FRONTLINE PERSPECTIVE

MISSILE COMPONENTS USED IN DRONE ATTACKS IN NORTHEAST SYRIA

December 2022

BACKGROUND

In October 2019, Türkiye[1] launched 'Operation Peace Spring', a military offensive into north-east Syria that was intended to remove the Syrian Democratic Forces from a 30-kilometre-deep 'safe zone' where Türkiye could resettle displaced Syrian refugees.[2] This buffer area would run the length of Türkiye's border with the Kurdish-controlled Autonomous Administration of North and East Syria.[3]

In response to the cross-border intervention, several European governments—including those of Czechia, Finland, France, Germany, Italy, the Netherlands, Norway, Sweden, and the United Kingdom—announced a halt to new export licences for arms sales to Türkiye.[4] Some of these national restrictions were not lifted until 2021. The Turkish military operation ended in late October 2019, with separate ceasefires brokered by the Russian Federation and the United States. Since the ceasefire, Turkish forces have continued to occupy captured territory with the support of the Syrian National Army in the Tal Abyad/Gire Spi and Ras al-Ayn/Sere Kaniye districts of north-east Syria.

Conflict Armament Research (CAR) field investigation teams have deployed to north-east Syria on eight occasions between February 2020 and November 2022.[5] Investigators have documented 698 weapons and 15,360 rounds of ammunition, as well as other related materiel such as uncrewed aerial vehicles (UAVs)—commonly referred to as 'drones'—and components for improvised explosive devices, in the custody of the Syrian Democratic Forces, the military arm of the autonomous governing authority.

Between September 2021 and June 2022, CAR field investigators documented the physical remnants of 17 air-to-surface missile attacks with the cooperation of local security forces. The missile systems were manufactured in Türkiye and likely fired from UAVs (see the section 'Documenting missile strikes in Syria'). CAR's investigations have

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shown that some of the missile components were manufactured abroad and imported for use in Türkiye's defence industry. These include critical components that are commercially available and do not appear to be covered by existing export controls.

This Frontline Perspective provides a technical overview of the missiles themselves, including CAR's identification process and the internal components identified within these systems. It focuses on how electromagnetic brakes, which are used in accurate steering in missile technology, were manufactured by a company based in the European Union (EU) and were subsequently diverted from their stated end use in medical vehicles.

CAR has contacted all governments and companies substantively 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.

KEY FINDINGS

- CAR's investigation of 17 air-to-surface missile strikes in north-east Syria have identified that the missiles involved were all part of the MAM series made in Türkiye, and were likely fired from UAVs. These missiles include key components that were manufactured abroad, including in the EU.
- CAR's tracing operations identified that electromagnetic brakes sold to be used in ambulances in Türkiye were instead incorporated into missiles for use in north-east Syria. The manufacturer confirmed to CAR that, as a result, it decided to no longer do business with the company involved.
- Export control authorities notified CAR that current EU regulations would not apply to these transfers. This includes the 'catch-all' clause, which is restricted only to contexts where the purchasing country is under multilateral embargo.

DOCUMENTING MISSILE STRIKES IN SYRIA

Air-to-surface missile attacks have continued to occur regularly throughout north-east Syria since 2019. The UN Commission of Inquiry has reported that strikes increased in frequency in 2022.[6] These strikes have not been limited solely to the Turkish border area or to the area targeted by the 2019 military operation. In some instances, missiles have impacted up to 50 km into north-east Syria. In addition to the UN Commission of Inquiry, other non-governmental sources have identified several strikes against civilian vehicles and populated areas that resulted in reported civilian casualties.[7]

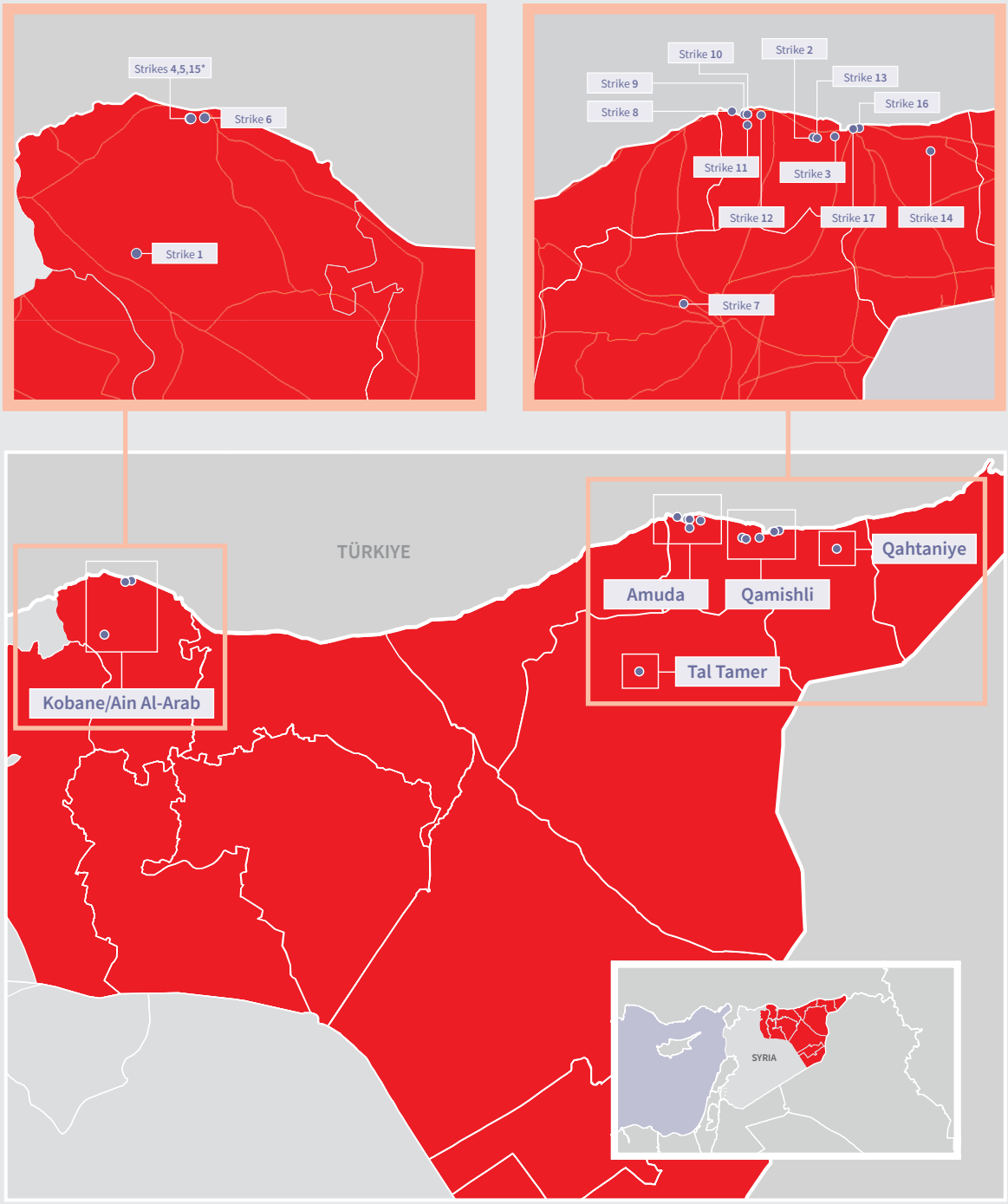
When attacks take place within their area of control, local security forces recover any weapon or missile remnants to conduct investigations into the strikes. In some cases, they have safely recovered fragments from the sites. These fragments include a variety of internal missile components or parts of their external structures. CAR receives notifications from local security forces regarding attacks and cross-references this information with additional sources, including local civilian sources and news media. CAR field teams then independently examine and verify the recovered items from each strike while on deployment in north-east Syria.

CAR examined the wreckage that security forces recovered from 17 different missile strikes, which were carried out between July 2021 and June 2022 (see Map 1 and an example of recovered fragments from a missile strike shown in Figure 1).[8] In most cases, CAR also reviewed photographs of the recovery site, including the destroyed vehicles and impact craters.

In each case, CAR investigators determined that the wreckage was part of the Mini Akıllı Mühimmat (MAM) missile system.[9] MAM air-to-surface missiles can be launched by five Turkish-manufactured UAVs as well as one model of light attack aircraft, also manufactured in Türkiye.[10] Since 2019, Turkish-manufactured aerial platforms capable of deploying the MAM series missile are reported to have been exported to Azerbaijan, Burkina Faso, Djibouti, Ethiopia, Kazakhstan, Kyrgyzstan, Libya (Government of National Accord), Morocco, Niger, Pakistan, Qatar, Saudi Arabia, Somalia, Togo, Tunisia, Turkmenistan, and Ukraine.[11] None of these importing countries are known to operate in the airspace of north-east Syria.

Map 1

Missile strike locations in north-east Syria



*Strikes 4, 5, and 15 share near-identical coordinates but took place on different dates.

(Strike coordinates sourced from information provided by local partners, cross-referenced with news media and local civilian sources.)

Administrative boundaries (c) UNOCHA, accessed September 2022. Road data (c) Center for International Earth Science Information Network (CIESIN) Columbia University, and Information Technology Outreach Services (ITOS) University of Georgia, accessed November 2022.

Figure 1

MAM missile fragments from a 25 December 2021 attack at a CAR documentation site in Kobane/Ain Al-Arab in April 2022.

MISSILE IDENTIFICATION

The MAM is a series of GPS and laser-guided missiles produced by Roketsan Roket Sanayii ve Ticaret A.Ş., an Ankara-based Turkish defence industry manufacturer that designs, develops, and produces rockets and missiles.[12] According to the manufacturer, the MAM is a lightweight munition developed for UAV and light attack aircraft. Roketsan currently produces three types of MAM missile: the MAM-C, the MAM-L, and the newer MAM-T. The MAM-C is the lightest and smallest, with a range of 8 km. The MAM-L is 160 mm in diameter and has a 15 km range. The MAM-T is the largest of the three at 1.4 m in length and 240 mm in diameter. It is designed for long-range strikes of up to 30 km.

