# Damage Assessment of Health and Educational Facilities in Sievierodonetsk Raion, Ukraine:

# Evidence of Widespread, Indiscriminate, and Persistent Bombardment by Russia and Russia-Aligned Forces Between 24 February - 13 June 2022

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Yale SCHOOL OF PUBLIC HEALTH
*Humanitarian Research Lab*

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# I. Executive Summary

## INTRODUCTION

This report is the result of a damage assessment of healthcare and educational facilities in Sievierodonetsk raion (district) in Luhansk oblast (region) of Ukraine by the Yale School of Public Health's Humanitarian Research Lab (Yale HRL). The assessment was conducted as part of HRL's participation in the Conflict Observatory[1] and in support of the Organization for Security and Cooperation in Europe's (OSCE) 2 June 2022 invocation of the Moscow Mechanism.[2]

The sources for this report are commercial satellite imagery and publicly available information found online. A methodology section is included below (*see* Appendix II for further detail). This document is a summary of case files that the Yale HRL team created for each visibly damaged facility it investigated in Sievierodonetsk raion.

Due to the sensitive geolocation data present in each case file that could facilitate further attacks, the full dossier is not being released publicly at this time. The case files may be released upon request to Yale HRL and the Conflict Observatory in support of future judicial proceedings, law enforcement investigations, and public health research. The full dossier that forms the basis of this summary report includes:

- Case files with supporting documentation of geolocation, methodologies used, and imagery analysis annotation;
- Annex of sites identified and classification of visible damage to facilities;
- Annotated imagery with notation of satellite source, acquisition date, ground sampling distance, and off-nadir angle;
- Yale HRL damage classification, key findings showing pre- and post-impact of evident bombardment on structures; and
- Image files (unannotated) and complete associated metadata.

## MAIN FINDINGS

*Widespread, Indiscriminate, and Persistent Damage to Protected Civilian Objects*

A total of 21 healthcare facilities and 30 public primary and secondary schools in the cities of Sievierodonetsk, Lysychansk, Rubizhne, and Popasna in Sievierodonetsk raion in Ukraine have been damaged by bombardment by Russia and Russia-aligned and affiliated forces between 24 February and 13 June 2022.[3] Yale HRL determined that these facilities sustained damage due to evident aerial and artillery bombardment by cross-corroborating forensic analysis of very high resolution (VHR) commercial satellite imagery and multiple sources of publicly available online information.

The alleged attribution of responsibility to Russia and Russia-aligned forces for the indiscriminate, widespread, and persistent bombardment of civilian objects documented by this damage assessment is based on multiple press accounts of the presence of Ukrainian forces and civilians under intense aerial and artillery bombardment in the urban areas analyzed in this damage

1. "Conflict Observatory." Accessed 21 June 2022. https://conflictobservatory.org/. Archived at https://perma.cc/Y3L4-XZ3A

2. Permanent Council of the Organization for Security and Co-operation in Europe. "1360th Plenary Meeting of the Council." Organization for Security and Co-operation in Europe, March 3, 2022. PC.JOUR/1360. https://www.osce.org/files/f/documents/d/7/514480.pdf. Archived at https://perma.cc/35EH-MT4A.

3. In this report, each medical and educational institution is counted as a separate "facility". Facilities can either consist of a single building or incorporate multiple structures. In three instances, Yale HRL identified hospital complexes wherein multiple, separate medical facilities were situated. In these cases, Yale HRL recorded damage incurred at each facility within the same complex as individual instances of a facility being counted as damaged.

assessment.[4] The imagery and open source data analyzed by Yale HRL independently corroborates reports of Russia and Russia-aligned forces bombarding Ukrainian forces and civilians in urban areas of Sievierodonetsk raion.

Table 1. Healthcare and Educational Facilities

| | FACILITIES IDENTIFIED | FACILITIES DAMAGED CONSISTENT W/ BOMBARDMENT | % ANALYZED FACILITIES DAMAGED |
|---|---|---|---|
| Schools | 59 | 30 | 51% |
| Medical | 30 | 21 | 70% |
| Total | 89 | 51 | 57% |

This review of 30 healthcare facilities and 59 public primary and secondary schools across the four main urban areas in Sievierodonetsk raion found that 57 percent of all facilities analyzed have sustained some form of visible damage. Eight have been destroyed and 22 facilities have sustained more than one wave of bombardment. Of the remaining 38 facilities with no visible direct damage, 20 had visible damage to buildings within a 400 meter radius, and 18 had no damage to the surrounding area.

