

Understanding Civilian Harm in Raqqa and Its Implications for Future Conflicts

Annex

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About This Annex

This is the annex to a report that provides insights into the causes of civilian harm during the U.S.-led operation to liberate Raqqa, Syria, from the Islamic State of Iraq and Syria from June to October 2017. The purpose of the report is twofold: to help readers understand the causes of civilian harm in Raqqa and to help U.S. Department of Defense (DoD) policymakers and planners mitigate the risks of civilian harm in future conflicts.

Human Subject Protections (HSP) protocols were used in this study in accordance with the appropriate statutes and DoD regulations governing HSP. Additionally, the views of the sources rendered anonymous by HSP are solely their own and do not represent the official policy or position of DoD or the U.S. government.

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Introduction

The battle to capture Raqqa from the Islamic State of Iraq and Syria (ISIS) officially lasted from June 6 to October 20, 2017. When Syrian forces, supported by the U.S.-led anti-ISIS coalition, captured the city, commentators compared the extent of the damage in Raqqa with that in Dresden, Germany, following Allied carpet bombing in February 1945.¹ According to an assessment by the United Nations Institute for Training and Research (UNITAR)'s Satellite Analysis and Applied Research program (UNOSAT, previously the UNITAR Operational Satellite Applications Programme), between February 3 and October 21, 2017, 11,001 buildings were damaged or destroyed.² This included “5 destroyed bridges,” “approximately 159 structures corresponding to educational facilities,” “26 structures likely related to health facilities,” “8 water towers [that] are completely destroyed,” and “damage to one electric substation and a sewage treatment facility.”³ Meanwhile, strike releases from Combined Joint Task Force (CJTF) – Operation Inherent Resolve (OIR) indicate that there were approximately 5,000 air and artillery strikes during this same period.⁴

Although CJTF-OIR mostly used precision-strike munitions to mitigate civilian harm, locals and journalists questioned the merit of this claim given Raqqa's near-total destruction. In October 2018, for instance, returned Raqqa resident Abu Ward described what had happened as “destruction. Systematic destruction. This is what people believe—my relatives, my friends, my neighbors. No one can change their minds.”⁵

The purpose of the open-source geospatial intelligence (GEOINT) analysis described in this annex is to understand the net effect of air and artillery strikes during the Raqqa operation—that is, why Raqqa ultimately looked like it had been carpet-bombed despite CJTF-OIR's deployment of mostly precision-strike munitions. We found that CJTF-OIR employed mostly precision-strike munitions against individual buildings and infrastructure

¹ Kate Allen, “Raqqa in Ruins Like a Modern Dresden. This Is Not ‘Precision Bombing,’” *The Guardian*, May 23, 2019; Victor J. Blue, “After the ‘War of Annihilation’ Against ISIS,” *Time*, April 6, 2019; and Tom Bowman and Ruth Sherlock, “Raqqa: View from the Ground,” NPR, November 1, 2018.

² UNITAR-UNOSAT, “Damage Density of Ar Raqqa, Ar Raqqa Governorate, Syria,” map, Geneva, November 21, 2017c; and United Nations Institute for Training and Research, “Damage Assessment of Ar Raqqa, Ar Raqqa Governorate, Syria,” map, Geneva, June 13, 2017b. This database was updated with October 21, 2017, satellite data, but the data set's corresponding map and metadata were not updated.

³ UNITAR-UNOSAT, “Infrastructure and Roads Damage Assessment of Ar Raqqa, Ar Raqqa Governorate, Syria,” map, Geneva, December 1, 2017d.

⁴ Combined Joint Task Force – Operation Inherent Resolve, “Strike Releases,” webpage, undated.

⁵ Ruth Sherlock, Lama Al-Arian, and Kamiran Sadoun, “‘This Is Not Liberation’: Life in the Rubble of Raqqa, Syria,” NPR, October 26, 2018.

throughout the battle for Raqqa. But the frequency of the strikes, the density of the city, and ISIS urban warfare tactics—notably, rapidly moving between protected buildings and legitimate targets, bunkers, and tunnels and using civilians as human shields—were among the factors that ultimately “negated the promise of precision strike capability, resulting in . . . its [Raqqa’s] inhabitants facing a future little different than if they had been hammered with dumb bombs and indiscriminate artillery salvos.”⁶

The analysis also provides some snapshots of the destruction caused by Syrian Arab Republican Government (SARG) and ISIS forces prior to the battle for Raqqa.