The use of MAM missiles has been reported in numerous conflicts since 2016, including in previous operations in areas in northern Syria (Operation Euphrates Shield, Operation Olive Branch, and Operation Peace Spring) and in northern Iraq.[13] This is the first time that CAR has, in any of its global operations, documented MAM missiles.

EXTERNAL FEATURES

Although the number and condition of missile fragments recovered from each strike varied, CAR investigators identified the diameter, fins, wings, bracket types, and screw patterns that are characteristic of the MAM missile (see Figure 2). CAR identified at least one feature for every documented strike. These consistent features enabled CAR to identify the weapon system.

The physical evidence available for documentation following these strikes varied. In four strike sites, local security forces recovered the remains of the main marking plates.[14] The markings on these plates share several consistent features, such as the font type and size, the colour pattern, and the marking sequence.[15] The plates all bear full or partial Turkish marks, reading 'HAVADAN KARAYA LAZER GÜDÜMLÜ MÜHİMMAT' (air-to-surface laser-guided munition), as well as standardised NATO lot numbering format (see Figure 3).[16] In two cases, CAR identified production date markings on the missile fragments indicating that the missiles were manufactured by Roketsan in December 2020 and May 2021.[17]

Several distinctive features of the MAM-L missile support its identification. They include, when recovered together, the combination of rear fins and fixed wings: Roketsan uses a two-bracket, two-screw configuration to attach the four rear fins on the tail section of both the MAM-L (see Figure 2) and the MAM-T.[18] The MAM-L uses a four-screw configuration on each of the four fixed wings, which are located on the middle section of the missile. It also has a larger diameter than the MAM-C.

Based on analysis of available missile fragments, CAR concluded that the MAM-L missile was used in eight of the 17 strikes. In a further eight strikes, CAR isolated the possible missile involved as being either the MAM-L or the MAM-T. Investigators were not able to determine the model of missile used in one of the 17 strikes because no marking plates, fins, or wings were found among the recovered fragments. Nevertheless, in this case, CAR identified that the missile was part of the MAM series based on a cross-analysis of fragments and internal components with the other strike data across north-east Syria. These components are detailed in the following section.

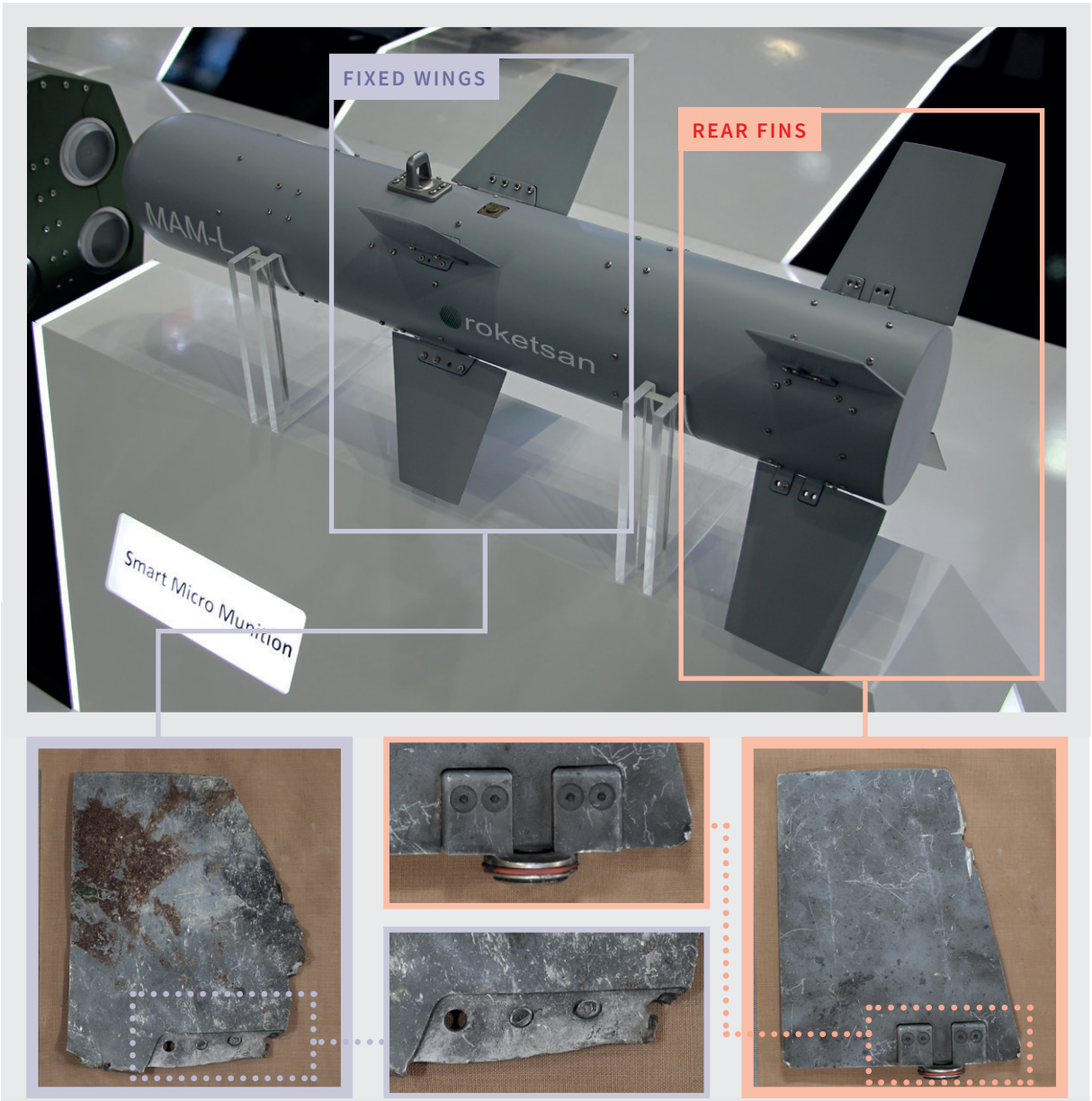


Figure 2

Fragments recovered from a missile strike on 1 April 2022 compared to a complete MAM-L missile. The photograph of the full missile was taken at the IDET International Defence and Security Technologies Fair in Brno, Czechia, in 2017 (source: Wikicommons).

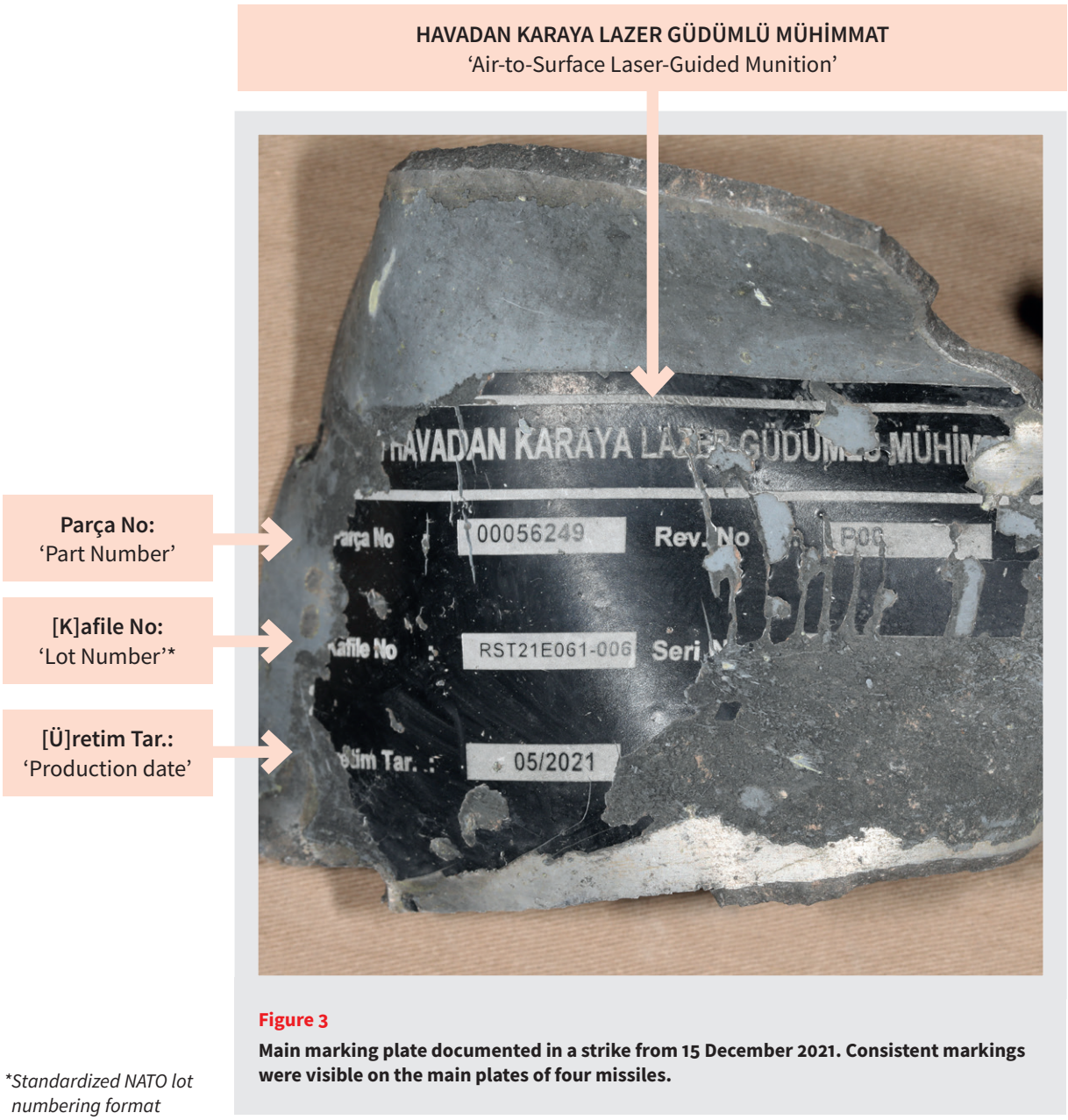


Figure 3

Main marking plate documented in a strike from 15 December 2021. Consistent markings were visible on the main plates of four missiles.

