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~~CONFIDENTIAL INTELLIGENCE ANALYSIS NOT FOR PUBLIC RELEASE~~

## ARES Conflict Damage Assessment YEM049

Factory in Matnah, Yemen (23 September 2015)

PREPARED FOR: [REDACTED]

DATE: 151124 (24 November 2015)

SUBJECT: 150923 Ceramic Radfan factory complex

LOCATION: Yemen/Sana'a/Matnah (Site YEM049) [REDACTED]

SUMMARY OF FINDINGS: ARES assesses with **high confidence** that one or more precision guided munitions of 200 kg – 300 kg NEQ struck Site YEM049. ARES assess with **high confidence** that at least one of these munitions was a Hakim A series precision guided munition.

**DISCLAIMER:** Note that the conclusions drawn in this report result from the limited data available. It is likely that additional photographs or additional recovered materiel would allow for further analysis to be undertaken. ~~All information is presented for the express and sole use of the client listed above. All publication or public citation of the analysis contained herein is to be conducted in conjunction with Armament Research Services.~~ Some sources may be available upon request; others are withheld on security grounds. Note that ARES does not necessarily hold copyright over images used in this report.

[REDACTED]

## Incident Summary

According to a local activist organisation based in Sana'a, Yemen, the *Ceramica Radfan* factory complex, located in Matnah, south-west of Sana'a city, was struck by one or more munitions on the morning of Wednesday 23 September 2015. According to Yemeni sources, one or more jet aircraft launched either three or four munitions which hit the factory complex during the strike.



Figure 1.1 – Matnah in relation to Sana'a, Yemen (left) and factory location within Matnah (right).

## Primary Findings

ARES assesses with **high confidence** that one or more precision guided munitions of 200 kg – 300 kg net explosive quantity (NEQ) struck Site YEM049. The impact site most visible from the available imagery (designated Site YEM049-Alpha) is consistent with this assessment (see Figure 1.2). Given the lack of significant fragmentation damage to surrounding areas and the presence of a solid rocket motor venturi, we currently assess that the munition in question was not a conventional aerial bomb, such as the General Purpose Low Drag (GPLD) Mk 82 or [REDACTED]. Further, the impact site damage is not consistent with the limited damage attributable to precision guided air-to-surface missiles primarily intended for use in the anti-tank role. When compared to the order of battle of the known combatant parties and their respective ordnance inventories, we assess with **high confidence** that at least one of the munitions which struck Site YEM049 was a Hakim A series precision guided munition (see details below), **very likely** delivered by a United Arab Emirates Air Force (UAEAF) Dassault Mirage 2000-9 or F-16E/F 'Desert Falcon' fighter.



Figure 1.2 – Impact crater and other damage at Site YEM049-Alpha (IMG\_3990).



Figure 1.3 – Solid rocket motor venturi documented at Site YEM049 (IMG\_4007).

This conclusion is supported by an examination of the remnants documented at the impact site. Critically, the presence of a solid rocket motor venturi indicates that a rocket-propelled munition was employed (see Figure 1.3). This rocket motor component appears to be consistent with the known diameter (127 mm) of the Hakim series rocket motors, manufactured by Atlantic Research Corporation (now Aerojet Rocketdyne) and designated the MARC 223. Other signature fragments, including key components of guidance and propulsion systems, were also photographed. Amongst these, two synthesizer modules produced by GEC-Marconi Dynamics of Oldham, United Kingdom are visible (see Figure 1.4). These components were **very likely** manufactured between 1991 and 1998.



Numerous other components were documented at Site YEM049. A structural baffle plate is seen marked '70 MHZ IF', indicating an intermediate frequency of 70 MHz, consistent with guided munition telemetry of this the likely time period (see Figure 1.5). A munition body fragment, marked in part with 'LASER A' (full label reads 'LASER APERTURE') is also consistent with known markings present on Hakim A series munitions (see Figure 1.6). Specifically, [REDACTED]. These components are consistent with those recovered from another Hakim A series munition documented in Yemen in November 2015.



Figure 1.4 – GEC-Marconi Dynamics synthesizer modules documented at Site YEM049 (IMG\_4012 & IMG\_4043).



Left: Figure 1.5 – Structural baffle plate showing markings indicating an intermediate frequency of 70 MHZ documented at site YEM049 (IMG\_3999).

Right: Figure 1.6 – Munition body fragment reading, in part, 'LASER A' (IMG\_4004).

## Acquisition and Operational Employment Assessment

Whilst the Hakim A series munition can be identified based solely upon munition remnants documented at Site YEM049, this analysis is further supported by an examination of acquisition and operational employment factors.