In this GEOINT analysis, we assess only what is available through open-source satellite imagery. We do not attempt to estimate civilian casualties or critique existing estimates. Similarly, it is not possible to determine to what extent a strike against one building might have affected nearby buildings (e.g., laterally propelled strike debris might have inadvertently damaged adjacent structures) beyond what is visible in the vertically oriented open-source satellite imagery.

Methodology and Scope of the Geospatial Intelligence Analysis

We employed open-source satellite imagery from Maxar Technologies, used in Google Earth Pro, to identify civilian infrastructure damaged or destroyed during each of the conflict stages.⁷ Maxar satellite imagery provides a reasonable balance between absolute image quality and ease and speed of accessibility, both important requirements for this project. Key infrastructure damage identified in this annex can be more closely examined through Maxar or Airbus commercial-level imagery or classified data produced by the National Geospatial-Intelligence Agency.

To determine damage occurring between March 6, 2013, and October 21, 2013, we conducted a manual remote sensing analysis to identify civilian buildings and infrastructure in Raqqa that were damaged or destroyed.⁸ To determine damage occurring between October 22, 2013, and October 21, 2017 (including during the battle for Raqqa), we leveraged the UNITAR-UNOSAT infrastructure database to identify buildings and infrastructure in Raqqa that were damaged or destroyed.

In ArcGIS 10.8, we separated the master UNITAR-UNOSAT shapefile (.shp) into discrete time periods and converted each resulting shapefile into Google Earth Pro-compatible keyhole markup language files (.kmz).⁹ Where possible, we cross-referenced our findings with official CJTF-OIR strike releases and accounts from Human Rights Watch; the Syrian Network for Human Rights (SNHR); Airwars; the open-source intelligence group Bellingcat; and

⁶ Amos C. Fox, “Precision Fires Hindered by Urban Jungle,” Association of the U.S. Army, April 16, 2018.

⁷ Because of constraints imposed by the ongoing COVID-19 pandemic, we were unable to conduct a classified-level GEOINT analysis using National Geospatial-Intelligence Agency data.

⁸ For an introduction to Raqqa-focused GEOINT, see Eric Robinson, Daniel Egel, Patrick B. Johnston, Sean Mann, Alexander D. Rothenberg, and David Stebbins, *When the Islamic State Comes to Town: The Economic Impact of Islamic State Governance in Iraq and Syria*, Santa Monica, Calif.: RAND Corporation, RR-1970-RC, 2017, especially pp. xvi–xvii, 22, 30–40.

⁹ The UNITAR-UNOSAT snapshot dates are October 22, 2013; February 12, 2014; May 29, 2015; February 3, 2017; and October 21, 2017.

trusted Western news agencies, including Reuters, the Associated Press, CNN, and the BBC World Service.

We provide an overall assessment of the infrastructure damage during the battle for Raqqa and in previous instances of visible civilian harm in the city, and we selected a series of satellite images that typify the types of infrastructure damage identified and the potential motivations of the likely perpetrator. Where possible, we seek to identify the general munition class used, but data concerning precise munitions used by SARG, ISIS, the U.S.-led coalition, and the Syrian Democratic Forces (SDF) are not comprehensive.

Notes on Time and Terminology

In this annex, we adopt the CJTF-OIR timeline for the battle for Raqqa, as well as that group's terminology and geographical toponyms (e.g., "Raqqa" not "Raqqah" or "Ar-Raqqah").¹⁰ For events before the battle for Raqqa, we adopt the timeline determined by existing research.¹¹ Where specific building names are unknown, we use the name of the neighborhood, the street on which the building is situated, or both.

¹⁰ CJTF-OIR, "OIR Quick Reference Fact Sheet," Public Affairs Office, 2019a.

¹¹ Robinson et al., 2017; and Nate Rosenblatt and David Kilcullen, *How Raqqa Became the Capital of ISIS: A Proxy Warfare Case Study*, Washington, D.C.: New America, July 25, 2019.