**Standardized NATO lot numbering format*

INTERNAL COMPONENTS

When a guided weapon functions as designed, there is a high probability that associated systems and components will survive the explosive event. This is due to the size and nature of the weapon system and the location and effects of the explosive payload. CAR documented several internal components associated with the missiles from each strike (see Table 1). A thorough analysis of these components indicates that each component type is often sourced from the same manufacturer and consistently used in the manufacture of the missiles. The presence of several of these identical components in the one strike where no key external MAM identifiers were recovered allowed CAR to positively identify them as the remains of a MAM series missile (MAM-L, MAM-T, or MAM-C). Table 1 provides a breakdown of where CAR observed these key components across the 17 missile strike sites. It shows the number of linear actuators, gyroscopes, and printed circuit boards that were identified within the recovered fragments of each strike.

In cases where markings on the components were visible and identifiable, CAR instigated formal tracing processes with the companies in question to understand the supply chains of these items. The following sections examine the components for which CAR has initiated trace investigations. CAR has no evidence that any of the companies whose products were identified in these missiles were involved in any illegality or wrongdoing.

Table 1

Missile components documented by CAR shown by strike site.

Strike Number and date		COMPONENTS					
		LINEAR ACTUATOR		GYROSCOPE	PRINTED CIRCUIT BOARD		
		Electromagnetic Brake	Other actuator components		SSC	Galaxytak	Roketsan
1	30 July 2021	1	2			1	1
2	19 August 2021	3	2	1			1
3	22 August 2021		4			1	1
4	20 October 2021	2	3			1	
5	24 October 2021	1	2				
6	25 December 2021[19]	3	3	1		2	
7	21 January 2022					1	
8	3 February 2022						
9	9 February 2022	2	1				
10	9 February 2022	3	3				
11	9 February 2022[20]	3	3			1	1
12	12 February 2022						
13	24 February 2022		2	1		2	4
14	1 April 2022	3	3	2	1		1
15	11 May 2022	3	1				
16	30 May 2022		1				
17	9 June 2022		3			1	
Total strike locations where each component was observed		**10**	**14**	**4**	**1**	**8**	**6**

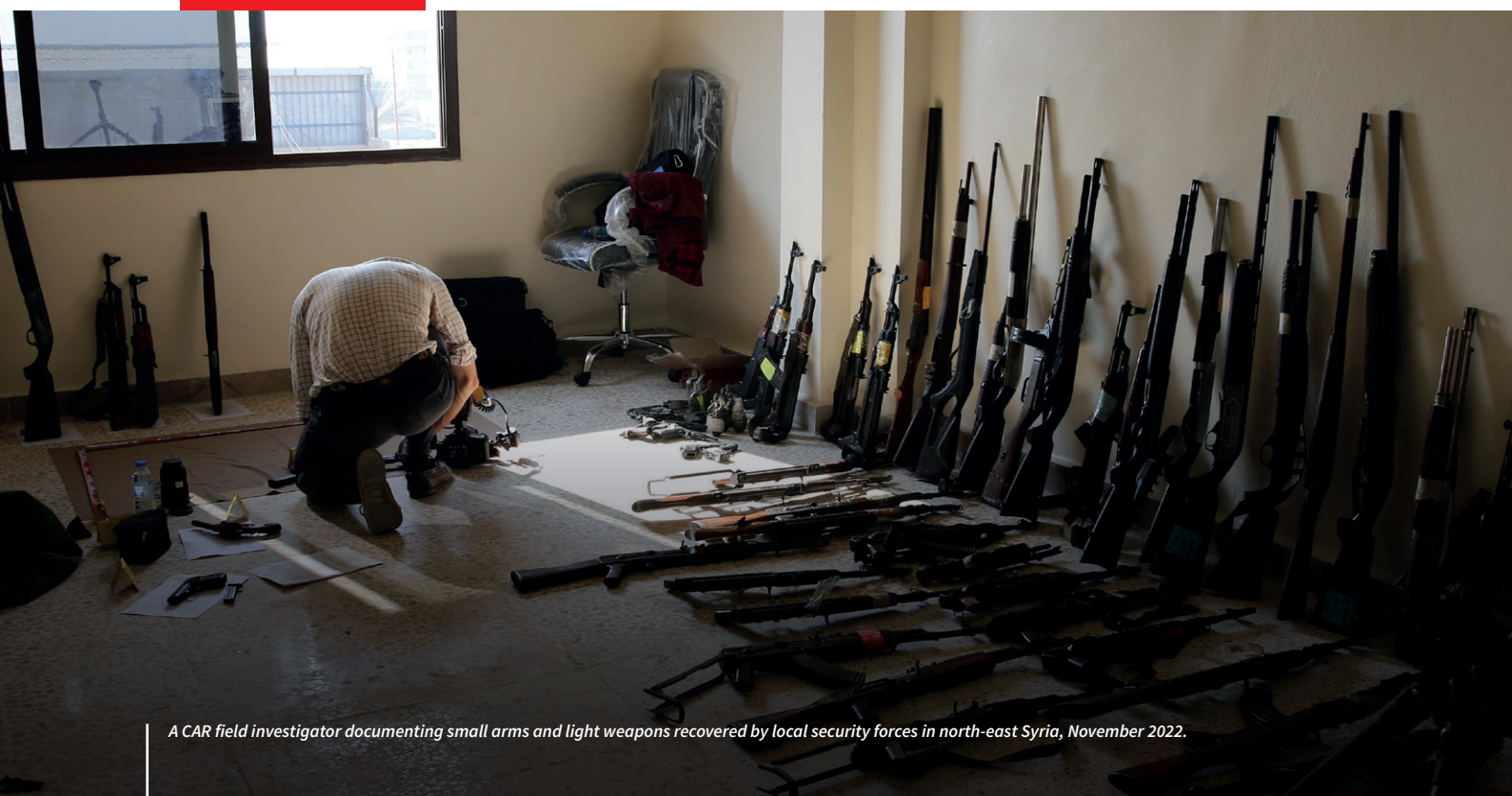
ELECTROMAGNETIC BRAKES

Electromagnetic brakes are incorporated into the linear actuator that controls the missile fins (a diagram of a linear actuator can be found on page 15). CAR documented 24 electromagnetic brakes among the remains of MAM missiles recovered from 10 of the 17 strike sites in north-east Syria. Brakes were not recovered from all the missile remnants, but in several cases CAR documented multiple brakes from the same missile (see Table 2).[21] All these brakes shared consistent characteristics, including labels, markings, and fonts. Most (22) of the documented brakes bore a legible or partially legible logo for Kendrion NV. The remaining two brakes were identical to the aforementioned, but the label was damaged in the explosion, obscuring the Kendrion logo. Kendrion NV is a Netherlands company headquartered in Amsterdam that develops, manufactures, and markets electromagnetic systems and components for industrial and automotive applications. CAR observed two models of brake: primarily model 86 62102S07 (20 items), but also model 86 62102S05 (three items) (Figure 4).[22]

This report focuses on CAR's further investigations into the chains of custody for these brakes, starting on page 12.

Figure 4

An example of Kendrion brake model 86 62102S07, manufactured in November 2020 and documented following a strike on 19 August 2021 (left), and Kendrion brake model 86 62102S05, manufactured in November 2018 and documented following a strike on 24 February 2022 (right). The different logos indicate an evolution in marking practices over time, as confirmed by Kendrion.[23]



A CAR field investigator documenting small arms and light weapons recovered by local security forces in north-east Syria, November 2022.

Table 2
Electromagnetic Kendrion brakes documented in missile fragments in Northeast Syria

STRIKE	DATE	MISSILE	NO. OF BRAKES	MODEL	KENDRION LOGO	MARKINGS
1	30 July 2021	MAM-L	1	86 62102S07	KEN[illegible]	[illegible]41 / 2[illegible] / 94
2	19 August 2021	MAM-L	3	86 62102S07	KENDRION	457955 / 20B / 018
				86 62102S07	[Illegible]	[illegible]955 / 20B / 020
				86 62102S07	KENDR[illegible]	[illegible] / 20B / 128
3	22 August 2021	MAM-L	Internal component could not be identified from recovered fragments			
4	20 October 2021	MAM-L or MAM-T	2	86 62102S07	KENDRION	457936 / 20A / 085
				86 62102S07	KEND[illegible]	[illegible]7910 / 20A / 0[illegible]1
5	24 October 2021	MAM-L	1	Not documented	Illegible markings	
6	25 December 2021	MAM-L	3	86 62102S07	KEN[illegible]ION	457910 / 20A / 174
				86 62102S07	[illegible]DRION	457935 / 20A / 185
				86 62102S07	KEN[illegible]	[illegible]41 / 2[illegible] / 194
7	21 January 2022	MAM-L or MAM-T	Internal component could not be identified from recovered fragments			
8	03 February 2022	MAM-L or MAM-T	Internal component could not be identified from recovered fragments			
9	09 February 2022	MAM-L or MAM-T	2	86 62102S07	[illegible] ENDRION	461815 / 20B / 021
				86 62102S07	K[illegible] ENDRION	46[illegible]36 / 20C / 169
10	09 February 2022	MAM-C/L/T	3	86 62102S07	[illegible] ENDRION	460871/ 20B / 04[illegible]
				86 62102S07	[illegible]RION	461836 / 20C / 136
				86 62102S07	KEN[illegible]	[illegible]029 / [illegible] / [illegible]
11	09 February 2022	MAM-L or MAM-T	3	86 62102S07	KENDRION	469890 / 212 / 047
				86 62102S07	KENDRION	461812 / 20B / 189
				86 62102S07	KENDRION	460867 / 20B / 003
12	12 February 2022	MAM-L or MAM-T	Internal component could not be identified from recovered fragments			
13	24 February 2022	MAM-L	Internal component could not be identified from recovered fragments			
14	01 April 2022	MAM-L	3	86 62102S05	KENDRION	330226 /18B / 99
				86 62102S05	[illegible]ION	329249 / 18B / 287
				86 62102S05	KENDRION	330226 / 18B / [illegible]
15	11 May 2022	MAM-L or MAM-T	3	86 62102S07	KENDRION	460867 / 20B / 148
				86 62102S07	KENDRION	461827 / 20C / 173
				86 62102S07	KENDRION	[illegible]6 / 20C / 173
16	30 May 2022	MAM-L or MAM-T	Internal component could not be identified from recovered fragments			
17	09 June 2022	MAM-L	Internal component could not be identified from recovered fragments			

GYROSCOPES

CAR investigators documented two gyroscopes among the recovered missile fragments from a strike that took place on 1 April 2022 on the M4 highway near Tal Berham village (Figure 5). The two gyroscopes each bore still-legible markings indicating their manufacture by a company called Analog Devices. Gyroscopes are part of the inertial sensor suite used in the missile's guidance and control systems to maintain stability and course on target. Items with similar features were also observed among the fragments from three other strikes (on 19 August 2021, 25 December 2021, and 24 February 2022; see Table 1), but the degree of damage from the explosions on each occasion meant that CAR investigators were not able to document traceable markings.

