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# THE DIFFICULTIES OF DETECTING EXPLOSIVES LEFT IN WAR ZONES USING OPEN-SOURCE DATA ANALYSIS THROUGH THE EXAMPLE OF THE SYRIAN CIVIL WAR

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ABSTRACT: *The unexpected turn of events in December 2024 during the Syrian Civil War – the fall of President Bashar al-Assad – may inspire long-unseen hopes among the population of this war-ravaged country. However, detecting and removing the explosives left behind by the war will take many years, provide work for masses of specialists, and consume vast financial resources. In this article, the author illustrates how difficult it is to estimate the amount of unexploded ordnance remaining in war zones, even when relying on otherwise high-quality information.*

KEYWORDS: *Middle East, Syrian Civil War, explosive ordnance disposal, explosive devices*

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## INTRODUCTION

The collapse of the Assad regime in December 2024 took the world by surprise: the dynasty that had ruled since 1970 survived the thirteen-year civil war, only to be ousted from power following a two-week blitz offensive. While the change in government undoubtedly offers new hope for the Middle Eastern state, the decreasing intensity of the fighting has also brought to light a long-swept-under-the-rug problem: the removal of vast quantities of explosives scattered throughout the country.

The detection, marking, and removal of explosive devices is a difficult task from multiple perspectives:[1] as we will see later, even high-quality studies produced through extensive research are unable to determine the exact number of remaining devices or the size of the contaminated areas. Today's popular open-source-based data analytics may offer some guidance in carrying out the task, but even so, it is impossible to achieve perfect results. The situation is further worsened by the fact that, although fighting between armed groups formerly under government control and various non-state actors seems to be subsiding, in a highly fragmented Syria, even a small spark is enough to ignite another armed conflict.

[1] Daruka – Szalkai 2024.

The clearance of explosives in the Middle Eastern state is, however, an urgent task: as the civil war has subsided, civilians who previously fled the country have begun to return, and it is likely that efforts to repair the damage, clear the rubble, and restore previously unusable farmland will soon begin. Yet the explosives, hidden among the debris for months or even years, still lie in wait for their victims.

## DETERMINING THE NUMBER OF WEAPONS USED IN SYRIA

Efforts to detect and remove explosives left behind from the Syrian conflict critically depend on three key pieces of information: the spatial distribution, type, and quantity of these devices.

### Spatial distribution

The approximate determination of the locations of explosive devices – while a formidable task in itself – is the easiest among the three factors. Different phases of the civil war affected various regions of the country to different extents, allowing conclusions to be drawn about which areas of Syria are the most contaminated.

The most comprehensive available estimate of unexploded ordnance in Syria was produced by The Carter Center. Their analysis, based primarily on open sources, seeks to determine the number of weapons used between 2012 and 2021, a period that coincides with the most intense phase of the conflict: from the escalation in 2012 to Türkiye's "Operation Spring Shield" in 2020,[2] and the ceasefire that followed in March of the same year.

The research reveals that during the first ten years of the civil war, the majority of explosives were concentrated in just five of Syria's fourteen governorates. In order, these areas were: Hama, Idlib, Aleppo, Rif Dimashq, and Daraa. Altogether, these five regions accounted for an estimated 79% of the explosives used in the country up to 2021 (see Table 1).

Table 1 *Approximate number of explosive weapons used in Syria by governorate (2012–2021)*[3]

| Governorate | Number of recorded incidents | Percentage |
|---|---|---|
| Latakia | 31,080 | 3.2% |
| Idlib | 177,027 | 18.2% |
| Aleppo | 172,039 | 17.7% |
| Raqqa | 18,910 | 1.9% |
| Al-Hasakah | 15,408 | 1.6% |
| Tartus | 71 | 0.007% |
| Hama | 188,994 | 19.4% |
| Deir ez-Zaur | 39,951 | 4.1% |
| Homs | 51,851 | 5.3% |

[2] "Operation Spring Shield" was launched by the Turkish Armed Forces on February 27, 2020, against Syrian government forces and their allied militias in Idlib Governorate. The aim of the operation was to secure areas located near the Turkish border.