Based on this evidence above, Yale HRL concludes with high confidence that Russia and Russia-aligned forces have engaged in widespread, indiscriminate, and persistent bombardment of protected civilian objects in Sievierodonetsk raion on a massive scale.[5] Widespread, indiscriminate, and persistent bombardment of protected civilian objects can constitute a war crime and crime against humanity (*see* Section III.b. for legal context).

First, civilian objects in this raion have been subjected to "widespread" bombardment because more than half of the healthcare and educational facilities analyzed have incurred some degree of damage. This damage is generally consistent with the buildings having been struck from above in a way conforming with either an artillery or aerially delivered munition. Second, these attacks are "indiscriminate" because they have made no distinction between military targets and civilian objects. Lastly, the bombardment of these civilian objects can be reasonably described as persistent given the overwhelming evidence that many of these locations have been recently hit by multiple waves of bombardment.

Yale HRL does not present findings in this report on intentionality. However, Yale HRL reviewed indicators that can in some places be probative of intentional targeting of civilian objects. While probative evidence of intent was collected and analyzed, this report does not make an overall determination on the intent to target civilian facilities – regardless, the damage documented herein is clear evidence of alleged war crimes by Russia and Russia-aligned forces.

4. Associated Press. "Russian troops push further into Sievierodonetsk, leaving city 'completely ruined.'" May 30, 2022.

5. N.B. General Protection of Civilian Objects from Protocol Additional to the Geneva Conventions of 12 August 1949 and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977: "1. Civilian objects shall not be the object of attack or of reprisals. Civilian objects are all objects which are not military objectives as defined in paragraph 2. 2. Attacks shall be limited strictly to military objectives. In so far as objects are concerned, military objectives are limited to those objects which by their nature, location, purpose or use make an effective contribution to military action and whose total or partial destruction, capture or neutralization, in the circumstances ruling at the time, offers a definite military advantage. 3. In case of doubt whether an object which is normally dedicated to civilian purposes, such as a place of worship, a house or other dwelling or a school, is being used to make an effective contribution to military action, it shall be presumed not to be so used. International Committee of the Red Cross (ICRC). "Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I)," § Article 52, 8 June 1977, 1125 U.N.T.S. 27. https://ihl-databases.icrc.org/ihl/WebART/470-750067. Archived at https://perma.cc/7WX8-25GA.

*Potential War Crimes and Crimes against Humanity*
This alleged pattern of practice by Russia and Russia-aligned forces could constitute a violation of international humanitarian law, international human rights law, and international and Ukrainian national criminal law. These violations may rise to the level of war crimes and crimes against humanity regardless of whether these facilities were attacked intentionally or as a result of indiscriminate use of force. Each time a facility is attacked — even the same facility being attacked multiple times across separate incidents — may count as individual and distinct criminal acts.

*Four Levels of Damage Classification*
This report classifies facilities by assigning each of them one of four levels on the following damage assessment scale based on available satellite imagery at the time of analysis: 1) no visible damage; 2) minimal damage: some degree of damage is visible; 3) partial damage: substantial damage is visible; and 4) total damage: building appears destroyed. Yale HRL did not attempt to determine whether individual incidents of facility bombardment were the result of indiscriminate fire or intentional targeting. (For additional detail on damage classification, *see* Appendix I.)

Table 2. Facilities with Visible Damage

| LEVEL OF DAMAGE | TOTAL | PARTIAL | MINIMAL | TOTAL N°. FACILITIES |
|---|---|---|---|---|
| Schools | 3 | 16 | 11 | 59 |
| Medical | 5 | 8 | 8 | 30 |
| Total | 8 | 24 | 19 | 89 |

*Evidence of Multiple Waves of Bombardment on Individual Facilities*
Yale HRL observed that several identified locations incurred damage on multiple separate occasions between 24 February and 13 June 2022. Although the exact date of a damage incident cannot always be verified by imagery alone, the geospatial team was able to conclude with available imagery that several identified locations incurred independent and progressive incidences of damage over time, in this report termed waves, such that the degree of damage for these identified locations increased across the reporting period.