Analog Devices, Inc., is an American semiconductor company specialising in the design and manufacture of high-performance analogue and digital signal processing integrated circuits used in electronic equipment.[24] The two items were identified as the model ADIS16135, a digital gyroscope sensing system for applications such as platform control, navigation, robotics, and medical instrumentation.

CAR has previously documented items manufactured by Analog Devices in UAVs seized in Yemen and in Lithuania in 2017 and 2021, respectively.[25]

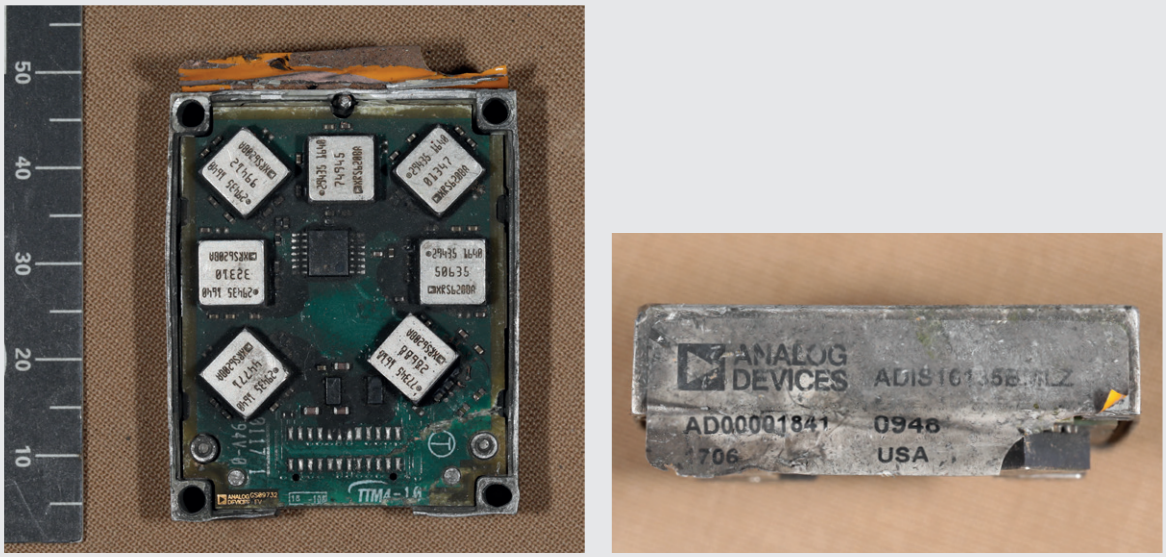
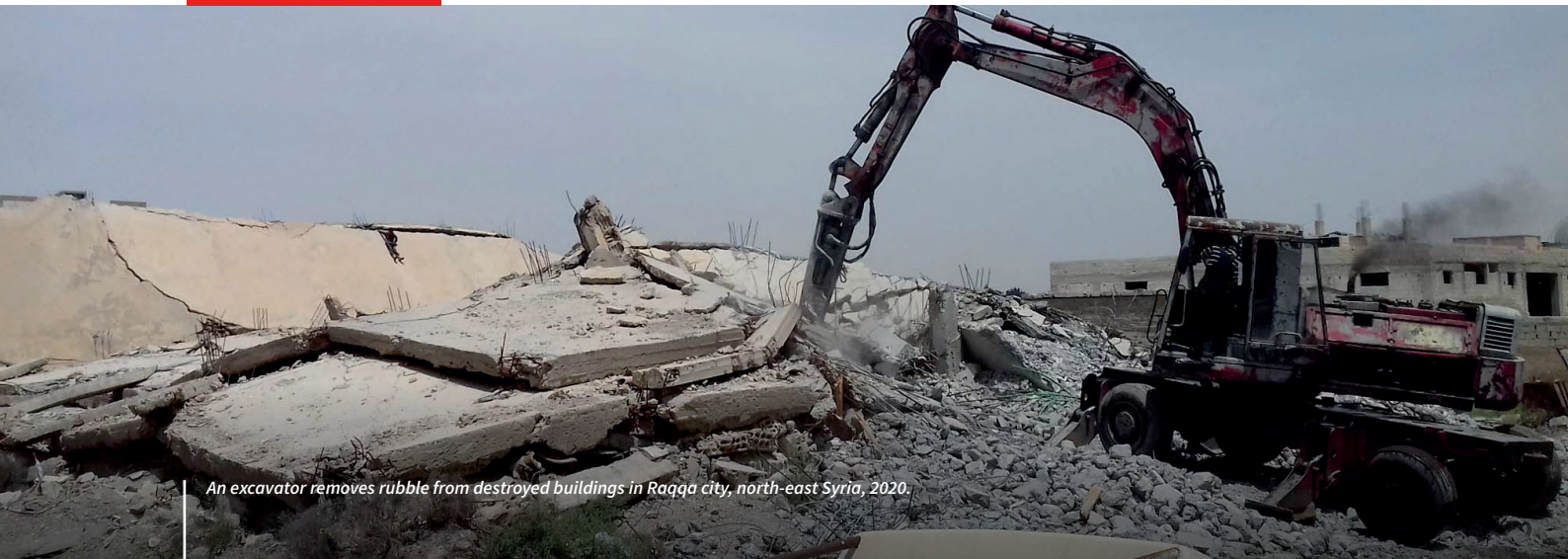


Figure 5

ADIS16135 digital gyroscope, documented in the remains of a 1 April 2022 strike (photographs are of the front and side).



An excavator removes rubble from destroyed buildings in Raqqa city, north-east Syria, 2020.

PRINTED CIRCUIT BOARDS

CAR investigators documented the remains of printed circuit boards among the fragments of the missiles recovered from 10 strike sites. The Roketsan logo with partial or full markings 'PCB-R94703381' was documented on the remains of circuit boards in three different missiles strikes (on 22 August 2021, 24 February 2022 [see Figure 6], and 1 April 2022). Items with similar features and partial markings were observed among the fragments of three additional strikes (on 30 July, 19 August 2021, and 9 February 2022), but the markings themselves were too damaged from the explosion to allow for formal tracing.

Investigators documented 10 printed circuit boards in eight missiles that were marked with the star logo of Galaxytak-pcb Co., Ltd, a Chinese company that specialises in manufacturing high-tech printed circuit boards (see Figure 7).[26] On one occasion, CAR documented an additional printed circuit board that was marked with the logo of a different Chinese company, Shennan Circuits Co., Ltd.[27] Shennan Circuits Co., Ltd., is a state-owned communications circuit board manufacturer based in Shenzhen. While these manufacturers have not to date responded to CAR's formal trace requests for these circuit boards, analysis of corporate registry information shows that both Galaxytak and Shennan Circuits have exported thousands of printed circuit boards to Türkiye in recent years, primarily to companies involved in the Turkish defence industry.

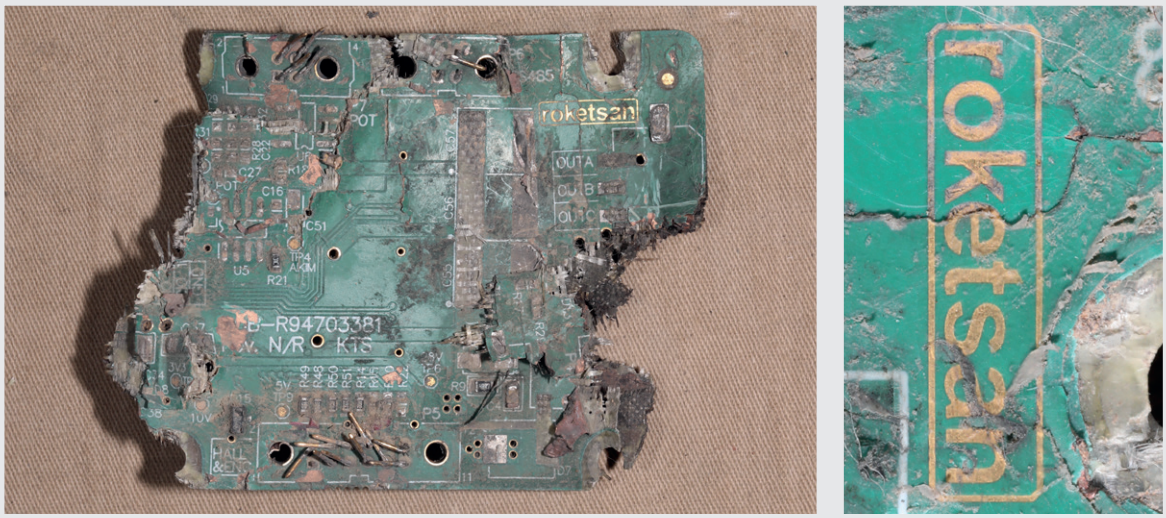


Figure 6

Roketsan logo with partial marking '[illegible]B-R94703381' documented among the remains of a MAM missile (24 February 2022).