Strikes and Civilian Harm from the Syrian Arab Republican Government

SARG forces deployed a combination of unguided and guided rockets and incendiary, barrel, and thermobaric bombs; the thermobaric bombs included both fuel-air explosives and vacuum bombs.¹ Damage caused by these relatively small-scale but highly lethal devices can be difficult to identify via satellite imagery. Some thermobaric devices are specifically designed to kill people and destroy buildings through their vacuum-creating shockwaves, and they do not leave major craters when detonated in open spaces.²

On September 29, 2013, for instance, Human Rights Watch documented a SARG thermobaric attack on the Ibn Tufail Commercial Secondary School (Figure A-2.1). A device that Human Rights Watch identified but did not confirm as a fuel-air explosive detonated in the front school yard, resulting in two diminutive craters, identified as primary Impact A and secondary Impact B. The device nonetheless killed at least 12 students. Ground-level footage highlighted that the device used was primarily designed to eliminate people, not buildings.³

SARG frequently executed ballistic missile strikes on Raqqa, potentially using what a *Defense One* writer identified as Russian-made R-40/-60, Kh-29T, or Kh-58 missiles.⁴ UNITAR-UNOSAT statistical data integrated with Maxar satellite imagery confirmed a Human Rights Watch–reported SARG ballistic missile attack in the Hurriyah neighborhood near the Shahada Mosque on April 24, 2013. The attack killed two civilians. Neighbors told Human Rights Watch that they believed it to be a SARG ballistic missile attack because “of the large-scale destruction, absence of any government positions in the direction the missile came from, and the absence of aircraft at the time of the attack.”⁵

¹ Amnesty International has suggested but not confirmed that many of these attacks were undertaken by Syrian Air Force MiG-29s upgraded via a Russian Aircraft Corporation maintenance, repair, and operations base at Mezze Air Base near Damascus, which first opened on the eve of the Syrian civil war in 2011 (Amnesty International, *Al-Raqqa Under Attack: Syrian Airforce Strikes Against Civilians*, London, 2015, p. 6).

² Ben Watson, “Weapons of the Syrian War: Airpower (Syrian),” *Defense One*, July 19, 2016; Mary Wareham, “Dispatches: Incendiary Weapons Pose Civilian Threat in Syria,” Human Rights Watch, June 21, 2016; Human Rights Watch, *Syria’s Use of Incendiary Weapons: Memorandum to Convention on Conventional Weapons Delegates*, New York, November 2013c, pp. 6–9; and Torie Rose DeGhett, “A New Kind of Bomb Is Being Used in Syria and It’s a Humanitarian Nightmare,” *Vice*, August 28, 2015.

³ Human Rights Watch, “Syria: Fuel-Air Bombs Strike School,” October 1, 2013b.

⁴ Watson, 2016.

⁵ Human Rights Watch, “Syria: Ballistic Missiles Killing Civilians, Many Children,” August 4, 2013a.

Figure A-2.1
SARG Fuel-Air Explosive Strike on Ibn Tufail Commercial Secondary School, September 29, 2013



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap; Human Rights Watch, 2013b.

UNITAR-UNOSAT integrated data identified other residential districts that sustained significant infrastructure damage during SARG attacks. Another strike destroyed much of two residential blocks in the al-Baryd neighborhood (Figure A-2.2). These attacks share similar satellite damage signatures as the Hurriyah attack, suggesting they were all caused by SARG ballistic missiles.

Figure A-2.2
Likely SARG Ballistic Missile Strike in the al-Baryd Neighborhood, Before October 22, 2013



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Civilian Harm in ISIS-Controlled Raqqa

UNITAR-UNOSAT data identified that an additional 113 buildings (all types) were destroyed or damaged between October 2013 and February 12, 2014, well before the start of U.S.-led coalition air strikes against ISIS targets in September 2014.¹ The majority of these buildings were likely damaged or destroyed by SARG strikes.

As previous RAND research has determined, ISIS primarily focused its efforts during this period on rebuilding rather than destroying damaged civilian infrastructure in an effort to legitimize its authority in Raqqa.² When ISIS did destroy civilian infrastructure, it targeted symbolically important buildings that it deemed blasphemous to its extremely conservative conception of Islam or that it suspected were being used for purposes threatening to its authority.³ ISIS deliberately targeted Shi'ite mosques, for instance, in order to “strike a deep chord within the Shi'a psyche.”⁴ On March 26, 2014, ISIS blew up Raqqa's famed Uwais al-Qarni Mosque (Figures A-3.1 and A-3.2). Similarly, ISIS destroyed statues and historical artifacts that it judged to have been co-opted to support secular Arab nationalism.⁵ In September 2014, the U.S. State Department reported, for instance, that ISIS had destroyed Raqqa's Assyrian-period gateway lion.⁶

¹ UNITAR-UNOSAT, “Damage Assessment of Ar Raqqa, Ar Raqqa Governorate, Syria,” map, Geneva, May 22, 2017a.