[3] The Carter Center, 2022, 24.

| Governorate | Number of recorded incidents | Percentage |
|---|---|---|
| Damascus | 31,744 | 3.3% |
| Rif Dimashq | 153,042 | 15.7% |
| Quneitra | 11,802 | 1.2% |
| Daraa | 78,031 | 8.0% |
| Al-Suwayda | 2,101 | 0.2% |

The geographic distribution of explosive use naturally correlates with the main hot spots of the civil war. Daraa is one of Syria's poorest regions,[4] and the anti-government protests in 2011 also began in its center, which is likewise called Daraa.[5] As the conflict escalated, the area saw the emergence of the Islamic State and other armed groups opposing the state.

Rif Dimashq Governorate encompasses the areas surrounding the capital, making it the main stronghold of pro-Assad government forces. While fighting in this region had largely subsided by 2018, the six years following the 2012 escalation saw intense clashes.[6] It is also important to note that although the city of Damascus suffered "only" 3.3% of the explosive incidents estimated by The Carter Center, these events occurred within an area of just 118 square kilometers (for comparison, this is slightly more than one-quarter of the size of Budapest).

The spatial distribution of explosive device usage reveals that most such incidents occurred in three northern provinces of Syria: Hama (which was another focal point of the 2011 protests),[7] Idlib, and Aleppo. These three regions were the most severely affected areas of the civil war, where not only government forces, Russian peacekeepers allied with them, and anti-government militias clashed, but also Türkiye – possessing the region's largest military – intervened multiple times.

Between 2020 and 2024, the intensity of the civil war significantly declined. Although the Islamic State was not entirely destroyed, it lost a large portion of its territory, fighting subsided in the southern provinces, and government forces consolidated control over roughly two-thirds of the country. During this period, the only major confrontation broke out in October 2023, between the Turkish Armed Forces (and the militias they supported, concentrated mainly in Idlib in northwestern Syria) and the Syrian Democratic Forces (SDF),[8] which are predominantly Kurdish. The SDF control the northeastern third of Syria, beyond the Euphrates River, and Turkish artillery and air strikes primarily targeted the northern areas of Raqqa and Al-Hasakah governorates. According to opposition sources, between October 5 and 9, 2023, Turkish forces carried out approximately seventy air strikes and one artillery strike in those two governorates.[9]

4 Syrian Center for Policy Research, 2024, 7.
5 Yacoubian, 2021.
6 The Carter Center 2020a, 8–9.
7 Black – Ali, 2011.
8 The SDF (Syrian Democratic Forces) is a multiethnic but predominantly Kurdish-led secular paramilitary organization. Aside from the United States, it maintained a hostile relationship with every other prominent actor involved in the civil war. As of June 2025, negotiations have been going on between the SDF and the new government of Syria about a ceasefire.
9 Syrian Observatory for Human Rights, 2023.