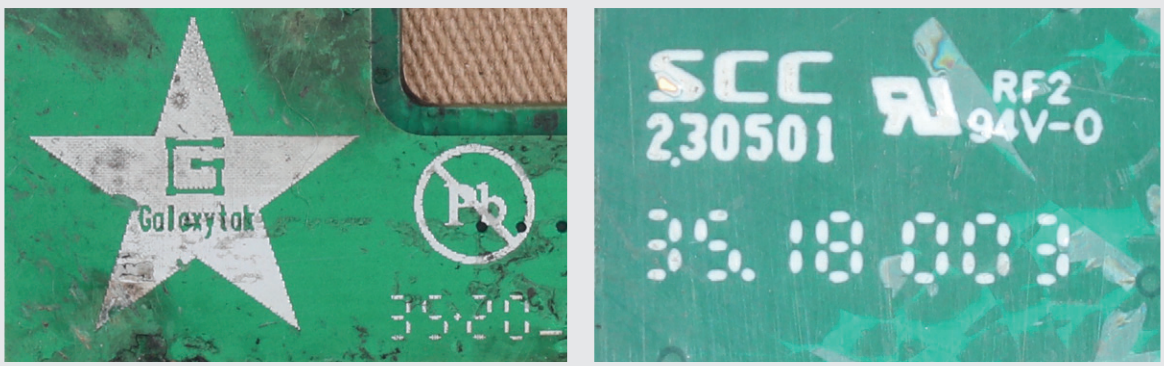


Figure 7

Printed circuit boards manufactured by Chinese companies Galaxytak-pcb Co., Ltd. (left) and Shennan Circuits Co., Ltd. (right) from two different strikes on 24 February and 1 April 2022.

TRACING ELECTROMAGNETIC BRAKES

As described above, CAR documented 24 brakes with partial or fully legible Kendrion markings in 10 of the 17 Turkish MAM series missile strikes. CAR conducted formal tracing efforts with Kendrion between November 2021 and July 2022 to determine the provenance of the brakes.[28] CAR is grateful to the manufacturer of these brakes, the Kendrion Group, for its comprehensive responses to initial trace requests in November 2021 and for providing supporting documentation.

In response to CAR's trace request issued on 5 November 2021, Kendrion confirmed that Kendrion Group in Germany had manufactured a brake with the model number 86 62102S07 and production code 457955/20B/018 in November 2020 (see Figure 8). Kendrion informed CAR that it had delivered the brake to FEMSAN Elektrik Motorlari Sanayi ve Ticaret A.Ş., based in Istanbul, Türkiye. FEMSAN subsidiary MOPA Endüstriyel Ürünler Pazarlama A.Ş. is listed as one of three sales partners for Kendrion industrial actuators and controls in Türkiye according to its website.[29] Kendrion informed CAR that it used a third-party sanctions monitoring database and that, at the time of this transfer, FEMSAN was not listed on any UN, EU, US, or UK sanctions lists. Security forces in north-east Syria recovered the brake from a MAM-L missile used in an attack on 19 August 2021 in which a Syrian Democratic Forces commander was reportedly killed.

In its response to CAR in November 2021, Kendrion outlined the steps the company had taken to confirm the end-use application for these brakes with FEMSAN. In February 2018, representatives of the UK branch of the company, Kendrion Limited (UK), met a senior representative of FEMSAN regarding the supply of 20,000 to 25,000 brakes over a five-year period from 2018 to 2023. FEMSAN confirmed to Kendrion representatives that the brakes would be used on blood analysing machines fitted to ambulances across Türkiye. In May 2018, FEMSAN provided Kendrion with an overview of the range of applications in which the brake could be used.[30] On 9 November 2020, in response to a question from Kendrion regarding the application in which the brake was being used, FEMSAN confirmed that there had been no changes in the application of the brake model 86 62102S07.[31]

Kendrion's internal records indicated that the company had previously delivered 261 model 86 62102S07 brakes to FEMSAN in 2016 and another 400 in 2017. Within the 2018–23 agreement with FEMSAN, Kendrion informed CAR that it had delivered a total of 4,948 brakes with model number 86 62102S07 in 2020 and an additional 820 by the time of the first correspondence with CAR on 5 November 2021. After receiving, in November 2021, information from CAR's field investigations about the presence of its products in missiles used in north-east Syria, Kendrion temporarily suspended the scheduled delivery of further items and requested that FEMSAN sign an end-user compliance statement. (See Figure 9 for a timeline of Kendrion's interactions with FEMSAN and CAR.)

Figure 8

Kendrion brake model 86 62102S07 documented on 27 September 2021 with production code 457955/20B/018.

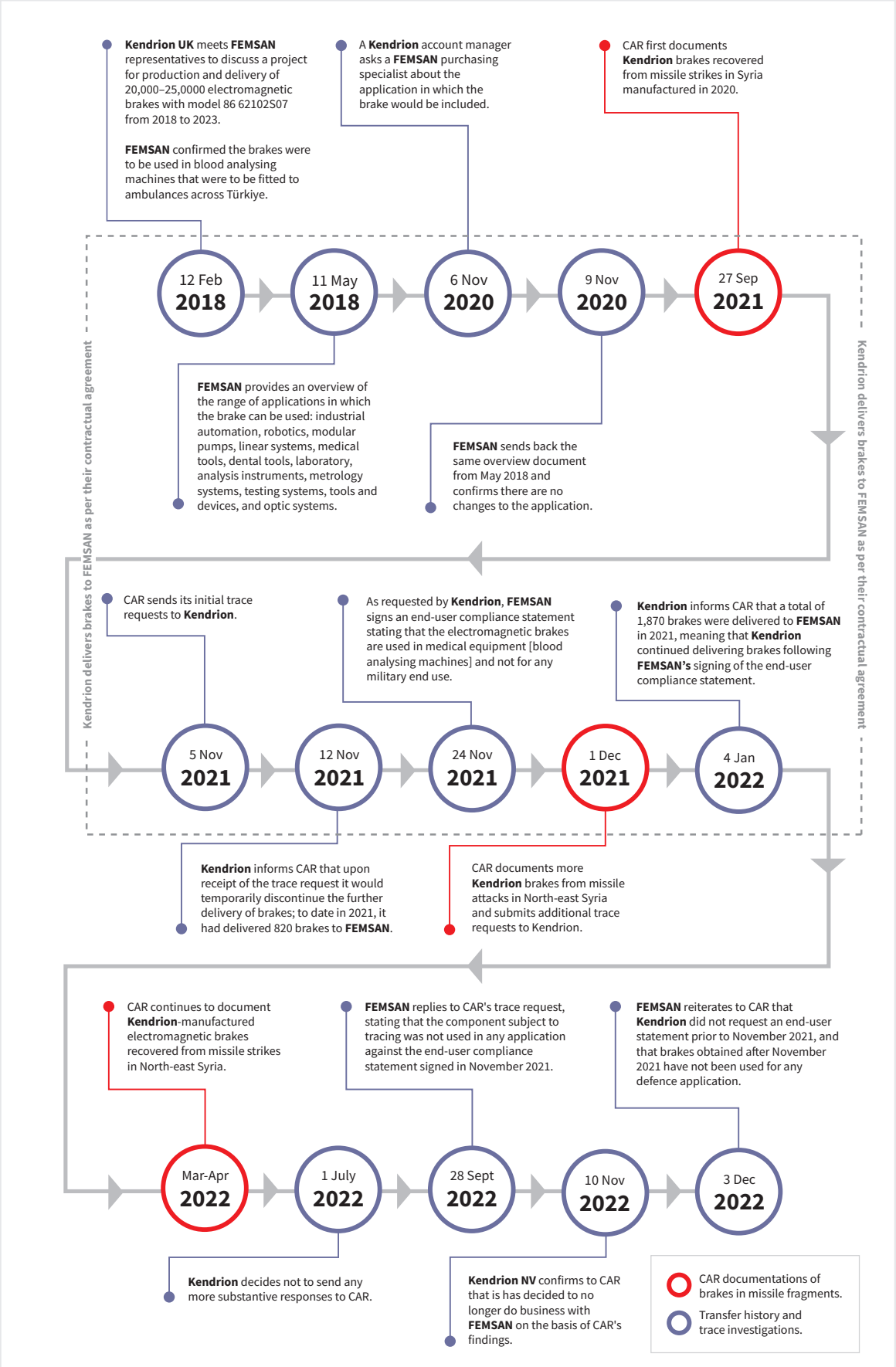


Figure 9

Key events in the transfer and documentation of electromagnetic brakes.

On 24 November 2021, FEMSAN signed the end-user compliance statement with Kendrion (Villingen) GmbH, the German-based manufacturer. Kendrion then provided a copy of this document to CAR. The end-user statement requires FEMSAN to confirm that:

> *[…]*
>
> *4. The items described in Section B [Brake with model number 86 62102S07] supplied or serviced, by Kendrion to FEMSAN ELECTRIK MOTORLARI SANAYI VE TICARET A.Ş.:*
>
> *a. shall only be used for the purposes described in section B [End-Use Medical application – blood analysing machines] and that the items are intended for final use in the country named in Section A4 [Turkey];*
>
> *b. shall only be used for civil, public or commercial end-use;*
>
> *c. shall not be used in any military activity or for military end-use;*
>
> *[…]*
>
> e. *shall not be used for any purpose connected with any illicit purposes, such as, but not limited to, human rights violations*
>
> *[…]*
>
> *6. This End-User Statement shall be governed by and construed in accordance with the laws of Germany.*
>
> *[…]*

Following FEMSAN's signature of the end-user compliance statement, Kendrion delivered another shipment of 1,050 brakes prior to the end of 2021.[32]

On 4 January 2022, Kendrion replied to CAR's trace request for a brake documented from the wreckage of a missile strike that reportedly took place in Kobane town on 20 October 2021. The brake was marked with the code 457936/20A/085. Kendrion's response indicated that 207 brakes with model number 86 62102S07 and production code 457936/20A/85 were manufactured in October 2020 by the Kendrion Group production location in Villingen-Schwenningen, Germany (see Figure 10 on the next page).

Of these, Kendrion delivered 95 to FEMSAN Elektrik Motorlari Sanayi ve Ticaret A.Ş. in November 2020 and another 112 to Partsmax LLC, a company based in Milford, Connecticut, USA, in December 2020, for use in CNC machinery.[33] Tracing is under way with Partsmax.

ON 10 NOVEMBER 2022, KENDRION NV CONFIRMED TO CAR THAT IT HAD DECIDED TO NO LONGER DO BUSINESS WITH FEMSAN ON THE BASIS OF CAR'S FINDINGS.

Figure 10

Kendrion electromagnetic brake model 86 62102S07 with production code 457936/20A/85 manufactured in October 2020 in Germany.