² Robinson et al., 2017, p. 107.

³ Robinson et al., 2017, p. 103.

⁴ Dimitar Mihaylov, “Cracks in the Crescent: The Looming Sectarian Clash Between Khilafah and Imamah,” *Israel Journal of Foreign Affairs*, Vol. 9, No. 1, 2015, p. 58.

⁵ Christopher W. Jones, “Understanding ISIS's Destruction of Antiquities as a Rejection of Nationalism,” *Journal of Eastern Mediterranean Archaeology and Heritage Studies*, Vol. 6, Nos. 1–2, 2018; Robinson et al., 2017, pp. 103–105; and T. Fateh, “Qaeda Terrorists Blasted Khalifa Harun al-Rashid Statue in Raqqa,” *Syria Times*, October 4, 2013.

⁶ U.S. Department of State, “Threats to Cultural Heritage in Iraq and Syria,” fact sheet, Office of the Spokesperson, September 23, 2014.

Figure A-3.1
Uwais al-Qarni Mosque, March 20, 2014



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Figure A-3.2
ISIS-Destroyed Uwais al-Qarni Mosque, May 31, 2014



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Coalition Air Strikes Before the Battle for Raqqa

The United States and key coalition partners, notably France and the United Kingdom, began striking known ISIS targets in Raqqa on September 22, 2014.¹ Targets included intelligence-confirmed ISIS offices, leadership houses, and critical transportation and military infrastructure. A coalition precision strike on or about February 17, 2017 (Figure A-4.1), rendered the Old Raqqa Bridge (also known as the al-Mansour Bridge) unusable to ISIS vehicles or military equipment.² Civilians turned to improvised slipways and ferries to transport people and goods across the Euphrates River. CNN suggested that the strike's precise nature—notably, eliminating one key section instead of obliterating the entire bridge—was deliberate to aid reconstruction at a later date.³

Coalition forces executed a similar precision strike against the New Raqqa Bridge (also known as the al-Rashid Bridge) before May 16, 2017 (Figure A-4.2). Both bridges share common strike signatures, again suggesting that the coalition made efforts to minimize infrastructure damage to help aid an eventual reconstruction. On or about May 16, however, coalition forces again targeted the New Raqqa Bridge, launching a dynamic strike against at least one ISIS tactical unit. The strike destroyed the bridge's southern half.⁴

¹ Martin Chulov, Spencer Ackerman, and Paul Lewis, "US Confirms 14 Air Strikes Against ISIS in Syria," *The Guardian*, September 23, 2014; Jim Sciutto, Mariano Castillo, and Holly Yan, "U.S. Airstrikes Hit ISIS Inside Syria for First Time," CNN, September 23, 2014; Robinson et al., 2017, p. 103; and Thomas Barrabi, "US Airstrikes in Syria: Timeline of Events That Led Obama to Target Islamic State," *International Business Times*, September 23, 2014. Only 14 coalition strikes had taken place, however, by January 6, 2015, according to Amnesty International, 2015, p. 9.

² U.S. Central Command, "Military Strikes Continue Against ISIS Terrorists in Syria and Iraq," press release, No. 17-072, February 18, 2017a.

³ Nick Paton Walsh, Dominique van Heerden, and Salma Abdelaziz, "Satellite Captures Rare Snapshot of Life in Raqqa," CNN, April 25, 2017.

⁴ U.S. Central Command, "Military Strikes Continue Against ISIS Terrorists in Syria and Iraq," press release, No. 17-186, May 17, 2017b.

Figure A-4.1
Coalition Strike Damage to the Old Raqqa Bridge, on or Around February 20, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Figure A-4.2
Initial and Subsequent Strike Damage, New Raqqa Bridge, Between May 16 and May 29, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

ISIS's Use of Civilian Infrastructure as a Defensive Tactic

In this section, we present a GEOINT analysis of how ISIS repurposed civilian infrastructure for self-defense. We focus on four types of civilian infrastructure that ISIS repurposed for military uses during the battle for Raqqa: schools, hospitals, mosques, and residential buildings. As articulated earlier, it is not possible to determine to what extent a strike against one building might have affected nearby buildings (e.g., laterally propelled strike debris might have inadvertently damaged adjacent structures) beyond what is visible in the vertically oriented open-source satellite imagery.