A number of munitions exported to Gulf countries including Saudi Arabia and the United Arab Emirates are known to have used GEC-Marconi Dynamics components. An analysis of these munitions to determine their potential use at Site YEM049 follows. Some, such as the Brimstone air-to-surface missile and the Hakim, were manufactured and sold by GEC-Marconi Dynamics (later Alenia Marconi Systems, then MBDA). Other munitions such as the ALARM (Air-Launched Anti-Radiation Missile) air-to-surface missile and the MICA (*Missile d'Interception, de Combat et d'Autodéfense*) air-to-air missile have at one time contained components manufactured by GEC-Marconi Dynamics. Some sources claim that the Storm Shadow and Black Shaheen air-to-surface missiles (a variant of the SCALP EG, a sister development of the Storm Shadow, produced for the UAE) also used GEC-Marconi components.

Export records from the Stockholm International Peace Research Institute (SIPRI) indicate that 350 Storm Shadow missiles were delivered from the UK to Saudi Arabia between 2011 and 2013 (another unknown quantity was ordered in 2013). ARES considers it **unlikely** that any Storm Shadow missiles delivered to Saudi Arabia were still using components manufactured by GEC-Marconi Dynamics, which would have been more than a decade before deliveries began to take place. The Black Shaheen, ordered in 1998 and delivered to the UAE between 2003 and 2008, is similarly regarded. Additionally, both of these munitions feature warheads with an NEQ in excess of 400 kg, which would likely result in a damage signature inconsistent with that observed at Site YEM049. Finally, signature fragments such as distinctive control surfaces were not documented.

From available evidence, the Brimstone, MICA, and ALARM missiles are **unlikely** to have been used during the strike on Site YEM049. Whilst the Brimstone air-to-surface missile was designed and tested during the mid-1990s, sources indicate that Saudi Arabia did not place an order for the Brimstone until 2008, well after GEC-Marconi Dynamics had ceased producing munitions and components under that name. The Brimstone is also a poor fit based on its relatively small 6.5 kg or 9.0 kg warhead options. The MICA is a **highly unlikely** candidate, as it is an air-to-air missile with a warhead of only 12 kg. 250 ALARM missiles were delivered to Saudi Arabia from the UK in the period spanning 1991 to 1998. Whilst this time period indicates that certain components within the ALARM missiles exported to Saudi Arabia are likely to be marked with 'GEC-Marconi Dynamics', the ALARM has a [REDACTED] which is inconsistent with the damage documented at Site YEM049. Additionally, the ALARM is a dedicated anti-radiation missile, intended to engage radar sites and other radio emitting targets. No evidence of any such targets was present in the available imagery from Site YEM049.

The Hakim family of precision guided munitions is the **most likely candidate**, explaining the presence of GEC-Marconi Dynamics components (delivered within the correct time period to a Gulf Coalition country conducting air strikes within Yemen at the time of the strike on Site YEM049) and bearing a warhead consistent with the level of damage documented at Site YEM049. According to SIPRI records, the UAE placed an order for 1750 Hakim series weapons (an unknown mixture of both 500 lb and 2000 lb variants) with ICS in 1985. Other sources indicate the order was placed in 1986. At the

time, the order was placed with a US company, however it is understood that the intent was to manufacture the munitions in the United Kingdom. After the acquisition of ICS missile business by Ferranti International and, later GEC-Marconi Dynamics (see below), manufacturing took place in the UK. SIPRI suggests delivery took place between 1989 and 1998, whilst Jane's suggests that first delivery took place in 1991 and all weapons were delivered as of 2001. Intelligence collected by ARES suggests that [REDACTED].

The UAEAF is the only air force known to operate the Hakim family of precision guided munitions. According to some sources, the weapon was declared operational on the Mirage 2000 in 1994. Jane's reports that MBDA and Lockheed Martin have also fully integrated the Hakim series for use with the F-16E/F 'Desert Falcon' fighter aircraft delivered to the UAEAF between 2004 and 2007. Hakim series weapons have previously been employed by the UAEAF in Libya, in 2011 (see Figure 1.7).



Figure 1.7 – UAEAF Dassault Mirage 2000 multirole fighters armed with Hakim A series munitions.

### **Hakim Series Munitions**

Hakim series weapons<sup>1</sup> were developed from early designs designated the PGM-1 and PGM-2, first undertaken by International Signal and Control (ISC), based in Lancaster, Pennsylvania, United States in the mid-1980s. Funding for the development came from the United Arab Emirates (the government of Abu Dhabi, specifically), and the weapon was developed specifically for use with the Dassault Mirage 2000 fighter aircraft. ISC was acquired by Ferranti International in November 1987. In 1991 Ferranti's missile business, including the PGM series, was acquired by GEC-Marconi following substantial financial damage incurred by the acquisition of ISC. Ferranti declared bankruptcy in 1994.