APPARENT DIVERSION OF END USE

In 2014, FEMSAN was commissioned to develop a range of slotless brushless DC (BLDC) motors in a contract signed between the Presidency of Defence Industries (SSB)[34] and Roketsan.[35] Slotless BLDC motors are valued in the aerospace industry owing to their low weight, small diameter, and high-speed application. Under the supervision of both SSB and Roketsan, FEMSAN completed the studies in 2016, and the products were certified for defence and aerospace in 2017.[36]

The motors are used in fin control actuation systems, which typically consist of four actuators to control the position of the missile fins in response to steering commands from the flight computer.[37] An electromagnetic brake forms one of the six integral sections of FEMSAN's actuators and connects to the slotless BLDC motor (see Figure 11).[38]

CAR has documented nuts, ball screws, and cylinders sharing identical characteristics to those found in FEMSAN's linear actuator among the fragments of 14 strikes (see Table 1). To date, all the electromagnetic brakes that CAR has documented among recovered MAM missile fragments in north-east Syria are consistent with Kendrion-manufactured items.

On 28 September 2022, FEMSAN responded to CAR's trace request. FEMSAN confirmed that it had imported brakes with the production codes referenced by CAR from Kendrion, but could not confirm which customer received the identified items. FEMSAN noted that its customer list contains Turkish defence companies but stated that it did not use the components in question in any application that would be considered contrary to the end-

user compliance statement agreed with Kendrion. FEMSAN reiterated it has been working with Kendrion since 2017 and was first required to sign an end-user compliance statement in November 2021, and it was possible that the items in question were incorporated into a FEMSAN-produced item that was then sold to a Turkish defence company.[39]

CAR's recurrent observation of these brakes among missile fragments in north-east Syria shows that the ultimate end use of at least some of the Kendrion-marked electromagnetic brakes was in the development of military products. Given FEMSAN's repeated confirmation to Kendrion between 2018 and 2020 that its products would be used only in civilian goods—specifically in ambulances—the subsequent presence of these brakes among missile fragments documented by CAR suggests that the stated end use had been changed without the knowledge of the exporter.[40]

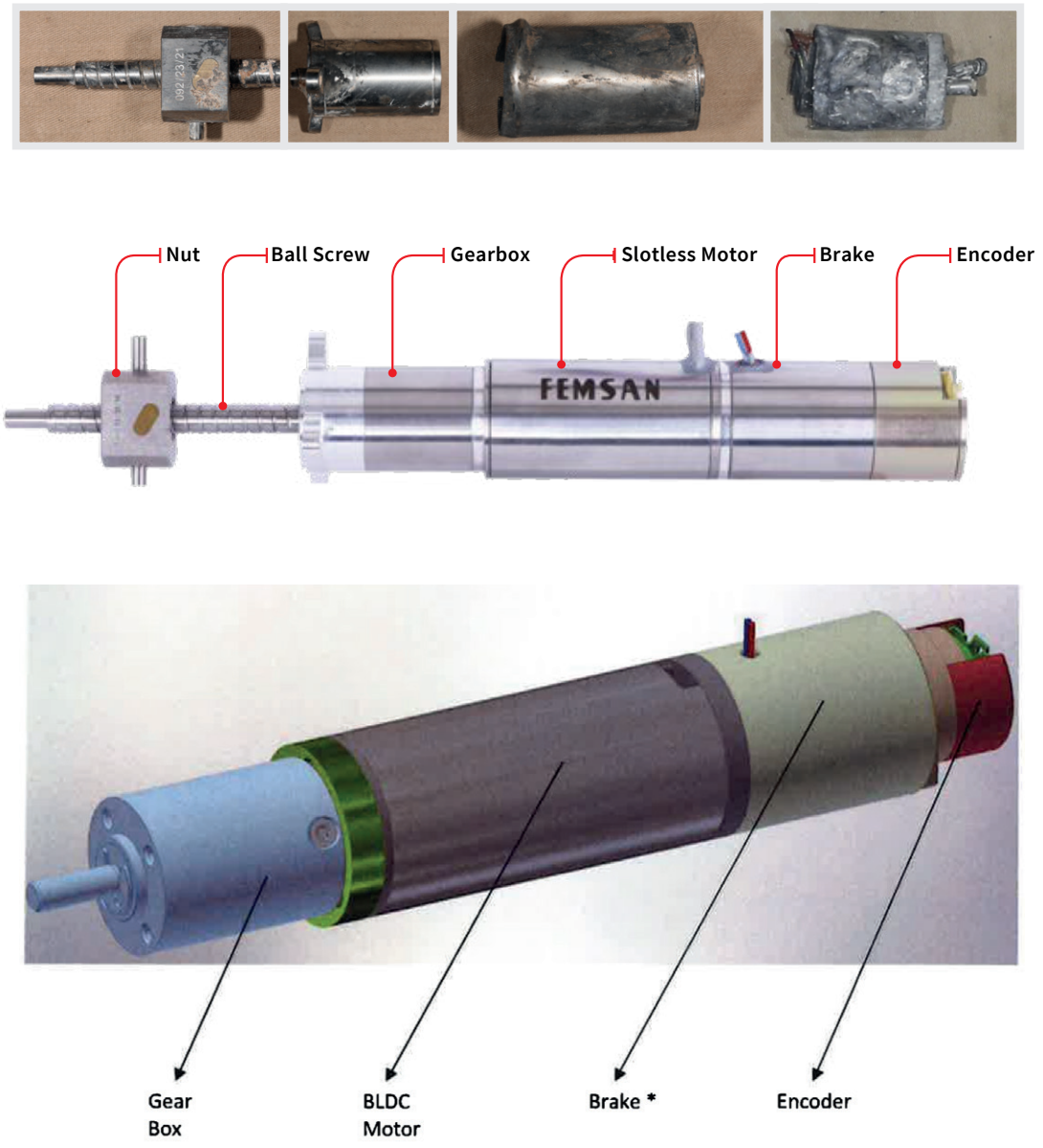


Figure 11

Kendrion brake with production code 461836/20C/136, identified among items recovered from a strike on 9 February 2022 (above), compared to a fin linear actuator advertised by FEMSAN (middle) and overview of application fields provided by FEMSAN to Kendrion (bottom).

GAPS IN DUAL-USE CONTROLS

The Netherlands, where Kendrion is headquartered, is one of several EU countries that introduced restrictive national export controls in relation to Türkiye's military operation in 2019. On 11 October 2019, the Netherlands stated that all new licence applications for the export of military goods with Türkiye as the final destination would be put on hold and that this applied both to military goods and 'dual-use goods with a military end use'.[41] In October 2021, the Netherlands relaxed these control measures but stated that 'a license will only be issued if the applicant can incontrovertibly demonstrate that the goods will not be used in northeastern Syria'.[42]

However, the Netherlands Ministry of Foreign Affairs, Export Control of Strategic Goods, notified CAR that it considered the electromagnetic brakes exported to FEMSAN not to require export authorisation under EU Regulation 2021/821. This regulation establishes the control regime for the export of dual-use commodities, regardless of whether they are being used in a restricted area like north-east Syria.[43] Regulation 2021/821 sets out two broad criteria by which dual-use items are controlled: being listed in an annex of goods that meet specific technical parameters, and falling under a 'catch-all' clause that seeks to capture any item that falls short of the technical criteria but that may still be intended for specific military end uses. Article 4 (1), which outlines these uses, states that goods would require export authorisations if the exporter has been informed by the competent authority that the items in question are, or may be intended for, use relating to:

- the development of chemical, biological, or nuclear weapons;
- military end use 'if the purchasing country or country of destination is subject to an arms embargo'; or
- use as parts or components of military items, where the items have already been 'exported from the territory of a Member State without authorisation or in violation of an authorisation'.[44]

Export control authorities in the Netherlands informed CAR that they did not consider these brakes to have met the technical criteria for controls under the regulation's annex, despite updates to the dual-use commodity list in 2021. Kendrion also stated to CAR that it understands that this model of brake does not qualify for export regulations as a controlled good.

A representative of the Netherlands Ministry of Foreign Affairs further informed CAR that the catch-all clause could not apply to these transfers, because the incorporation of the brakes into military items took place in Türkiye, where there is no arms embargo in place. In addition, FEMSAN is not listed on any of the existing US, UK, EU, or UN sanctions monitoring lists.[45] Paragraph b(ii) of Article 4 of EU Regulation 2021/821 only relates to items that may be intended for military end use when the destination or purchasing country itself is subject to an arms embargo. The regulation further specifies that this relates solely to multilateral embargoes decided by the EU, the Organization for Security and Co-operation in Europe, or the UN, as opposed to unilateral national measures (Article 2 (19)). While the EU has had an arms embargo related to Syria itself since 2011, Türkiye has never been subject to sanctions at the multilateral level. The phrasing of Article 4 (b)(ii) therefore establishes a narrow applicability of relevant controls for the transfer of dual-use items by emphasising the location of the end user rather than the context of the end use.

CAR WAS INFORMED THAT THE CATCH-ALL CLAUSE COULD NOT APPLY TO THESE TRANSFERS.

A view of the mountains towards the Turkish border from Jazira, north-east Syria, 2021.