Schools

ISIS deliberately commandeered primary and secondary educational institutions for its military operations. ISIS fighters established themselves in school buildings to hide from coalition strikes and used children and teachers as human shields.¹ CJTF-OIR strike releases do not identify whether coalition air strikes during the battle for Raqqa specifically targeted educational institutions, only that they eliminated “fighting positions.”² But the highly targeted nature of the strikes resulted in minimal satellite-visible damage to adjacent buildings, suggesting that coalition forces were seeking to avoid excessive damage to civilian property and life.

Rashid Primary School serves as one example of how the coalition faced the challenge of ISIS fighters hiding in schools. The school, located next to the Telecommunications and Post Corporation in the central Rashidiyeh neighborhood, was destroyed in a May 27, 2017, coalition air strike confirmed by SNHR. SNHR classified the strike as an “international coalition forces violation.”³ The telecommunication building was spared the brunt of the strike. CJTR-OIR strike releases acknowledge that coalition military forces struck “eight ISIS tactical units;

¹ Hollie McKay and Steven Nabil, “How ISIS Uses Human Shields in Fighting Coalition Forces,” Fox News, September 27, 2017.

² See, for example, U.S. Central Command, “Military Strikes Continue Against ISIS Terrorists in Syria and Iraq,” press release, No. 17-365, September 16, 2017k.

³ REACH Initiative, *Humanitarian Atlas: Ar-Raqqa City, Syrian Arab Republic*, Geneva, February 2018, p. 16, “Amin Neighbourhood (Ethe kana/Fardous/Rasheed): Satellite-Detected Severity of Structure Damage – 21 October 2017”; and SNHR, “International Coalition Forces Shelled al Rashid School in al Qwatli Street in Raqqa City on May 27,” May 27, 2017.

destroyed six fighting positions, three ISIS headquarters, an ISIS staging area and a VBIED [vehicle-borne improvised explosive device].”⁴

Satellite imagery evidences one reason—in addition to ISIS’s general strategy of repurposing essential civilian facilities for self-defense—why ISIS had likely seized Rashid Primary School as a neighborhood headquarters (Figure A-5.1). The school’s proximity to the telecommunications center, including its tower, antennae, and technical equipment—a potentially more legitimate military target under international law—could have afforded ISIS with a strategic cover. ISIS could have operated essential communications from the school, running cables to the antennae, even if the telecommunication building itself was damaged or destroyed in an air strike. ISIS recognized, too, that any strike targeting the school would be publicized by such human rights organizations as SNHR as a violation.

The stark damage contrast between the Rashid Primary School and immediate neighboring buildings suggests that coalition forces (1) acted on time-sensitive intelligence that ISIS was operating in that building and (2) targeted the building to minimize the risk to life and property in the school’s immediate environs, even leaving the telecommunication building relatively intact, at least according to open-source satellite imagery.

The destruction of the Tariq bin Ziyad School on July 24–25, 2017, shares satellite imagery damage signatures that are similar to those of the other schools (Figure A-5.2).

Figure A-5.1
Rashid Primary School, Destroyed May 27, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

⁴ U.S. Central Command, “Military Strikes Continue Against ISIS Terrorists in Syria and Iraq,” press release, No. 17-201, May 28, 2017c.

Figure A-5.2
Tariq bin Ziyad School, Destroyed on or Around July 24, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

UNITAR-UNOSAT data suggest, but do not confirm, that the strike targeted the side of the building closest to the street corner.⁵ According to Airwars, six confirmed (and up to 25 unconfirmed) civilians were killed in this strike, and an unknown number were wounded. Airwars stated, “The school had been converted into a collection point for civilians who could not flee outside the city.”⁶ CJTR-OIR strike releases note only that the coalition “destroyed six fighting positions.” The Royal Air Force may have executed this strike. The U.K. Ministry of Defence did not acknowledge responsibility for any specific attack, stating only that, “On 23 July, three flights of Tornados and Typhoons conducted missions over the city [Raqqa], in which they delivered successful attacks on six Daesh positions, using Paveway IV bombs and Brimstone missiles.”⁷ It is plausible that, if the Royal Air Force struck the Tariq bin Ziyad School, it did so with a Paveway IV bomb, given that the entire building was destroyed and Brimstone missiles are designed to eliminate moving targets, such as enemy convoys.⁸

⁵ REACH Institute, 2018, p. 25, “Furat Neighbourhood (Bain al Jisreen/Furat): Satellite-Detected Severity of Structure Damage – 21 October 2017.”