Table 3. Waves of Attack per Damaged Facility

| N°. OF WAVES | NO DIRECT DAMAGE | AT LEAST 1 CONFIRMED WAVE | AT LEAST 2 CONFIRMED WAVES | 3 OR MORE CONFIRMED WAVES |
|---|---|---|---|---|
| Schools | 29 | 14 | 12 | 4 |
| Medical | 9 | 15 | 3 | 3 |
| Total | 38 | 29 | 15 | 7 |

*Allegations of Ukrainian Military Assets Present at Educational Facilities*
Yale HRL identified at least two instances in open source information indicating possible placement of military vehicles and equipment at two educational facilities by Ukrainian forces in Sievierodonetsk raion during the time frame covered by this assessment.[6] In one image, the

6. In both cases, military equipment known to be in the Ukrainian arsenal was positioned near protected infrastructure on territory controlled by the Ukrainian government/military. In the case of the howitzers, there is a question of when the original image was taken; based on the absence of foliage and the presence of cold weather gear on the soldiers, the image was likely taken prior to Russian forces taking control of the area in late May - early June. The location has been confirmed through geospatial analysis and there is video of a battery of guns at the same location around the same time that corrobo-

burnt remains of what appear to be two military transport vehicles consistent with those used by Ukrainian forces are present in front of a damaged school building at Lysychansk Multidisciplinary Gymnasium.[7] In a separate image, a battery of three howitzers with crew is seen on the sports field at Sievierodonetsk School No. 11.[8] However, Yale HRL could not independently verify these two reports through the VHR satellite imagery available at the time of the assessment.

While those two locations may have become legitimate targets[9] if military assets had been positioned there by Ukrainian forces as online reports suggest, it does not obviate the obligation of Russia and Russia-aligned forces to respect the legally protected status of all other educational and health facilities. These instances of potential dual use do not limit in any way the responsibility of all parties to the conflict to ensure that reasonable precautions are taken to prevent damage to critical civilian infrastructure, such as schools and hospitals, at all times.

rates the authenticity of the image. Combined, these facts lead Yale HRL to conclude with a high level of confidence that the artillery in the image is Ukrainian. Similarly, the facility with destroyed trucks happened on territory under Ukrainian control, ruling out the possibility of mistaken attribution. The image is one of a series of images that were used to illustrate media articles and social media posts from Ukrainian government officials covering the incident (but not addressing the presence of the vehicle wrecks). Due to the degree of damage to the vehicles, it is not certain that the trucks were used for military purposes; however, they have characteristics that correspond to the military rather than civilian version of the vehicle including a roof rack and 3-axle wheelbase.

7. Still image as well as a video clip from an article published on Censor.net on 2 May 2022 shows two burned vehicle wrecks in front of Lysychansk Multidisciplinary Gymnasium, one appearing to be a ZiL-131 truck, the other being more difficult to identify, but possibly another ZiL-131, or a similar type of vehicle. These types of vehicles are used by the Ukrainian military. Censor.net is a Kyiv-based news website. Censor.NET. "As Result of Enemy Shelling, Lysychansk Gymnasium, Built More than 100 Years Ago, Burned down. VIDEO&PHOTOS," 2 May 2022. https://censor.net/en/photo_news/3338381/as_result_of_enemy_shelling_lysychansk_gymnasium_built_more_than_100_years_ago_burned_down_videophotos. Archived at http://archive.today/EOmMe.

8. An image showing three D-30 122mm howitzers set up in firing position with soldiers around them was first circulated widely on 2022.02.26 but it is not known when it was taken. Geolocation analysis has placed the battery on the athletic field in front of Sievierodonetsk School No. 11. D-30 and its variants are used by Ukrainian artillery forces. Royal Intel 👑[@RoyalIntel_]. "#Breaking #Russia #Ukraine The City of Severodonetsk, Artillery of the Ukrainian Army in Residential Areas. Https://T.Co/SWM9xnWIxF." Tweet. Twitter, 26 February 2022. https://twitter.com/RoyalIntel_/status/1497483438856749057. Archived at https://perma.cc/U2DS-S622.

