. © United Nations

Vertical gyroscopes

Some of the components found in Houthi UAVs are identical to those identified in Iranian-manufactured UAVs.[13] The model V10 vertical gyroscopes fitted to the industrially manufactured Qasef-1s, for instance, bear serial numbers that are close in proximity to an identical gyroscope found in an Iranian-made Ababil-3 UAV, which Islamic State forces reportedly recovered in Iraq (Lost Weapons, 2017; see Figures 24–25). The gyroscopes appear to be of the same make—yet not the same model—as a unit that Saudi authorities recovered following the aerial attack on the Aramco oil facility in Abqaiq, Saudi Arabia, on 14 September 2019 (Reuters, 2019; see Figure 26). According to UAV experts familiar with this technology, such vertical gyroscopes have not been observed in any UAVs other than those manufactured by Iran.[14]

Figure 24

A model V10 vertical gyroscope bearing the serial number 2099 found in an industrially manufactured Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 25

A model V10 gyroscope with serial number 2301 found in an Iranian-made Ababil-3 UAV, which Islamic State forces reportedly recovered in Iraq.

© Lost Weapons

Figure 26

A model V9 vertical gyroscope recovered following the attack on the Aramco oil facility in Abqaiq, Saudi Arabia, on 14 September 2019.

© Reuters

Tillotson-labelled engine carburettors

The engines of the Sammad-pattern UAV and an Iranian-manufactured Ababil-3, which Sudan People's Liberation Army–North (SPLA-N) forces shot down in March 2012 in South Kordofan State, Sudan, are each fitted with identical Tillotson-labelled carburettors (HSBA, 2012; see Figures 27–28).

The carburettor of the Sammad-pattern UAV features the label 'Tillotson Ireland'. In response to a trace request issued by CAR, Tillotson stated that it could not confirm that the item that CAR documented was genuine. The company noted that if the carburettor was genuine, the item's date code indicated that it was manufactured in week 33 of 2014. Tillotson confirmed that it sold items with that date code to three companies: 3W-Modellmotoren GmbH (the manufacturer of the engine in the Sammad-pattern UAV), Partner sp. z o.o., and V.E. Petersen Co.[15]

▼ **Remains of an Iranian manufactured Shahed-141 UAV.**
© CAR

Figure 27

A Tillotson-labelled carburettor found in a Sammad-pattern UAV.

Documented by a CAR field investigation team in Abu Dhabi, UAE, September 2018.

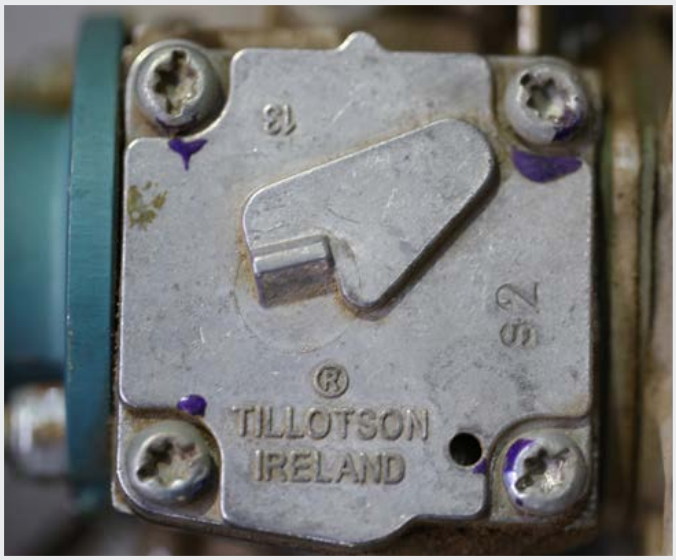


Figure 28

A carburettor produced by Tillotson, found in an Iranian-manufactured Ababil-3 UAV, South Kordofan, Sudan, March 2012 (HSBA, 2012).

Hitec servomotors

An Iranian-manufactured Shahed-141 UAV—which Israeli forces reportedly shot down on 10 February 2018, after it was launched from Syria into Israeli air space—is fitted with the same make, but not the same model, of Hitec servomotor as those used in the Qasef-1 and Sammad-pattern UAVs (see Figures 29–32).

The UN Panel of Experts on Yemen traced an HS-7955TG Titanium Gear servomotor, which was found in a Qasef-1, with its manufacturer, Hitec RCD Korea. Since the servomotor does not bear an individual serial or lot number, the manufacturer was unable to identify the precise recipient of the item. The Panel highlighted, however, that Hitec RCD Korea confirmed that it had supplied a consignment of servomotors to an Iranian company, Tehran Hobby Ltd., in mid-2015 (UNSC, 2018, pp. 154–56).

Figure 29

Hitec HS-7955TG Titanium Gear servomotor found in an industrially manufactured Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 30

Hitec HS-7955TG Titanium Gear servomotor found in a hybrid Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.

Figure 31

Hitec HS-7955TG Titanium Gear servomotor found in a Sammad-pattern UAV.

Documented by a CAR field investigation team in Abu Dhabi, UAE, September 2018.

Figure 32

A Hitec HS-M7990TH Monster Torque ME servomotor found in an Iranian-manufactured Shahed-141 UAV, which the Israeli air force shot down after it crossed into Israeli airspace from Syria in February 2018.

Documented by a CAR field investigation team in Tel Aviv, Israel, May 2018.