⁶ Airwars, “Civilian Casualties: Airwars Assessment,” incident CS1253, July 23, 2017a.

⁷ Airwars, 2017a.

⁸ Benjamin D. Katz, “Brimstone Missile Joins Syria as U.K. Hits Islamic State,” Bloomberg, December 3, 2015. In an Airwars report, Samuel Oakford argues that a “500lb bomb”—presumably the Paveway IV—was the Royal Air Force’s “present munition of choice for urban actions” (Samuel Oakford, *Credibility Gap: United Kingdom Civilian Harm Assessments for the Battles of Mosul and Raqqa*, London: Airwars, 2018, p. 3).

Hospitals and Clinics

ISIS deliberately established command and control centers; prison, interrogation, and torture units; munition depots; and fighting positions in hospitals and clinics, thereby causing the medical establishments to “lose [their] protected status afforded by the Law of Armed Conflict by using a facility otherwise protected under the Geneva Conventions.”⁹ Doctors, nurses, and patients were routinely used as human shields.

By the end of the battle for Raqqa, all of the city’s hospitals and clinics had been damaged or destroyed. This notably included the city’s branch of the national hospital, which was the site of an ISIS base and one of the last buildings that the coalition captured when it seized the city. The national hospital may have also been targeted with several air strikes, according to various allegations.¹⁰ Multiple sources, however, acknowledged that ISIS had turned the national hospital into a multi-use headquarters military facility and trapped civilians inside as human shields.¹¹ Although the accuracy of the intelligence used when coalition forces ultimately did strike these buildings is unknown, the open-source satellite imagery nonetheless evidenced that efforts were taken to minimize collateral damage to immediately surrounding civilian infrastructure.

Mosques

The destruction of some mosques and other religious establishments in the city preceded the battle for Raqqa. ISIS turned other mosques, many of which were embedded in the heart of residential districts, into military sites, thereby removing their protected status and threatening the safety of those who lived nearby.

The Abdul Rahamm Ibn Awf mosque in the Tas-Heeh residential neighborhood typifies ISIS’s use of mosques for military purposes (Figure A-5.3).¹² The mosque was surrounded by two- to three-story planned middle-class, multi-family residences, largely constructed between 2007 and 2012 and organized in a moderately dense configuration with small, planned open spaces.¹³ A children’s hospital and the Union of Artisans building were located within 1,000 ft of the mosque. Although CJTF-OIR strike releases for the period do not explicitly mention targeting a mosque, satellite imagery damage signatures suggest that a coalition air strike

⁹ CJTF-OIR, “ISIS Actions Lead to Loss of Protected Status,” press release, December 10, 2018. See also CJTF-OIR, “French Air Support to Takeover Hajin,” press release, January 12, 2019b; and Ryan Dillon and Jeff Davis, “Department of Defense Briefing by Colonel Dillon via Teleconference from Baghdad, Iraq,” transcript, U.S. Department of Defense, June 29, 2017.