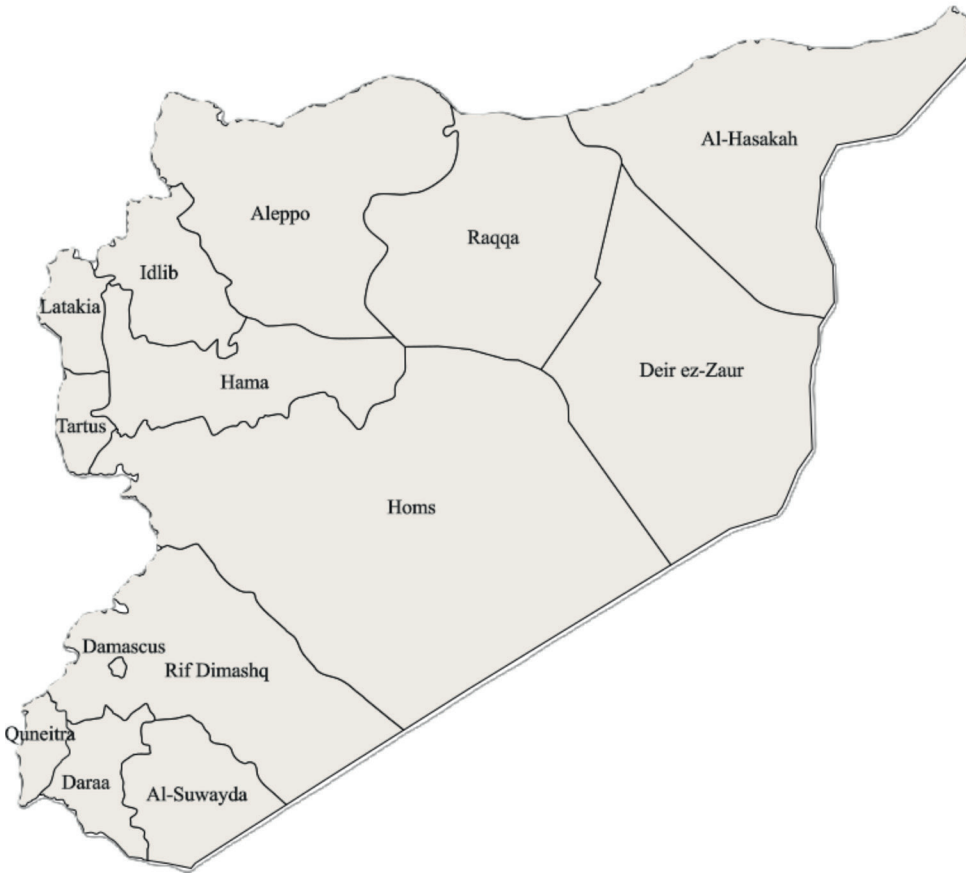


Figure 1 *The governorates of Syria*[10]

Due to the relative recency of the conflict, there is no reliable information available on the quantity of ammunition used during the December 2024 blitz offensive launched by anti-government forces, primarily Hayat Tahrir al-Sham (HTS).[11] However, based on the focal points of the fighting, it is possible to infer where the ratio of deployed – and potentially unexploded – explosives may have shifted, compared to previous analyses by the Carter Center.

The most intense battles occurred in the governorates of Aleppo and Hama, where Syrian government forces tried to halt the rebels, using artillery and air strikes, particularly around Idlib, a stronghold of HTS. The Turkish Armed Forces and the Syrian National Army

[10] Own work, original blank map by Siirski via Wikimedia Commons https://commons.wikimedia.org/wiki/File:Blank_Syria_map.svg

[11] Hayat Tahrir al-Sham is a radical Sunni Islamist political-military coalition and the successor organization to the al-Nusra Front, which was affiliated with al-Qaeda. During the civil war, its main adversary was the Assad regime, but it has clashed with every other actor in the conflict apart from Türkiye. Since December 2024, HTS has become the leading political power in Syria.

(SNA)[12] – currently allied with HTS – also clashed with SDF units stationed in Raqqa and Al-Hasakah. Additionally, the warring parties, including Iraqi militias aligned with the government, engaged in combat in Deir ez-Zor Governorate. In this region, the United States, which supports the SDF, bombed both Syrian government forces and remnants of the Islamic State. While Rif Dimashq and Damascus largely avoided the brunt of the fighting, these areas – as well as the remaining Syrian-controlled parts of Quneitra Governorate (much of which is occupied by Israel as part of the Golan Heights) – were bombed by the Israel Defense Forces (IDF). It is worth noting that the IDF air strikes primarily targeted Syrian military assets and thus likely reduced the overall number of explosive devices present in the country.

From the above, it can be inferred that compared to earlier estimates, the number of explosive devices left behind and posing potential danger to civilians increased most significantly in the already heavily contaminated governorates of Aleppo, Hama, and Idlib. However, Raqqa, Al-Hasakah, and Deir ez-Zor – particularly the areas along the Euphrates – now also contain a greater amount of unexploded ordnance.

## PROBLEMS WITH THE USE OF OPEN-SOURCE INTELLIGENCE IN DETERMINING THE NUMBER OF EXPLOSIVE DEVICES

While the geographical distribution of potentially remaining unexploded ordnance (UXO) in Syria can be roughly outlined based on the intensity of the fighting and the known positions of the parties involved, estimating the exact number of weapons used is virtually impossible for several reasons.