▲ Qasef-1 UAV frames, which UAE forces seized in Yemen.
© CAR

Bahar enclosure boxes

CAR has documented Bahar enclosure boxes in the imported Qasef-1s as well as in several RCIEDs, which Bahraini security forces captured from militant factions in Bahrain (see Figures 33–34). The manufacturer of the items, Beijing Bahar Technology Co. Ltd., is headquartered in China, maintains an office in Germany, and has distribution companies in Ukraine and Iran. Bahar responded promptly to a CAR trace request regarding the enclosure boxes, which CAR documented in Bahrain and Yemen. The company confirmed that the items were authentic, but noted that it could not trace their chain of custody. Bahar stated that most of its sales are made to the domestic Chinese market. The company's Iranian subsidiary still maintains a Farsi-language website, but due to international sanctions Bahar has not sold any products to Iran since 2017.[16]

Figure 33

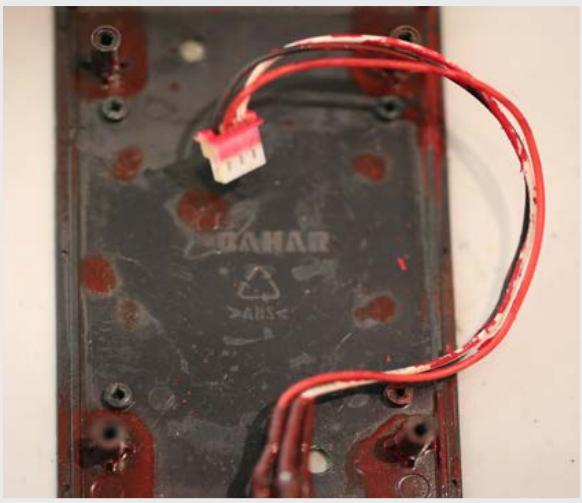
A Bahar enclosure box contained in an industrially manufactured Qasef-1 UAV.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 34

A Bahar enclosure box containing RCIED electronics, recovered from militant factions in Bahrain between August 2017 and February 2018.

Documented by a CAR field investigation team in Manama, Bahrain, in April 2018.



Quality control stickers

The placement of quality control (QC) stickers on or inside electronic components of UAVs and IEDs is a physical characteristic that CAR field investigation teams have only documented on materiel employed by Houthi forces and captured in Yemen, materiel captured from militant groups in Bahrain, and in an Iranian-manufactured Shahed-141 UAV (CAR, 2019; see Figures 35–39). The stickers are also visible on components recovered from the *Jihan 1*. The stickers are typically, but not always, placed across the joining point of an enclosure box containing electronic components. They are probably affixed at a central production facility, to confirm the integrity of a relatively sophisticated electronic device, before its transfer to groups that may not possess the skills or materials necessary to construct such devices. The consistent application of the stickers to electronic components strongly suggests that the production process is standardised and that the components are manufactured in significant quantities in a controlled, industrial environment before they are transferred to various non-state groups in the region.

Figure 35

A QC sticker on the case of an ion battery pack found in an industrially manufactured Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

Figure 36

A QC sticker on an RCIED electronics case captured by Saudi-led Coalition forces from Houthi forces on Yemen's west coast.

Documented by a CAR field investigation team in Mokha, Yemen, July 2018.

Figure 37

A QC sticker on the case of an RCIED receiver, recovered from Bahraini militant factions.

Documented by a CAR field investigation team in Manama, Bahrain, April 2018.

Figure 38

A QC sticker on a servomotor recovered from a Shahed-141 UAV that was manufactured in Iran and shot down by the Israeli air force after it crossed into Israeli airspace from Syria in February 2018.

Documented by a CAR field investigation team in Tel Aviv, Israel on 31 May 2018.

Figure 39

A QC sticker on an RCIED component kit recovered from the *Jihan 1*.

Documented by UN investigators in Aden, Yemen, February 2013. © United Nations

STMicroelectronic general-voltage regulators

CAR has documented authentic and counterfeit STM general-voltage regulators connected to electronic components in all Houthi UAVs, in addition to IEDs recovered in Yemen from Houthi, Al-Qaeda in the Arabian Peninsula (AQAP), and Islamic State in Yemen forces. In addition, CAR has documented authentic and counterfeit STM-labelled general-voltage regulators used in RCIEDs that security forces seized from militant factions in Bahrain.

STM informed CAR that its general-voltage regulators in the industrially manufactured Qasef-1 were manufactured in Shenzhen, China, in 2012 (see Figure 40).[17] The hybrid Qasef-1 also contained an STM general-voltage regulator (see Figure 41); STM confirmed that the item was shipped to a recipient in late 2009 but provided no further information.[18] The Sammad-pattern UAV also contained STM-labelled general-voltage regulators (see Figure 42); in a written

Figure 40

STM general-voltage regulators found in an industrially manufactured Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, February 2017.

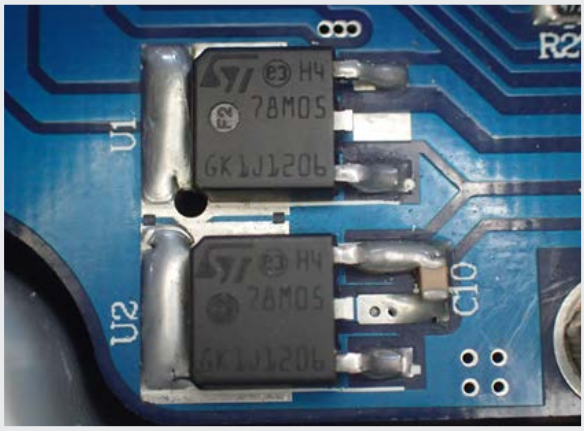


Figure 41

An STM general-voltage regulator found in a hybrid Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.