9. ICRC Customary International Humanitarian Law Rule 10. "Civilian objects are protected against attack, unless and for such time as they are military objectives." Henckaerts, Jean-Marie, and Louise Doswald-Beck. Customary International Humanitarian Law. Vol. 1. 2 vols. Cambridge University Press, 2005. https://ihl-databases.icrc.org/customary-ihl/eng/docs/v1_rul_rule10. Archived at https://perma.cc/Y58B-UTDK.

# II. Background, Legal Context, Methods, and Limitations

## BACKGROUND ON MOSCOW MECHANISM AND THE ONGOING CONFLICT IN SIEVIERODONETSK RAION

### 2 JUNE 2022 INVOCATION OF MOSCOW MECHANISM

The OSCE Moscow Mechanism was invoked for a second time by the OSCE after consultation with Ukraine on 2 June 2022 by 45 countries, including the United States. This is the second invocation of the Moscow Mechanism since Russia's invasion of Ukraine on 24 February 2022. The Moscow Mechanism "provides the option of sending missions of experts to assist participating States in the resolution of a particular question or problem relating to the human dimension."[10]

This invocation of the mechanism, among other objectives, specifically includes efforts to "[e]stablish the facts and circumstances of possible cases of war crimes and crimes against humanity, including due to deliberate and indiscriminate attacks against civilians and civilian infrastructure."[11] This report seeks to provide evidence to the Moscow Mechanism pertaining to deliberate and indiscriminate attacks against civilians and civilian infrastructure.

### CONFLICT IN SIEVIERODONETSK RAION AND ATTRIBUTION OF INDISCRIMINATE BOMBARDMENT

Sievierodonetsk raion is an area located within Luhansk oblast and part of the larger Donbas region of Ukraine. Parts of the raion have been contested or under partial occupation by Russia and Russia-aligned forces intermittently since 2014.[12] An estimated 14,000 people died as a direct result of the conflict in the eight years preceding the full-scale invasion of Ukraine by Russia and its allies and affiliated forces in February 2022.[13] Multiple ceasefires under the monitoring of the OSCE Special Monitoring Mission during the pre-invasion period had been attempted; the longest took effect in July 2020.[14]

In April of this year, Russia announced "Phase II" of its purported "special operation" in Ukraine, shifting significant military forces that had been committed in the area of Kyiv and Chernihiv to Donbas.[15] This new phase of the war has put Sievierodonetsk raion, particularly the cities of Rubizhne, Sievierodonetsk, Popasna, and Lysychansk, at the frontline of what has quickly become an artillery duel between Ukrainian and Russia-aligned forces. These forces work to seize small villages, tree lines, and areas of topographic advantage in the region.

Large numbers of civilians reportedly fled urban areas in the region when the fighting intensified in April, though thousands of civilians appeared to remain trapped in many urban areas.[16] As of this

10. Organization for Security and Co-operation in Europe. "Resources: Moscow Mechanism." Accessed 21 June 2022. https://www.osce.org/odihr/20066. Archived at https://perma.cc/5ECP-QSBJ.

11. U.S. Mission to the OSCE. "Invocation of the Moscow Mechanism to Address the Human Rights and Humanitarian Impacts of Russia's Invasion and Acts of War Against Ukraine," 2 June 2022. https://osce.usmission.gov/invocation-of-the-moscow-mechanism-to-address-the-human-rights-and-humanitarian-impacts-of-russias-invasion-and-acts-of-war-against-ukraine/. Archived at https://perma.cc/KZZ7-6BES.

12. International Crisis Group. "Conflict in Ukraine's Donbas: A Visual Explainer," 29 June 29 2021. https://www.crisisgroup.org/content/conflict-ukraines-donbas-visual-explainer. Archived at https://perma.cc/3YZT-4ZK6.

13. Ibid.

14. Polishchuk, Olha, and Franklin Holcomb. "Breaking the Pattern: The Relative Success of the Latest Ceasefire Agreement in Ukraine." ACLED, 24 November 2020. https://reliefweb.int/report/ukraine/breaking-pattern-relative-success-latest-cease-fire-agreement-ukraine. Archived at https://perma.cc/FFE5-R2C5.

15. Demirjian, Karoun, and Rachel Pannett. "Russia Learns from Failure to Take Kyiv as New Offensive Begins, U.S. Says." Washington Post, 19 April 2022. https://www.washingtonpost.com/world/2022/04/19/russia-invasion-eastern-ukraine-donbas-war/. Archived at https://perma.cc/SH35-BCC2.