Although it is almost certain that the regular armed forces involved in the conflict – such as Russia, Syrian government forces, and NATO member states – documented the quantity, type, and deployment areas of the weapons they used, these data are only partially accessible. Furthermore, the Syrian government forces, which likely expended the most ammunition, probably have incomplete records due to the chaos of the civil war and a general lack of discipline.

In the case of militias opposed to the government forces, even the existence of such documentation is questionable. While in general, effective combat against regular armed forces would require these groups to maintain a certain level of logistical organization, over the years of civil war, these formations frequently disbanded, split, or merged depending on current interests. Therefore, the likelihood that they have accurate records of the ammunition they used is minimal. For militias, the only probable source of such documentation might come from their supporting donor states; however, in this case, once again, there is a lack of publicly available information.

A less reliable, yet increasingly popular approach is the use of so-called open-source intelligence (OSINT), which involves analyzing various online materials, primarily those found on social media platforms, as well as personal accounts. However, OSINT by its very nature carries numerous sources of error: written and spoken reports are not particularly reliable. For example, a Syrian resident of Aleppo might state in a personal interview that a

[12] The Syrian National Army is an armed group supported by Türkiye, composed of several smaller militias. Throughout various phases of the civil war, it has fought against every participant except Ankara, though its primary enemy was the Assad regime. After December 2024, it officially merged into the new government forces dominated by HTS.

nearby apartment block was previously hit by something, but they could be mistaken about the date or, as a layperson, unable to identify the type of weapon used in military terms.

Analyzing various visual materials can provide a somewhat more accurate picture of the presumed location and type of explosives, but even this research method comes with difficult-to-eliminate issues.

When relying on open sources, a serious dilemma arises as early as in the process of mapping the spatial distribution of explosive devices, and it reappears when estimating their quantity and type: the quality of the information. As seen earlier, the available figures generally correspond to major hot spots of the civil war. It is logical to conclude that the more densely populated an area is, the more verbal, visual, or written reports are produced about the use of weapons there. Fighting near populated areas also receives much greater media coverage. This does not imply, for example, that fewer explosive attacks occurred in the relatively densely populated Idlib Governorate than reported, but rather that from many sparsely populated or remote areas, news of such incidents simply never reaches the outside world.

To illustrate the additional obstacles to determining the number and types of weapons used, it is useful to refer to the previously mentioned study by The Carter Center – specifically to the part that deals with the northwestern Syrian governorates, which were the most severely affected by the civil war. The analysis classifies the weapons used into four categories: those launched from the air, those fired from ground-based weaponry, those delivered via so-called cluster munitions, and those consisting of planted mines[13] or improvised explosive devices (IEDs).[14] Within these categories, researchers attempted to identify specific weapon types as precisely as possible.

Table 2 *Explosive weapons used in northwestern Syria by type (2013–2019)*[15]

| Munitions category | Munitions type | No. of incidents recorded | % of total |
|---|---|---|---|
| Air-launched | Helicopter-launched | 12,242 | 10.82% |
| | Fixed-wing aircraft-launched | 40,914 | 36.17% |
| Ground-launched | Artillery shells | 6,750 | 5.97% |
| | ATGM[16] | 145 | 0.13% |
| | Cruise missiles | 2 | 0.00% |
| | Hand and rifle grenades | 51 | 0.05% |
| | Mortar shells | 5,249 | 4.64% |
| | Ballistic missiles | 8,016 | 7.09% |
| | RPGs[17] | 1 | 0.00% |
| | Unknown munition | 36,384 | 32.17% |
| | Tank shells | 225 | 0.20% |
| Cluster | Air- and ground-launched | 883 | 0.78% |

13 Kovács 2024.
14 Kovács 2012, 2; Daruka 2013a, 2, 8; Daruka 2013b, 2.
15 The Carter Center 2020b, 5.
16 Anti-Tank Guided Missile.
17 Rocket-Propelled Grenade.