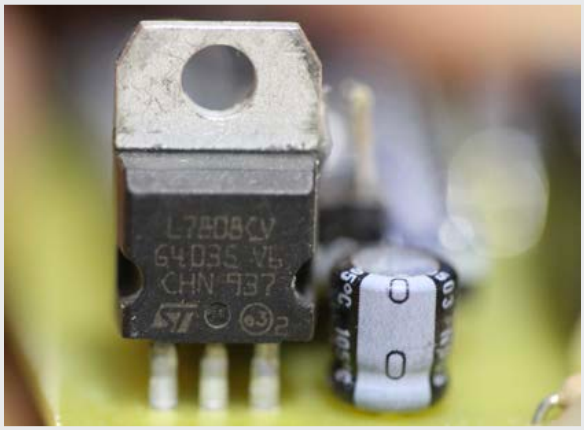


Figure 42

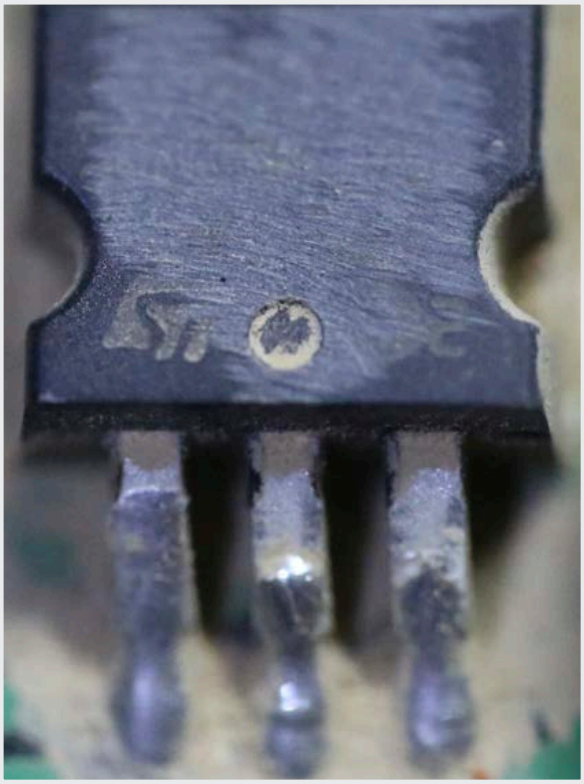
An STM general-voltage regulator contained in a Sammad-pattern UAV.

Documented by a CAR field investigation team in Abu Dhabi, UAE, September 2018.

Figure 43

An STM general-voltage regulator in an RCIED with obliterated markings, which UAE forces captured from Houthi forces in Yemen.

Documented by a CAR field investigation team in Mokha, Yemen, July 2018.



response to CAR, however, STM stated that the items could not be traced as insufficient information was available on their transfer.[19]

Between 2017 and 2019 in Yemen, CAR documented authentic and counterfeit STM general-voltage regulators that were mounted on RCIEDs, which UAE and Yemeni counter-terrorism forces captured from AQAP and Islamic State forces in Yemen. In addition, UAE forces captured from Houthi forces an STM general-voltage regulator, whose markings had been deliberately obliterated in order to obscure its provenance (see Figure 43). According to STM, the device that Yemeni counter-terrorism forces seized from AQAP had been assembled and shipped to a distributor in 2007, yet the distributor could not be identified (see Figure 44).[20] Further, STM confirmed to CAR that the device that UAE forces had seized from AQAP was counterfeit (see Figure 45).[21] In addition, STM established the counterfeit nature of a device that Yemeni counter-terrorism units had seized from Islamic State forces in Yemen (see Figure 46).[22]

Lastly, CAR documented one authentic STM general-voltage regulator and one counterfeit version, which Bahraini security forces had seized in Bahrain. The first was seized on 15 March 2015 from a passenger bus, which had travelled from Iraq, through Saudi Arabia, and into Bahrain (see Figure 47). In response to a trace request issued by CAR on 18 August 2017, STM confirmed that it manufactured the item in November 2013 and sold it to a distributor either in China, Hong Kong, or South Korea.[23] CAR has not been able to confirm which distributor received the item. CAR documented a second STM general-voltage regulator, which Bahraini security forces had seized from militant factions during operations between August 2017 and February 2018 in Bahrain (see Figure 48). In a written response to CAR, however, STM stated that the item in question was counterfeit.[24]

Figure 44

An STM general-voltage regulator in an RCIED, which Yemeni counter-terrorism units seized from AQAP forces in Shabwa governorate, Yemen.

Documented by a CAR field investigation team in Aden, Yemen, December 2017.