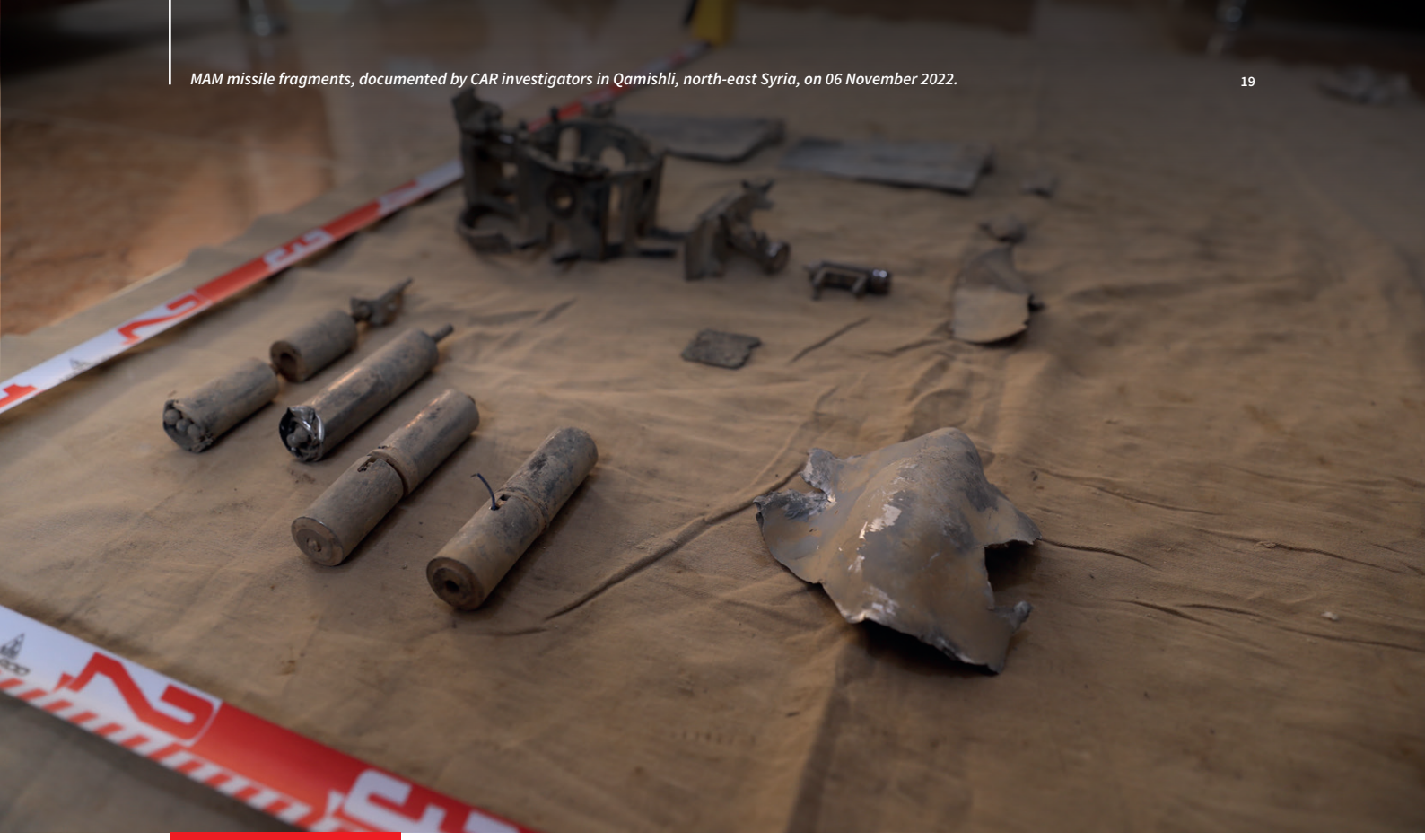
CONCLUSION

Missile components documented by CAR's investigators in north-east Syria show how commercial products manufactured in the EU have been diverted for use in missile production. According to information provided to CAR by the commercial exporter, electromagnetic brakes documented at 10 of the 17 missile strike sites in north-east Syria had ostensibly been sold for use in ambulances in Türkiye. The end user repeatedly stated the brakes' intended medical use in verbal and written form between 2018 and 2020. However, as CAR's findings demonstrate, the brakes were subsequently incorporated into missiles and used for military purposes in north-east Syria.

These findings have implications for understanding and responding to diversion. Diversion, in the context of transfers of conventional weapons, is typically understood to occur when unauthorised parties (that is, parties other than the intended end users) gain custody of (usually complete) weapon systems. When it comes to the acquisition of components that have potentially unforeseen applications in civilian and military manufacturing, diversion can be understood in relation to not only the end user but also the final end use. In the case presented in this Frontline Perspective, while the end user clearly had the permission of the supplier to receive the electromagnetic brakes, the ultimate end use to which the end user put those components occurred without the knowledge or consent of the original exporter.

This case, therefore, highlights both the critical importance and the relative complexity of commercial due diligence for material of these types. By its very nature, such equipment may serve multiple purposes, some of which the manufacturer may not even be aware, and which may be extremely sensitive. Compared with the

Part of a linear actuator within the remains of a MAM missile, documented by CAR investigators in Qamishli, north-east Syria, 28 March 2022.



MAM missile fragments, documented by CAR investigators in Qamishli, north-east Syria, on 06 November 2022.

transfer of conventional weapons and ammunition, anticipating the possible end uses of multipurpose commercial products is a more complex, but no less essential, control measure to prevent possible diversion.

The complexity of such technology also poses a challenge for effective transfer controls. Sophisticated military equipment, such as guided weapon systems or UAVs, may include key technology that falls outside the scope of conventional control regimes. Increasingly, CAR's investigators encounter this technology in conflict zones, where it has been incorporated into lethal weapon systems.[46] Although officials periodically review and update dual-use control lists, these lists may struggle to keep abreast of shifting developments in weapon design and production. While one possible response to this case could be to change the technical criteria of the EU's control list to include these specific electromagnetic brakes, such measures may not always be practical or possible nor would they necessarily ensure that the underlying factors behind diversion are addressed. In such instances, it is important that 'catch-all' clauses effectively capacitate national authorities to act when items have been diverted to military end uses. However, in this case the current framework did not apply, in the view of the relevant national authority, because its controls are restricted only to contexts where the purchasing country is under multilateral embargo.

THIS CASE HIGHLIGHTS BOTH THE CRITICAL IMPORTANCE AND THE RELATIVE COMPLEXITY OF COMMERCIAL DUE DILIGENCE FOR MATERIAL OF THESE TYPES.

Finally, this case demonstrates the critical importance of end-use monitoring. As stated earlier, it can be challenging for licensing officials to accurately assess the risks related to the wide variety of dual-use goods, especially those that may fall outside of technical control lists but that are still vulnerable to incorporation into weapon systems. By identifying purchasers and circumstances through which commercial products are put to military purposes, companies and governments could inform effective early warning systems to identify or flag high-risk sales. Field investigations by organisations such as CAR provide exporters and licensing officials with near-live information, which can be used to inform the development of appropriate controls and prevent further end-use diversion.

ABBREVIATIONS

BLDC	brushless direct current
CAR	Conflict Armament Research
EU	European Union
MAM	Mini Akıllı Mühimmat (smart micro munition)
SSB	Presidency of Defence Industries
UAV	uncrewed aerial vehicle

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ENDNOTES

1 On 1 June 2022, the Turkish foreign minister submitted an official letter to the UN, requesting the country name be changed to Türkiye. The change was adopted on 3 June 2022.

2 International Crisis Group (2019).

3 The Autonomous Administration of North and East Syria has been the de facto governing authority for the regions of Afrin, Deir Ez-Zor, Euphrates, and Jazira since 2012. See Mehchy, Haid and Khatib (2020).

4 Emmott (2019); Nûçeyan (2019).

5 CAR had previously conducted field operations in north-east Syria in 2014 and 2015. CAR's previous publications including research from north-east Syria are *Islamic State Weapons in Iraq and Syria* (2014), *Islamic State Ammunition in Iraq and Syria* (2014), *Islamic State Weapons in Kobane* (2015), *Tracing the Supply of Components Used in Islamic State IEDs* (2016), and *Weapons of the Islamic State* (2017).

6 The UN Independent International Commission of Inquiry on the Syrian Arab Republic has reported an increase in drone strikes suspected to have been carried out by Türkiye: 'Analysis of photos of the remnants of the weapon used indicate that a Turkish manufactured air-to-surface MAM-L missile fired from a Turkish drone caused the injuries and damage. This type of attack is in line with the Commission's findings that drone attacks by Türkiye are on the increase in the north-east of the Syrian Arab Republic controlled by the Syrian Democratic Forces.' See UNHRC (2022).

7 See, for example, Airwars (2022) and Rojava Information Center (2022). The full list of reported missile strikes is on file with CAR (CAR, 2022).

8 CAR directly documented the fragments from the 17 strikes; however, this is not an exhaustive list of all reported attacks in the region.

9 Although the MAM-series are precision-guided munitions, this report uses the term 'missile' throughout, also used by the manufacturer in promotional material.

10 These Turkish-manufactured UAVs are the Bayraktar Akıncı, Bayraktar TB2, TAI Aksungur, TAI Anka, and Vestel Karayel, and the light attack aircraft is the TAI Hürkuş. See Baykartech (n.d.a, n.d.b); Giovanzanti (2021); MSI Defence Review (2019); Savunma TR (2021); Türk Havacilik Uzay Sanayii (n.d.).

11 See Daily Sabah (2022); Farooq (2022); Lake (2022); RFI (2022a); RFI (2022b).

12 Roketsan (n.d.).

13 First noted by Triebert (2015).

14 Each missile would have one main marking plate.

15 Internal Security Forces provided CAR with a photograph of the main markings on a fragment of the missile that was recovered from a strike on 30 July 2021. CAR investigators were unable to physically document the markings, as the fragment had been handed into the custody of coalition forces following the incident.

16 The NATO standardised lot numbering format includes a code for the manufacturer, year, and month of manufacture, as well as the lot interfix, identifier, and sequence code. MIL-STD-1168A (Ammunition Lot Numbering— Revision A) [Published 28 February 1975; 1975–1998].

17 The MAM-T was first officially tested in April 2021. On 18 August 2022, CAR submitted a trace request to Roketsan regarding these items. Given the absence of a response to this request to date, CAR cannot assess the legality of the transfer(s) in question.

18 Both missiles share similar rear wings, making the distinction between the two models challenging when documentation is limited to the tail section.

19 On one occasion, there were multiple strikes within a close target radius on the same day (strikes 9, 10, and 11). Additional fragments were recovered within a 2 km radius by security forces during a secondary sweep of strike sites 9, 10, and 11 the same day. CAR was unable to ascertain to which of the three strike sites those fragments belong.

20 Linear actuators consist of six parts: nut, ball screw, gearbox, slotless motor, brake, and encoder. This is detailed on page 15. CAR investigators did not document all six parts of an actuator among the fragments recovered at each strike location but recorded where these parts were present. The quantities in this column refer to the minimum number of different linear actuators CAR believes were present at a strike site after identifying components other than brakes (i.e., gearbox, motor, nut, and ball screw).

21 A full control actuation system typically has four brakes. These lock out the fins to keep them stable during flight and enable movement when the system is ready to fire or has been fired.