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<sup>1</sup> Also rendered 'Al Hakim', 'Al-Hakim', 'Hakeem', 'Al Hakeem', 'Al-Hakeem', etc. Translation: 'wise one'.





Figure 1.8 – Hakim A1 semi-active laser guided munition. Note GEC-Marconi Dynamics markings.

These projects were further developed by GEC-Marconi Dynamics, one of a number of subsidiary companies in the GEC-Marconi group, headquartered in Stanmore, UK. According to one source, in 1992 “about half GEC-Marconi Dynamics’ orders [were] for export”. Subsidiaries of GEC-Marconi, including GEC-Marconi Dynamics, were later merged with Alenia Difesa, a division of Finmeccanica, in December 1998 to form Alenia Marconi Systems. In December of 2001, Alenia Marconi Systems became a part of MBDA along with Aerospatiale-Matra Missiles and Matra BAe Dynamics. Subsequently, MBDA continued to market the PGM 500 and PGM 2000 series precision guided munitions.

The Hakim series was developed as a modular system, capable of accepting a range of interchangeable terminal guidance systems, namely semi-active laser (Hakim 1), TV (Hakim 2), and IIR<sup>2</sup> (Hakim 3) configurations. Weapons were developed in the 500 lb and 2000 lb class (warheads of 227 kg and 908 kg, respectively). In UAE service, the 500 lb weapons are referred to as the Hakim A series, whilst the 2000 lb weapons are referred to as the Hakim B series. These are combined with numerals to indicate guidance type (e.g. Hakim 1A, 2A, etc.). Whilst commonly referred to as a ‘missile’, Hakim series weapons function primarily as glide bombs, using a solid rocket motor to extend the range of the weapon to more than 50 km (for a high-altitude release).



Figure 1.9 – Hakim A and Hakim B munitions displayed at Paris Air Show 2005 (note, these weapons are marked as ‘PGM 500’ and ‘PGM 2000’).

<sup>2</sup> Imaging infra-red.

## Technical Specifications

These indicative technical specifications are drawn from official MBDA and GEC-Marconi documents. The Hakim A has comparable specifications to the PGM 500.

	PGM 500	PGM 2000
<b>Total Weight</b>	404 kg	1060 kg
<b>Overall Length</b>	3384 mm	4623 mm
<b>Diameter</b>	355 mm	457 mm
<b>Guidance</b>	Laser, TV, or IIR	Laser, TV, or IIR
<b>Warhead</b>	500lb class blast fragmentation (HE-FRAG) or 'penetrator' HE-FRAG	2000lb class blast fragmentation (HE-FRAG) or 'penetrator' HE-FRAG
<b>Fuze</b>	Impact or proximity	Impact or proximity
<b>Precision</b>	1 meter CEP <sup>3</sup>	1 meter CEP
<b>Range</b>	Low-altitude release: 15km Medium-altitude release: up to 30km High-altitude release: over 50 km	Low-altitude release: 15km Medium-altitude release: up to 30km High-altitude release: over 50 km



Figure 1.10 – A PGM 500 precision guided munition manufactured by MBDA. Analogous to the Hakim A series munitions.

<sup>3</sup> Other sources give the Hakim A CEP as 2 m.



## References

Selected references available on request.

Image sources: Mwatana Organization for Human Rights where labelled with 'IMG\_'. Other image sources may be available on request.

## Credits

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Impact site images: Mwatana Organization for Human Rights

## Safety Information

Remember, all arms and munitions are dangerous. Treat all firearms as if they were loaded, and all munitions as if they were live, until you have personally confirmed otherwise. If you do not have specialist knowledge, never assume that arms or munitions are safe to handle until they have been inspected by a subject matter specialist. You should not approach, handle, move, operate, or modify arms and munitions unless explicitly trained to do so. If you encounter any unexploded ordnance (UXO) or explosive remnants of war (ERW), always remember the 'ARMS' acronym:

**AVOID** the area

**RECORD** all relevant information

**MARK** the area to warn others

**SEEK** assistance from the relevant authorities

## Safety Disclaimer

This report is presented for informational purposes only. It is not intended to provide instruction regarding the construction, handling, disposal, or modification of any weapons systems. Armament Research Services (ARES) strongly discourages non-qualified persons from handling arms and munitions. Arms or munitions of any variety should not be handled without the correct training, and then only in a manner consistent with such training. Subject matter experts, such as armourers, ATOs, and EOD specialists, should be consulted before interacting with arms and munitions. Make a full and informed appraisal of the local security situation before conducting any research related to arms or munitions.