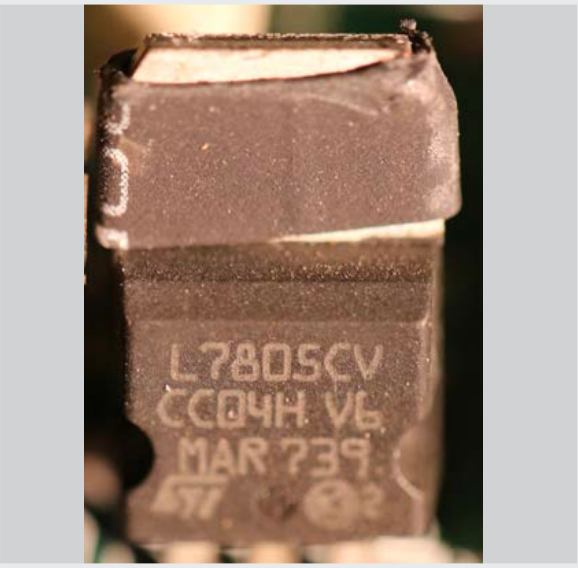


Figure 45

A counterfeit STM-labelled general-voltage regulator in an RCIED, which UAE forces captured from AQAP forces in Shabwa governorate in June 2019.

Documented by a CAR field investigation team in Mukalla, Yemen, June 2019.

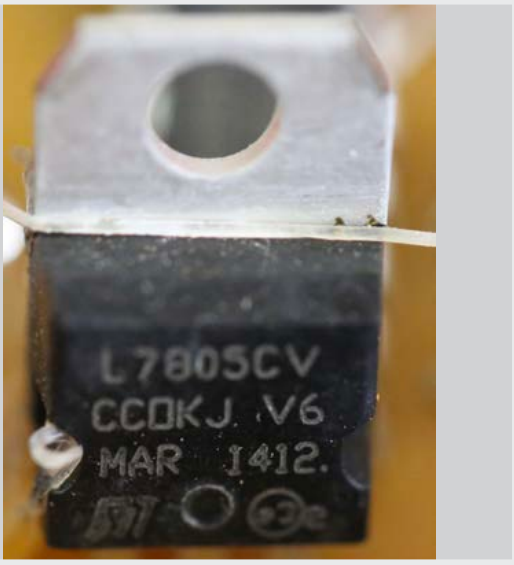


Figure 46

A counterfeit STM general-voltage regulator in an RCIED, which Yemeni counter-terrorism units seized from Islamic State forces in Yemen.

Documented by a CAR field investigation team in Aden, Yemen, January 2018.

Figure 47

An STM general-voltage regulator in an RCIED, which Bahraini security forces seized on 15 March 2015 from a passenger bus that had travelled from Iraq, through Saudi Arabia, and into Bahrain.

Documented by a CAR field investigation team in Manama, Bahrain, July 2017.

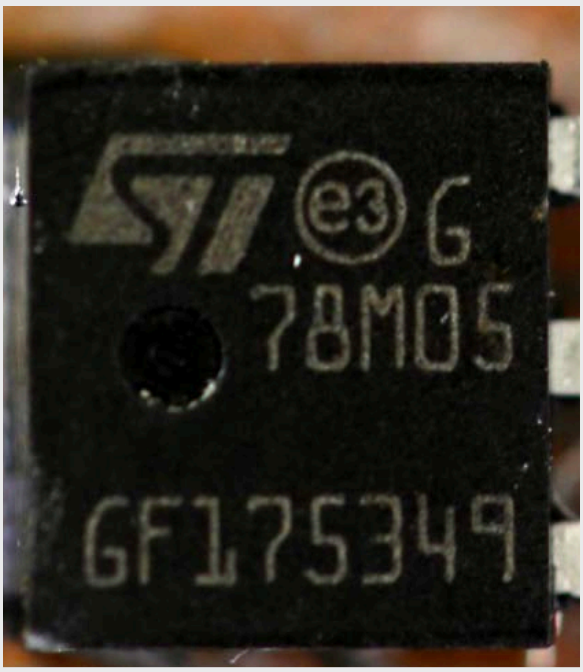
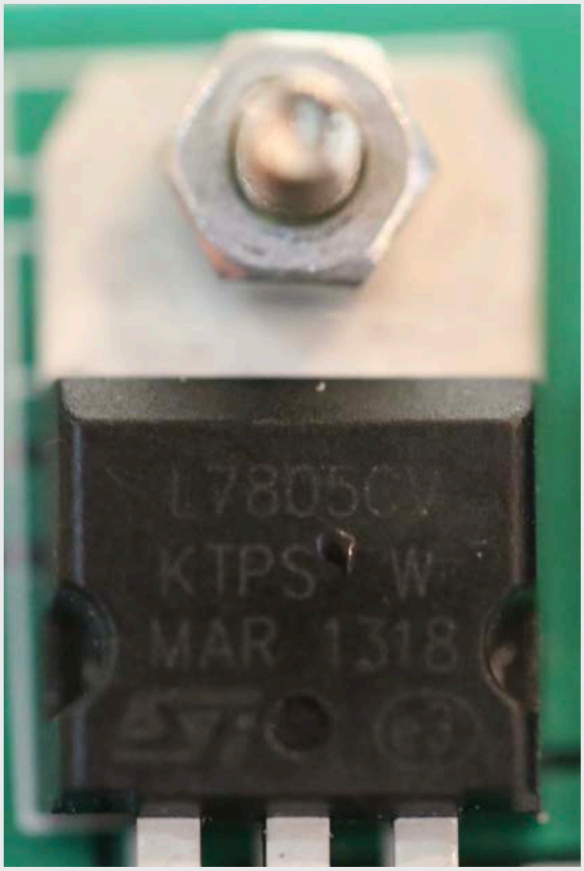


Figure 48

A counterfeit STM general-voltage regulator in an RCIED, which Bahraini security forces seized from militant factions during operations between August 2017 and February 2018 in Bahrain.