22 In one case (Strike 5, which took place on 24 October 2021), CAR investigators were not able to confirm the model of the documented brake.

23 On 4 January 2021, Kendrion NV responded to a formal trace request issued by CAR on 10 December 2021. The response confirmed that the reference 20A in the production code 45736/20A/85 referred to the month and the year in which the item has been manufactured and explained that 20A=October 2020 and 20B=November 2020. As such 18B=November 2018.

24 Analog Devices (n.d.).

25 CAR (2021, p. 201). CAR is yet to receive a response to trace requests issued for these items. Given the absence of a trace response, CAR cannot assess the legality of the transfer(s) in question.

26 Strikes 1, 3, 4, 6, 7, 11, 13, and 17. CAR initially sent official trace requests for two of these items. On 1 November 2021, and 5 November 2021, CAR submitted trace requests to Galaxytak for two of these items. Given the absence of a response to these requests to date, CAR cannot assess the legality of the transfer(s) in question. For information on GalaxyTak, see http://www.galaxytak-pcb.com.

27 Strike 14. On 4 May 2022, CAR submitted a trace request to Shennan Circuits Co. Given the absence of a response to this request to date, CAR cannot assess the legality of the transfer(s) in question. For information on Shennan Circuits Co., see http://www.scc.com.cn/Content/en/gysn_en/index.html.

28 CAR sent traces for 16 of the documented items; items were only traced once if the lot or batch was the same on more than one item. CAR did not send formal trace requests for items with illegible markings.

29 Kendrion (n.d.); Mogeser (n.d.).

30 The range of applications was stated as follows: industrial automation, robotics, modular pumps, linear systems, medical tools, dental tools, laboratory, analysis instruments, metrology systems, testing systems, tools and devices, and optic systems.

31 On 12 November 2021, Kendrion NV responded to a formal trace request issued by CAR on 5 November 2021. This response confirms that: 1) Kendrion Group manufactured the 86 62102S07 model brake bearing the production code '457955/20B/018', the subject of CAR's trace request, at its Villingen-Schwenningen factory (Wilhelm-Binder-Straße 4-6, 78048 Villingen-Schwenningen, Germany); 2) the '8662102S07' brake model does not qualify as a dual-use good under the Customs Union of the European Commission; 3) in February 2018, Kendrion Limited (UK) held a meeting with the General Manager of FEMSAN Elektrik Motorları A.Ş. to discuss the delivery of 20,000 to 25,000 brakes between 2018 and 2023; 4) FEMSAN Elektrik Motorları A.Ş. confirmed to Kendrion Group that the brakes would be used on blood analysing machines fitted to ambulances across Turkey; 5) FEMSAN Elektrik Motorları A.Ş. confirmed that there were no changes in the application fields of the brake model '86 62102S07' in May 2018 and again in November 2020; 6) after checking that FEMSAN Elektrik Motorları A.Ş. was not listed on any of the existing EU, UK, UN, or US sanction monitoring lists in Format Software Service GmbH's Software Sanctions Monitor, Kendrion Group signed a supply commitment agreement with FEMSAN Elektrik Motorları A.Ş. for the period 2018 to 2023; 7) Kendrion Group delivered 4,948 '86 62102S07' model brakes to with FEMSAN Elektrik Motorları A.Ş. (Istanbul, Turkey) in 2020 (Kendrion Limited (UK) delivered 50

units, Kendrion GmbH (Germany) delivered 4,898 units); 8) in 2021, Kendrion GmbH delivered 1,870 brakes to FEMSAN Elektrik Motorları A.Ş.; 9) following receipt of CAR's trace request, Kendrion Group asked FEMSAN Elektrik Motorları A.Ş. to sign an end-user statement to confirm the intended use of the brakes in blood analysing machines. On 24 November 2021, the requested document was signed and returned to Kendrion Group; and 10) Kendrion Group included a copy of the end-user statement in its response to CAR.

32 On 10 November 2022, Kendrion N.V. responded to an advance notification issued by CAR on 4 November 2022. This response confirms that: 1) based on CAR's findings and assuming the accuracy thereof, the ultimate end use of these brakes was changed without Kendrion N.V.'s knowledge and deviated from Femsan's repeated end use application; and 2) although Kendrion cannot conclude or confirm that Femsan itself used Kendrion brakes in applications that contradicted Femsan's repeated end use application, Kendrion N.V. decided not to pursue any further business with Femsan.

33 On 4 January 2022, Kendrion NV responded to a formal trace request issued by CAR on 10 December 2021. This response confirms that: 1) Kendrion Group manufactured the 86 62102S07 model brake bearing the production code '457936/20A/085', the subject of CAR's trace request, at the Villingen-Schwenningen factory (Wilhelm-Binder-Straße 4-6, 78048 Villingen-Schwenningen, Germany), in October 2020 (as evidenced by the code '20A', denoting the year and month of manufacture); 2) the '085' part of the production code signifies the product number within the batch; 3) the '86 62102S07' brake model does not qualify as a dual-use good under the Customs Union of the European Commission; 4) Kendrion Group delivered 95 '86 62102S07' model brakes bearing the production code '457936/20A' to FEMSAN Elektrik Motorları A.Ş., Istanbul, Turkey on 5 November 2020, for use in blood analysing machines fitted to ambulances across Turkey, and 112 '86 62102S07' model brakes bearing the production code '457936/20A to Partsmax LLC (formerly New Jersey Components LLC), Milford, United States for use in CNC machinery, on 18 December 2020; 5) Kendrion Limited (UK) delivered 50 units of '86 62102S07' model brakes to FEMSAN Elektrik Motorları A.Ş. (Istanbul, Turkey) and Kendrion GmbH (Germany) delivered 4,898 units to FEMSAN Elektrik Motorları A.Ş. (Istanbul, Turkey), a total of 4,948 units in 2020; 6) in 2021, Kendrion GmbH (Germany) delivered 1,870 units to FEMSAN Elektrik Motorları A.Ş. (Istanbul, Turkey); 7) Kendrion Group delivered a total of 500 86 62102S07 model brakes to Partsmax LLC in 2020 and 2,000 in 2021; 8) prior to delivery, Kendrion Group checked that neither company was listed on any of the existing EU, UK, UN, or US sanction monitoring lists in Format Software Service GmbH's Software Sanctions Monitor; 9) following receipt of a previous trace request issued by CAR in November 2021, Kendrion Group requested that FEMSAN Elektrik Motorları A.Ş. sign an end-user statement to confirm the intended use of the brakes in blood analysing machines. On 24 November 2021, the requested document was signed and returned to Kendrion Group; 10) Kendrion Group included a copy of the end-user statement in its response to CAR; and 11) for any future business dealings with Partsmax LLC, Kendrion Group will request a signed end-user statement.

34 On 14 December 2020, the United States imposed sanctions on SSB and four senior representatives for attempting to procure a surface-to-air missile system from the Russian Federation. US Department of State (2020).

35 *MSI Turkish Defence Review* (2018, p. 62).

36 *MSI Turkish Defence Review* (2018, p. 63).

37 *Defence Turkey* (2019, p. 38).

38 In a marketing catalogue issued by FEMSAN's Defence Division that profiles electric motors, Kendrion is listed as one of its associated industrial products in the Groups Companies section. The Kendrion logo is visible on page 18 of FEMSAN (2019).

39 On 28 September 2022, Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. responded to a formal trace request issued by CAR on 18 August 2022. This response confirms that: 1) in late 2020, Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. imported the 86 62102S07 model brake bearing the production code '457955/20B/018', the subject of CAR's trace request, from Kendrion; 2) Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. does not record its sales by the '457936/20A/085' code and therefore cannot confirm which customer received the item subject to CAR's trace request; 3) Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş.'s customer list contains Turkish defence companies; 4) Femsan Elektrik Motorlari Sanayi ve

Ticaret A.Ş. prefers to manufacture its own brakes for use in defence applications, as it is a simple item to design and produce, and it negates the need for signing an end-user compliance statement; 5) Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. did not use the item, subject to CAR's trace request, in any application that would be considered against the end-user compliance statement agreed with Kendrion, however it is possible that the item was incorporated into a Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş-produced item, that was then sold to a Turkish defence company; 6) if any suppliers used by Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. requested detailed information about the intended use of the items purchased, Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. would have clearly responded to their questions; 7) Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. does not sell raw components that are not incorporated in Femsan-manufactured applications; and 8) Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. has been working with Kendrion since 2017 and was first required to sign an end-user compliance statement in November 2021.

In addition, Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. provided the following supplementary information: a) its customers have never requested a specific branded product and only provide the specifications for the item in general; b) there are no additional marks (other than the '457936/20A/085' production code) that would enable Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. to trace the chain of supply of the item subject to CAR's trace request; and c) for the companies that request Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. to sign an end-user compliance statement, Femsan Elektrik Motorlari Sanayi ve Ticaret A.Ş. strictly adheres to the end use specified in the compliance statement.

40 On 3 December, FEMSAN reiterated to CAR that Kendrion did not request an end-user statement prior to November 2021, and that brakes obtained after November 2021 have not been used for any defence application.

41 The Netherlands national policy further clarified: 'Companies that have a valid licence for Turkey that was issued before the change in policy for goods that could possibly be used in Syria will be asked to voluntarily refrain from using this licence.' Ministry for Foreign Trade and Development Cooperation and Ministry of Foreign Affairs (2020).

42 Ministry of Foreign Affairs (2021). Germany, where the brakes subject to CAR's trace requests were manufactured, likewise had instituted its own restrictive measures, stating in October 2019 that "In view of the Turkish military offensive in northeast Syria, the German Government will not grant new export licences for any arms that could be used by Turkey in Syria." Foreign Minister Heiko Maas, cited in Federal Foreign Office (2019

43 A dual-use item is defined in the regulation as, 'Items, including software and technology, that can be used for both civil and military purposes.' EU (2021, art. 2 (1)).

44 EU (2021, art. 4).

45 Email correspondence with the Netherlands Ministry of Foreign Affairs, Export Control of Strategic Goods, 22 April 2022. Notes on file.

46 See, for example, CAR's investigations of materiel recovered from the self-declared Donetsk and Luhansk 'People's Republics' in Ukraine (CAR, 2021).

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