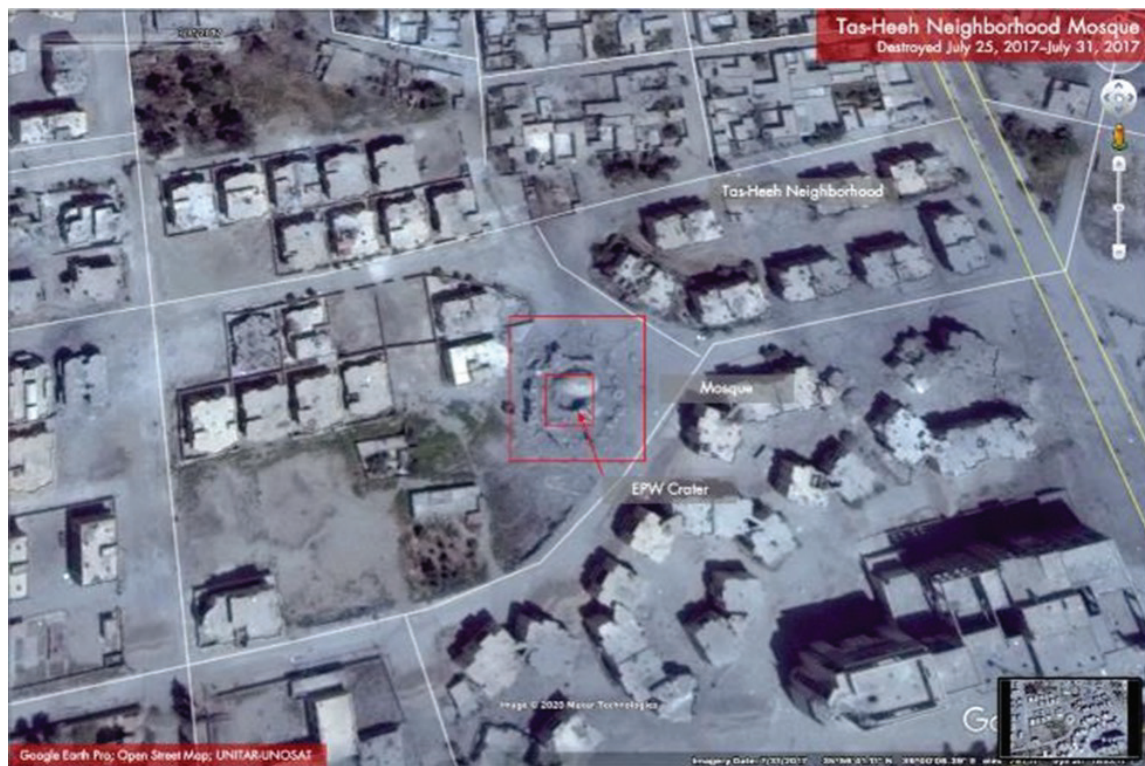
¹⁰ Physicians for Human Rights, “Heavy Bombardment by U.S. and Coalition Forces Devastate Hospitals in Raqqa,” undated.

¹¹ Airwars, “U.S.-Led Coalition in Iraq & Syria: Airwars Assessment,” incident CS1643, October 17, 2017; David Sim, “Battle for Raqqa Photos: ISIS Confined to Hospital and Stadium, with Hostages and Snipers in Both,” *International Business Times*, October 3, 2017; Maher Al-Hamdan, “The Ongoing Medical Crisis in Raqqa,” Atlantic Council, May 16, 2018; and Ryan Dillon and Adrian Rankine-Galloway, “Department of Defense Press Briefing by Colonel Dillon via Teleconference from Baghdad, Iraq,” transcript, U.S. Department of Defense, September 21, 2017.

¹² REACH Institute, 2018, p. 19, “Tas Heeh Neighbourhood (Benurama/Al Baasil): Satellite-Detected Severity of Structure Damage – 21 October 2017.”

¹³ This information is based on time-lapse Maxar satellite imagery from Google Earth Pro, 35°56’41.0”N, 39°00’09.1”E.

Figure A-5.3
Abdul Rahamm Ibn Awf Mosque, Destroyed via Earth-Penetrating Weapon Between July 25 and July 31, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.
 NOTE: EPW = earth-penetrating weapon.

destroyed the Abdul Rahamm Ibn Awf mosque between July 25 and July 31, 2017, during the first two months of the coalition-backed SDF’s assault on Raqqa.¹⁴ The strike is noticeable by the apparent lack of significant collateral damage to surrounding residential infrastructure, even buildings only a few hundred feet away.

Specifically, the mosque’s distinct damage signature suggests that the coalition used an earth-penetrating weapon that was surgically targeted and set with a delay so that it would detonate beneath the surface and therefore reduce fragmentation that could damage adjacent infrastructure and injure or kill neighboring civilians. The weapon entered via the side of the mosque, exploding beneath the ground in the center and leaving a relatively deep but contained crater. The dome remained intact.

¹⁴ See U.S. Central Command, “Military Strikes Continue Against ISIS Terrorists in Syria and Iraq,” press release, Nos. 17-278, 17-281, 17-282, 17-284, 17-285, 17-286, and 17-287, July 24–31, 2017d–j.