Documented by a CAR field investigation team in Manama, Bahrain, April 2018.



HOUTHI FORCES NOW EMPLOY LONGER-RANGE UAVS, WHICH ARE DESIGNED TO DELIVER AN EXPLOSIVE PAYLOAD.

▼ **A Lithium battery pack found in a Qasef-1, which UAE forces seized in Yemen.**

© CAR

Microchip Atmel microcontrollers[25]

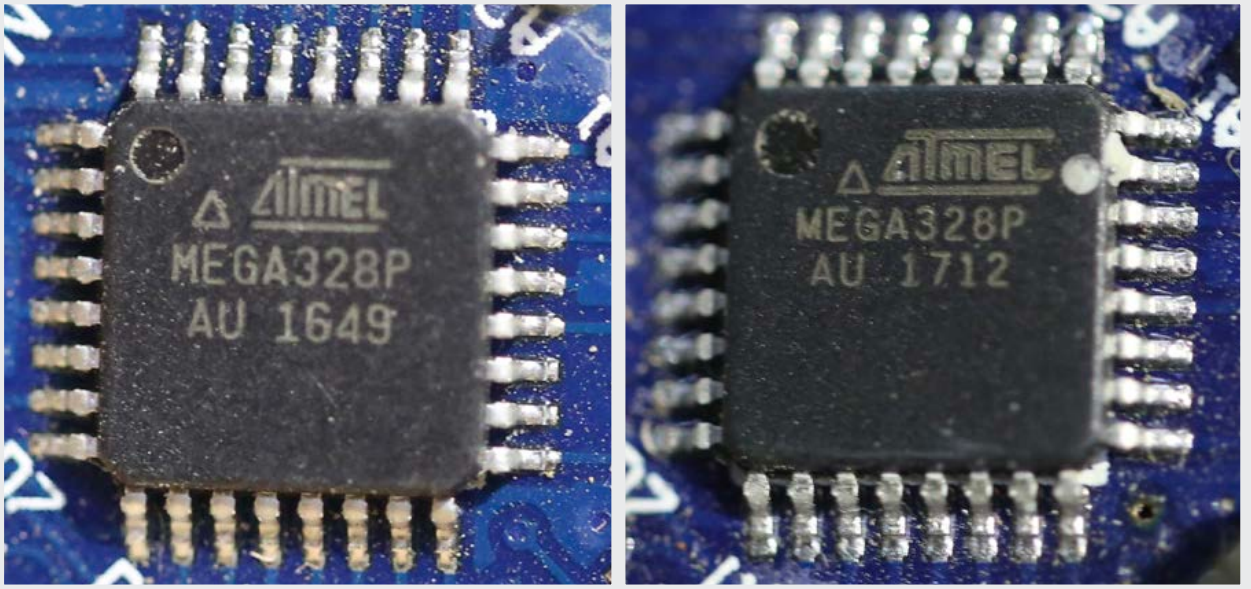
All of the Qasef-1s documented by CAR employed circuit boards attached with microcontrollers bearing an Atmel label. A CAR field investigation team also documented an identical Microchip Atmel microcontroller in a receiver for an RCIED, which Bahraini security forces had seized in March 2015 from a passenger bus that had travelled from Iraq, through Saudi Arabia, and into Bahrain.

The microcontrollers bear codes that are relatively close in proximity—1649[26] and 1712[27] in the hybrid Qasef-1, and 1429[28] in the RCIED receiver (see Figures 49–50).

Figure 49

Microchip microcontrollers with codes 1649 and 1712, found in a hybrid Qasef-1.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.



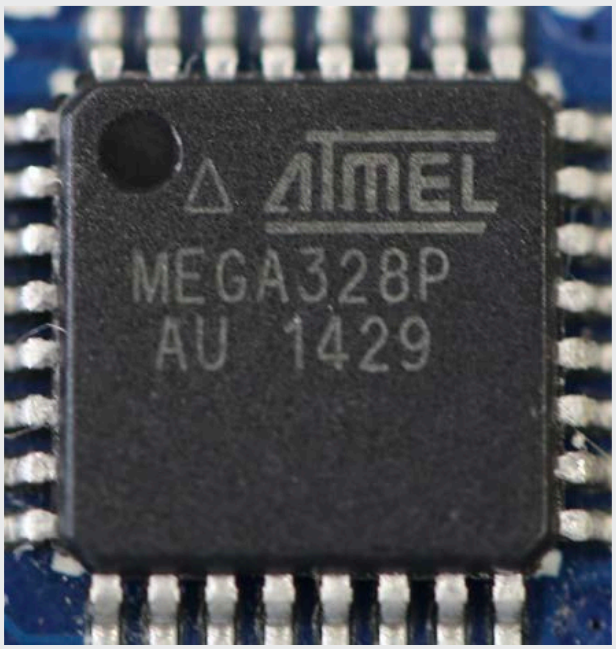


Figure 50

A Microchip microcontroller with code 1429, seized by Bahraini security forces on 15 March 2015 from a passenger bus that had travelled from Iraq, through Saudi Arabia, and into Bahrain.