| Munitions category | Munitions type | No. of incidents recorded | % of total |
|---|---|---|---|
| Landmine, IED, UXO | IEDs, unknown explosives | 1,438 | 1.27% |
| | Landmines | 216 | 0.19% |
| | PBIEDs[18] | 99 | 0.09% |
| | SVBIEDs[19] | 95 | 0.08% |
| | UXO[20] | 38 | 0.03% |
| | VBIEDs[21] | 359 | 0.32% |

From the table above, it can be seen that during the data collection period, a total of 30,425 incidents involving the use of explosive devices were identified, which are estimated to represent the deployment of at least 113,107 weapons. It is essential to highlight that while most similar studies count only one explosive per incident, The Carter Center records three munitions for any report that does not specify the number of weapons used but refers to them in the plural form. For example, in cases described as involving "intense artillery fire and air strikes," they register three artillery shells and three weapons launched from fixed-wing aircraft.[22] It is also important to note that in the case of cluster munitions containing multiple submunitions, the reported number refers to the containers, not the individual submunitions.[23]

It is also impossible to determine exactly what percentage of the ammunition used during combat ends up as UXO. Such anomalies depend on numerous factors, such as the specific circumstances of a weapon's deployment, the conditions under which it was stored prior to use, and the level of training of the personnel operating it. Added to this is the fact that different types of weapons have varying failure rates, data that manufacturers are understandably reluctant to disclose. A generally accepted rule of thumb is that 10–30% of explosive devices malfunction and become UXO.[24]

Although the researchers themselves emphasize that this method can only estimate an absolute minimum, overall findings of the four regional surveys correlate with reports about the intensity and locations of fighting in those areas.

Based on the documented incidents, in three of the four examined regions – Northwestern Syria (Aleppo, Hama, Idlib, Latakia, Tartus), Southern Syria (As-Suwayda, Daraa, Homs, Quneitra), and Central Syria (Damascus, Rif Dimashq) – ground-launched weapons were predominant, while in the northeast (Al-Hasakah, Raqqa, Deir ez-Zor), air-launched weapons were more commonly used (see Table 3).

18 Person-Borne Improvised Explosive Device.
19 Suicide Vest-Borne Improvised Explosive Device.
20 Unexploded Ordnance.
21 Vehicle-Borne Improvised Explosive Device.
22 The Carter Center 2020a, 3–4.
23 The Carter Center 2020b, 4.
24 Feickert – Kerr 2024, 2.

Table 3 *Estimated percentage distribution of weapon categories used in Syria by regions (2013–2021)*[25]

| Region | Air-launched | Ground-launched | Cluster | IED, UXO, unknown |
|---|---|---|---|---|
| Southern Syria | 34.9% | 64.3% | 0.1% | 0.7% |
| Central Syria | 31.6% | 68.0% | 0.1% | 0.2% |
| Northeastern Syria | 38.1% | 61.2% | 0.2% | 0.5% |
| Northwestern Syria | 51.6% | 45.1% | 0.0% | 3.3% |

The reason why the proportion of air-launched weapons was higher in northwestern Syria compared to other parts of the country can be explained by the nature of the conflict: the region in question was considered a local stronghold of the Islamic State. The terrorist organization declared Raqqa to be its capital, and after losing it in 2017,[26] it retreated along the Euphrates and established new centers in towns located in Deir ez-Zor Governorate.[27] While in most other parts of the country the Syrian government forces – alongside supporting Russian troops and allied militias – fought mainly against anti-government armed groups, the Islamic State was treated as an enemy by every state actor in the region, including the United States, which primarily relied on its air force during the fighting. Therefore, the likely reason for the spike in air-launched weapon use in this region is that U.S. forces conducted their heaviest strikes here. In other parts of the country, ground-launched weapons were more prevalent. All in all, based on Table 4, the minimum number of UXO remaining in Syria in 2021 was estimated to be around 100,000, although the actual total may be significantly higher.