Civilian Housing

At least four types of civilian residential infrastructure existed in Raqqa. In Raqqa's Old City and much of the downtown, it was old, extremely dense two- to five-story apartments of relatively poor construction quality that predominated. One- and two-story single- and multi-family houses of similarly poor quality populated much of the peripheral Ammar Ibn Yasser, Ma'amoun, Yamuk, and Qadessiyeh neighborhoods. A combination of larger, more-ornate middle- and upper-class single- and multi-family homes and Soviet brutalist-style apartment complexes could be found in the Tas-Heeh, Furat, and Batani neighborhoods.¹⁵

A satellite imagery examination of coalition strike damage to major apartment complexes evidences three trends (Figures A-5.4 through A-5.7). First, ISIS militants likely reinforced these complexes with a combination of fighters, snipers, improvised explosive devices, and tunnels to significantly slow down the advance of coalition-backed SDF fighters in the first weeks of the battle for Raqqa.¹⁶ Second, the buildings' open-source GEOINT damage signatures suggest that coalition forces used precise munitions to dynamically strike ISIS positions in specific buildings, and it appears that the coalition sought to minimize collateral damage to adjacent buildings where SDF fighters or trapped civilians might have been located. The extent to which debris damaged buildings adjacent to the targeted structure, however, is unknown. Third, the coalition would have had to use a larger munition size to flatten reinforced cement apartment towers, especially those in the east Raqqa apartment complex highlighted in Figures A-5.4 through A-5.7.

¹⁵ REACH Institute, 2018, p. 3, "Ar-Raqqa City – Neighbourhood Reference Map."

¹⁶ SDF fighters assaulted these positions in the early weeks of the battle for Raqqa (David R. Kogan, *The Coalition Military Campaign to Defeat the Islamic State in Iraq and Syria AUG 2016–05 SEP 2017: The Sky Dragon Dismantles the "Caliphate,"* Combined Joint Task Force – Operation Inherent Resolve, 2017, p. 41).

Figure A-5.4
East Raqqa Apartment Complex, May 30, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Figure A-5.5
East Raqqa Apartment Complex: The First SDF Assault, June 10, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Figure A-5.6
East Raqqa Apartment Complex: Additional Targeted Damage, June 16, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Figure A-5.7
East Raqqa Apartment Complex: Destroyed and Intact Buildings, September 29, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Analysis of coalition strikes against presumed residential structures in Raqqa's Old City help us visualize how CJTF-OIR precision strikes followed the movement of ISIS units across a dense urban environment (Figures A-5.8 through A-5.11). Satellite imagery of one city block immediately south of the Harun al-Rashid fortress ruins in the Mahdi neighborhood supports the argument that coalition forces targeted individual buildings as intelligence and dynamic ground situations warranted. Between the commencement of the battle for Raqqa and July 18, 2017, for instance, coalition forces targeted a single building on the block's northeast corner. The following week, the coalition targeted an adjacent, interior building but otherwise left the rest of the block intact. A third building, this time on the block's western side, was eliminated between July 24 and August 12, 2017, forming a line of targeted buildings that cut across the block as coalition-backed SDF fighters fought building by building to control the Old City in early to mid-August 2017. This pattern suggests that ISIS militants were moving positions across the block, were in control of individual buildings, or both, thereby requiring dynamic strikes in support of SDF ground operations. The block was captured by the SDF between mid-August and early September 2017.¹⁷

¹⁷ Kogan, 2017, p. 42.

Figure A-5.8
City Block in Raqqa's Old City, July 6, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Figure A-5.9
Initial Targeted Strikes, July 5–18, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Figure A-5.10
Continued Targeted Strikes Supporting the SDF's Advance, July 24–August 12, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Figure A-5.11
City Block in Raqqa's Old City: Buildings Destroyed by Targeted Strikes Versus Buildings Damaged by Ground Fighting, August 12–October 1, 2017



SOURCES: Google Earth Pro, Maxar Technologies; OpenStreetMap.

Abbreviations

CJTF	combined joint task force
GEOINT	geospatial intelligence
ISIS	Islamic State of Iraq and Syria
OIR	Operation Inherent Resolve
SARG	Syrian Arab Republican Government
SDF	Syrian Democratic Forces
SNHR	Syrian Network for Human Rights
UNITAR	United Nations Institute for Training and Research
UNOSAT	Satellite Analysis and Applied Research program

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