Documented by a CAR field investigation team in Manama, Bahrain, July 2017.

Chansin power relays

A power relay found in the hybrid Qasef-1 was manufactured by the Chinese company Chansin (see Figure 51). In Mukalla, Yemen, CAR documented a similar power relay affixed to an RCIED component, which UAE forces captured from AQAP forces in Shabwa governorate in June 2019 (see Figure 52). The two power relays are nearly identical and feature closely aligned manufacture codes.[29]

Figure 51

A Chansin power relay found in a hybrid Qasef-1, which UAE forces captured in Yemen.

Documented by a CAR field investigation team in Abu Dhabi, UAE, July 2018.

Figure 52

A Chansin power relay found in an RCIED, which UAE forces captured from AQAP in Shabwa governorate in June 2019.

Documented by a CAR field investigation team in Mukalla, Yemen, June 2019.

▼ **Qasef-1 UAV wings, which UAE forces captured in Yemen.**

© CAR

CONCLUSION

Since March 2015, when the current conflict in Yemen began, Houthi forces have demonstrated an increasing ability to inflict damage through the use of UAVs. They deploy a variety of reconnaissance and combat UAVs, which they have assembled using imported parts, or a combination of imported and domestically manufactured components. Their use of UAVs has evolved thanks to growing domestic capabilities and to their acquisition of more sophisticated material from external sources.

Having previously relied on un-weaponised UAVs to destroy Saudi-led Arab Coalition weapon guidance systems—by crashing them into sensitive electronics, such as radar units—Houthi forces now employ longer-range UAVs, which are designed to deliver an explosive payload.

HOUTHI FORCES CONTINUE TO RELY ON SMUGGLING SMALLER COMPONENTS RENDERING THE UAVS CAPABLE OF DELIVERING INCREASINGLY LETHAL PAYLOADS.

These forces appear to have started producing a hybrid UAV, parts of which are manufactured domestically, rather than utilising only externally sourced industrial models. Since airframes are the largest component of a UAV, they are presumably more difficult to smuggle into the country. Houthi forces continue to rely on smuggling smaller components, whose design and construction are increasingly sophisticated, rendering the UAVs capable of delivering increasingly lethal payloads.

The components and parts found in Houthi UAVs are in many cases identical to those used in the construction of IEDs by non-state forces in Yemen and Bahrain. Some components are also identical to those contained in Iranian UAVs and among components seized from the *Jihan 1* merchant vessel, which Yemeni forces interdicted while the ship was ferrying weapons from Iran to Yemen.

As the UAV threat continues to evolve in the Gulf and wider Middle East, it is critical to assess commonalities in device construction and in the supply routes used by the various entities operating across the region. Enhancing knowledge of non-state groups' capacity to obtain and use commercially available components for lethal means, and the lines of supply with which such material is procured, is key to identifying the parties responsible for their supply.

▼ A Qasef-1 UAV, which UAE forces shot down in Yemen.
© CAR

ENDNOTES

1 There is insufficient information regarding the detailed characteristics of the Sammad variants to conclusively identify the type documented by CAR.

2 CAR interview with a UAV expert, 9 January 2020.

3 The Qasef-1 and Qasef-2K are nearly identical in design. Therefore, based on footage and remains from the attack, it is impossible to identify whether Houthi forces deployed a Qasef-1 or Qasef-2K in the attack. Houthi forces claimed the UAV used in the attack was a Qasef-2K, but CAR has not been able to verify this claim (Bellingcat, 2019).

4 Likewise, the Panel of Experts on Yemen finds that, 'based on: (a) the design of the unmanned aerial vehicles; and (b) the tracing of component parts, the material necessary to assemble the Qasef-1 unmanned aerial vehicles […] emanated from the Islamic Republic of Iran' (UNSC, 2018, p. 32).

5 CAR documented all of the components in this section in Abu Dhabi, UAE, in February 2017. CAR endeavoured to trace everything that had identifying and distinguishing marks. Diversion of traceable components does not imply any wrongdoing on the part of the manufacturer.

6 CAR issued a formal trace request regarding an identical engine that it had documented. On 22 November 2016, Mile Hao Xiang Technology Co., Ltd responded to the request. This response confirms that: 1) Mile Hao Xiang Technology is unable to keep end-user records for every purchase. It only keeps contact details of official dealers; 2) DLE engines are sold by official dealers and online in shops such as Taobao, Alibaba, and eBay; 3) the serial number CAR documented was on the ignition of the engine but the company does not keep serial number records; and 4) Mile Hao Xiang Technology believes the engine CAR documented may be counterfeit as genuine DLE engines do not have air intake tubes.

7 CAR sent a trace request to Hitec on 16 August 2019 and a reminder on 16 September 2019 for a Hitec HS-7955TG servomotor contained in the Sammad-pattern UAV seized by UAE forces in June 2018. CAR has yet to receive a response to either request.