Table 4 *Estimated minimum number of explosive weapons used in the Syrian Civil War until 2022*[28]

| Munitions category | Minimum No. of usage | % of total | No. of potential UXO |
|---|---|---|---|
| Air-launched | 363,839 | 37.4% | 36,500–109,250 |
| Ground-launched | 599,974 | 61.7% | 60,000–180,000 |
| Cluster | 1,658 | 0.2% | 150–450 |
| Landmine, IED, UXO | 6,633 | 0.7% | 750–2,000 |

## LIMITATIONS OF USING OPEN-SOURCE INTELLIGENCE TO DETERMINE THE TYPE OF WEAPONS DEPLOYED

However, the limitations of open-source-based analyses become evident when we examine the types of weapons used in the recorded incidents in more detail. A striking anomaly, for example, is that in the case of northern Syria, the study recorded only 145 anti-tank

[25] The Carter Center, 2022, 14–22.
[26] Raqqa 2017.
[27] Hassan 2017, 1–3.
[28] The Carter Center, 2022, 13.

guided missiles (ATGMs), 51 hand and rifle grenades, and just one rocket-propelled grenade (RPG). During the conflict, Syrian government forces extensively used 9M113 Konkurs,[29] 9M133 Kornet,[30] and 9K111 Fagot[31] ATGMs. RPGs of various kinds are popular worldwide, with the Soviet-developed RPG-7 being the most widely used handheld anti-armour weapon in the world, and hand grenades are now standard equipment in virtually all armed forces. Therefore, it initially seems anomalous that so few of these weapons were deployed in the region hardest hit by the civil war. It should be noted, however, that the ratio of such weapons was similarly low in the other areas; for example, only 123 hand and rifle grenades were recorded in Central Syria,[32] so this is by no means an isolated case.

The phenomenon, however, has a fairly straightforward explanation: a ballistic missile strike or an air strike is a "spectacular" event, involving a large, highly visible explosion that often results in numerous casualties. As a result, such incidents receive significantly more media coverage, even in a conflict zone where similar events may occur multiple times a day. In contrast, the use of various anti-tank weapons or hand grenades is such a routine occurrence that neither the combatants nor the media are likely to consider it important enough to document.

Naturally, this is also due to the fact that air-launched weapons or long-range ground-launched systems often strike deep behind the front lines, whereas smaller weapons are typically used at the heart of the fighting, places where journalists rarely venture, and where civilians, understandably, have no intention of taking the risk to record footage.

It is important to specifically address the issue of improvised explosive devices (IEDs). As shown by the investigations, the proportion of these weapons was highest in Northeastern Syria – the very region where the Islamic State, the group that used such devices most extensively,[33] had its strongholds. Documenting explosive devices that transition from IEDs to UXO is particularly difficult compared to other weapons used in Syria.

The challenge lies in the fact that, while conventional munitions ideally detonate upon impact, the very purpose of IEDs and landmines is to remain hidden until the moment of detonation. If the placement of such an explosive device is observed by civilians or enemy forces, the weapon loses its intended effect. As a result, if an IED fails to detonate, whether due to malfunction or some other reason, then, apart from those who placed it, others are unlikely to even be aware of its existence. This means that the proportion of IEDs or landmines that become UXO is likely higher than what open-source-based research is able to uncover, especially when compared to other types of explosive weapons.

## CONCLUSION

Following the apparent end of the civil war in Syria, significant attention will undoubtedly be directed to locating and neutralizing the explosives left behind in the country. However, as has become clear, it is virtually impossible to produce a reliable estimate of the number of UXO remaining after such asymmetric conflicts as the one in Syria. In-depth analyses based on open sources – such as those conducted by The Carter Center – can provide an

[29] Lyamin et al. 2016.
[30] Smallwood 2014.
[31] Janovský 2018.
[32] The Carter Center 2020a, 5.
[33] Kovács 2024, 109.

estimate of the possible minimum number of unexploded weapons and can identify the most heavily contaminated areas with relative confidence. Nonetheless, the actual number of UXO is likely significantly higher than reported. Accurately identifying the model – or even the broader category – of these weapons poses major challenges, especially in the case of relatively small devices used close to front lines.

Since 2021, several programs have been launched to clear explosives from the country, most notably by the United Nations Mine Action Service (UNMAS). However, drawing on experiences in other conflict zones, complete clearance could take decades, assuming that the highly unstable country does not descend into civil war once again.

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