8 On 19 December 2019, MINMAX Technology Co. Ltd. responded to a formal trace request issued by CAR on 18 December 2019. This response confirms that: 1) MINMAX Technology Co. Ltd. manufactured the MIW3021 unit with unique identifying number 1146, subject to CAR's trace request, in week 46 of 2011; 2) MINMAX Technology Co. Ltd. sold the item to Arman Optimized Systems (No. 111, Ebne Yamin Street, North Sohravardi Street, Tehran, Iran), the sole distributor of MINMAX products in Iran for the past 10 years; and 3) on 22 November 2011, YCS Express Group shipped the item to Arman Optimized Systems as part of a larger consignment comprising 90 MIW3021 units. MINMAX Technology Co. Ltd. included copies of the invoice, packing list, and airway bill in its response to CAR.

On 19 December 2019, MINMAX Technology Co. Ltd. responded to a formal trace request issued by CAR on 18 December 2019. This response confirms that: 1) MINMAX Technology Co. Ltd. manufactured the two MIW3021 units with unique identifying number 1207, subject to CAR's trace request, in week 7 of 2012; 2) MINMAX Technology Co. Ltd. sold the items to Arman Optimized Systems (No. 111, Ebne Yamin Street, North Sohravardi Street, Tehran, Iran), the sole distributor of MINMAX products in Iran for the past 10 years; and 3) on 21 February 2012, YCS Express Group shipped the items to Arman Optimized Systems as part of a larger consignment comprising 250 MIW3021 units. MINMAX Technology Co. Ltd. included copies of the invoice, packing list, and airway bill in its response to CAR.

9 On 12 January 2020, Arman Optimized Systems responded promptly to a formal trace request issued by CAR on 19 December 2019. This response confirms that: 1) Arman Optimized Systems has no records of the MIW3021 unit with manufacturing date mark 1146, subject to CAR's trace request; 2) there is no unique identifying mark on MINMAX products that enables the company to hold sales records; 3) Arman Optimized Systems did not receive

any MIW3021 units from MINMAX in November 2011; 4) Arman Optimized Systems received 20 MIW3021 units in October 2011, 30 MIW3021 units in December 2011 and 250 MIW3021 units in February 2012, as part of larger consignments comprising numerous items; 5) Arman Optimized Systems markets and sells electronic parts on the Iranian domestic market, with its main customers based in Tehran; 6) Arman Optimized Systems stopped marketing MINMAX products in 2015; 7) a small quantity of MIW3021 units were assigned for use in universities; and 8) Arman Optimized Systems does not export to any other country.

On 12 January 2020, Arman Optimized Systems responded promptly to a formal trace request issued by CAR on 19 December 2019. This response confirms that: 1) Arman Optimized Systems has no records of the two MIW3021 units with manufacturing date mark 1207, subject to CAR's trace request; 2) there is no unique identifying mark on MINMAX products that enables the company to hold sales records; 3) Arman Optimized Systems did not receive any MIW3021 units from MINMAX in November 2011; 4) Arman Optimized Systems received 20 MIW3021 units in October 2011, 30 MIW3021 units in December 2011 and 250 MIW3021 units in February 2012, as part of larger consignments comprising numerous items; 5) Arman Optimized Systems markets and sells electronic parts on the Iranian domestic market, with its main customers based in Tehran; 6) Arman Optimized Systems stopped marketing MINMAX products in 2015; 7) a small quantity of MIW3021 units were assigned for use in universities; and 8) Arman Optimized Systems does not export to any other country.

10 On 6 August 2018, Digi responded to a formal trace request issued by CAR on 10 July 2018. This response confirms that: 1) Digi manufactured the 9XTend Replacement, Legacy RPS, part XTP9B-DPS-001 with serial number 0013A200415C1E69, subject to CAR's trace request, in May 2017; 2) DIGI sold the item to one of their distributors, Schmidt & Co., (Hong Kong) Ltd. (3 Tung Wong Road, Shaukeiwan, Hong Kong), as part of a consignment of 500 units of XTP9B-DPS-001; 3) Digi does not have visibility on whom the distributor ultimately sold the product to; and 4) DHL Express Worldwide exported the consignment on 26 May 2017. Digi informed CAR that the date of delivery is unknown as DHL keeps only records for a limited period of time. CAR issued a trace request to Schmidt & Co., (HK) Ltd. on 8 August 2018, and reminders on 5 October 2018, 19 November 2018, and 28 February 2019, but has yet to receive a response.

11 On 21 September 2019, STMicroelectronics responded to a formal trace request issued by CAR on 15 August 2019. This response confirms that: 1) the ST voltage regulator L7808CV, subject to CAR's trace request, is a genuine STM product as marking on the product is in line with original product marking; 2) STM shipped the item between October and November 2009; 3) STM cannot determine the precise chain of custody of the item CAR documented as the company does not retain that information.

12 On 15 August 2019, 3W-Modellmotoren Weinhold GmbH responded promptly to a formal trace request issued by CAR on 13 August 2019. Due to insufficient information provided by CAR, 3W-Modellmotoren Weinhold GmbH is unable to establish the origin and supply route of the 3W-110i B2 cylinder engine with obliterated markings, subject to CAR's trace request.

13 Houthi UAVs also contain Tillotson-labelled carburettors and Hitec servomotors, which match those used in Iranian UAVs.

14 CAR interviews with UAV experts, November–December 2019.

15 On 5 September 2019, Tillotson responded promptly and comprehensively to a formal trace request issued by CAR on 13 August 2019. This response confirms that: 1) on 18 August 1986, Tillotson produced and released the model HS-232E carburettor for Dolmar Chainsaws 133s and 143; 2) Tillotson cannot confirm that the HS-232E carburettor with code 232E433, subject to CAR's trace request, is a genuine product; 3) if the item CAR documented is genuine, the 433 code on the item would represent the date code, indicating that the item was manufactured in week 33 of 2014; 4) Tillotson sold items with that date code between 26 September 2014 and 11 January 2017; and 5) Tillotson provided CAR with a list of recipients that purchased the HS-232E product manufactured in week 33 of 2014:

a) 3W-Modellmotoren GmbH (Lise-Meitner-Strasse 33, Hanau 63457, Germany) purchased 304 units on 26 September 2014; 80 units on 24 September 2015; 100 units on 18 February 2016; 12 units on 25 August 2016; and 320 units on 11 January 2017;

b) Partner sp. z o.o. (Ul. Jerzmanowska 21, 54-530 Wrocław, Poland) purchased one unit on 30 September 2015; and

c) V.E. Petersen Co. (28101 E. Broadway, Walbridge, Ohio 43465, United States) purchased two units on 31 October 2014; two units on 24 April 2015; three units on 30 September 2015; and two units on 18 December 2015.

16 On 14 October 2019, Bahar responded promptly to a formal trace request issued by CAR on 11 October 2019. This response confirms that; 1) Bahar manufactured the 3-5 RMB enclosures, subject to CAR's trace request; 2) 80-90% of these enclosures are sold on the domestic market in China, however Bahar additionally has distributors in Ukraine and Iran, a store in Shenzhen, a company in Germany, and sells its products through online distributors; 3) as a result of sanctions placed on the Islamic Republic of Iran, no sales have been made to Iran since 2017 as the Iranian government has restricted import goods; and 4) Bahar was unable to determine the product code of the item subject to CAR's trace request.

17 On 10 March 2017, STMicroelectronics responded promptly to an informal request for information sent by CAR on 9 March 2017. This response confirms that: 1) the two L78M05 voltage regulators documented by CAR were manufactured in Shenzhen manufacturing plant, China, in 2012; 2) the L78M05 voltage regulators were part of production lot W06; and 3) this type of product is used widely in electronic applications and is readily available for purchase on the web.

18 On 21 September 2019, STMicroelectronics responded to a formal trace request issued by CAR on 15 August 2019. This response confirms that: 1) the ST voltage regulator L7808CV, subject to CAR's trace request, is a genuine STM product as marking on the product is in line with original product marking; 2) STM shipped the item between October and November 2009; 3) STMicroelectronics confirmed that it cannot determine the precise chain of custody of the item CAR documented as the company does not retain that information.

19 On 21 September 2019, STMicroelectronics responded to a formal trace request issued by CAR on 15 August 2019. Due to insufficient information provided by CAR, STMicroelectronics are unable to establish the origins and supply route of the STPS61150CW, subject to CAR's trace request.

20 On 1 February 2018, STMicroelectronics responded to a formal trace request issued by CAR on 31 January 2018. This response confirms that STMicroelectronics assembled and shipped the L7805CV voltage regulator with CC04H V6 mark, subject to CAR's trace request, to one of its distributors, in 2007.

21 On 16 January 2020, STMicroelectronics responded promptly to a formal trace request issued by CAR on 8 January 2020. This response confirms that: 1) STMicroelectronics did not manufacture the ST voltage regulator L7808CV, subject to CAR's trace request; and 2) the trace code, marking layout, and marked assembly country codes do not follow that of genuine STMicroelectronics manufacture.

22 On 1 February 2018, STMicroelectronics responded to a formal trace request issued by CAR on 31 January 2018. This response confirms that the STMicroelectronic component with KTPSJ W mark, subject to CAR's trace request, is counterfeit.

23 On 18 August 2017, STMicroelectronics responded promptly to an informal request for information sent by CAR on 17 August 2017. This response confirms that: 1) STMicroelectronics manufactured the LM78M05 general-voltage regulator seized from an extremist group in Bahrain; 2) the item was assembled in China, in November 2013; and 3) the item was sold to different distributors in China, Hong Kong, and Korea.

24 On 18 October 2019, STMicroelectronics responded to a formal trace request issued by CAR on 23 September 2019. This response confirms that: 1) STMicroelectronics did not manufacture the ST voltage regulator L7808CV, subject to CAR's trace request; and 2) the trace code, marking layout and marked assembly country code does not follow that of genuine STMicroelectronics manufacture.

25 Microchip Technology Incorporated acquired Atmel Corporation in April 2016 (Microchip, 2016).

26 CAR issued a formal trace request to Microchip Technology Corporation on 16 August 2019 and a reminder on 20 December 2019. CAR has yet to receive a response to either request.

27 CAR issued a formal trace request to Microchip Technology Corporation on 16 August 2019 and a reminder on 20 December 2019. CAR has yet to receive a response to either request.

28 CAR issued a formal trace request to Microchip Technology Corporation on 29 August 2017 and a reminder on 12 December 2017. CAR has yet to receive a response to either request.

29 CAR issued a formal trace request to Chansin on 8 January 2020 regarding both items. CAR has yet to receive a response.

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ABBREVIATIONS

3W	3W-Modellmotoren Weinhold GmbH
CAR	Conflict Armament Research
IED	improvised explosive device
QC	quality control
RCIED	radio-controlled improvised explosive device
STM	STMicroelectronics
UAE	United Arab Emirates
UAV	unmanned aerial vehicle

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