16. Kuznetsov, Sergei. "Getting out Alive: Ukrainian Civilians Flee the Russian Onslaught." POLITICO, 23 April 2022. https://

writing on 24 June, Russia and Russia-aligned forces are attempting to encircle Ukrainian troops and the remaining civilian enclaves, such as the Azot chemical plant in Sievierodonetsk city.[17]

## LEGAL CONTEXT OF ATTACKS ON PROTECTED CIVILIAN OBJECTS

Four types of law apply to this conflict: International Humanitarian Law (IHL), International Human Rights Law (IHRL), national and international criminal law, and customary law.[18] This section presents the legal context provided by applicable IHL and IHRL, specific to the location types reviewed as part of this damage assessment. Determinations of liability related to Ukrainian national law are outside the purview of Yale HRL.

Healthcare facilities and educational facilities — both of which fall in the category of "protected civilian objects" — have their status as non-military targets guaranteed within international humanitarian law (IHL). These protections are explicitly enshrined in the 1949 IV Geneva Conventions and the Additional Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977 (Additional Protocols). Article 48 of Additional Protocols to 1949 IV Geneva Conventions (1977): Basic rule states:

> In order to ensure respect for and protection of the civilian population and civilian objects, the Parties to the conflict shall at all times distinguish between the civilian population and combatants and between civilian objects and military objectives and accordingly shall direct their operations only against military objectives.[19]

Article 52: General protection of civilian objects further states:

> 1. Civilian objects shall not be the object of attack or of reprisals. Civilian objects are all objects which are not military objectives as defined in paragraph 2.
>
> 2. Attacks shall be limited strictly to military objectives. In so far as objects are concerned, military objectives are limited to those objects which by their nature, location, purpose or use make an effective contribution to military action and whose total or partial destruction, capture or neutralization, in the circumstances ruling at the time, offers a definite military advantage.
>
> 3. In case of doubt whether an object which is normally dedicated to civilian purposes, such as a place of worship, a house or other dwelling or a school, is being used to make an effective contribution to military action, it shall be presumed not to be so used.[20]

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www.politico.eu/article/ukrainian-civilians-flee-ukraine-donbas-russia-war-onslaught/. Archived at http://archive.today/NJIxo.

17. "UK Says Hundreds of Civilians Sheltered in Ukraine's Azot Chemical Plant." Reuters, 15 June 2022, sec. Europe. https://www.reuters.com/world/europe/uk-says-hundreds-civilians-sheltered-ukraines-azot-chemical-plant-2022-06-15/. Archived at http://archive.today/xjIXy.

18. Office of the Special Representative of the Secretary General for Children and Armed Conflict. "Protect Schools and Hospitals: Guidance Note on Security Council Resolution 1998." United Nations Secretariat, May 2014, 35. https://childrenandarmedconflict.un.org/publications/AttacksonSchoolsHospitals.pdf. Archived at https://perma.cc/D3EY-DGPX.

19. International Committee of the Red Cross (ICRC). "Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I)," § Article 48, 8 June 1977, 1125 U.N.T.S. 25. https://ihl-databases.icrc.org/ihl/WebART/470-750061?OpenDocument. Archived at https://perma.cc/RJP3-6ULJ.

20. International Committee of the Red Cross (ICRC). "Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I)," § Article 52, 8 June 1977, 1125 U.N.T.S. 27. https://ihl-databases.icrc.org/ihl/WebART/470-750067. Archived at https://perma.cc/7WX8-25GA.

*The Rome Statute and Violations of the Protected Status of Civilian Objects*
Violations of prohibitions against attacking these protected objects can constitute a war crime under the 1998 Rome Statute of the International Criminal Court (ICC).[21] The Rome Statute identifies attacks on both healthcare and educational facilities as a serious violation of the "laws and customs applicable in international armed conflict." These violations are commonly understood to be war crimes under IHL. Article 8 (2.b.ix) precludes "Intentionally directing attacks against buildings dedicated to religion, education, art, science or charitable purposes, historic monuments, hospitals and places where the sick and wounded are collected, provided they are not military objectives."[22]

Listed below are the five elements of the specific war crime of attacking protected objects, according to the Rome Statute. The evidence reviewed for this report addresses "Element 2" of the five elements, the object of attack. However, the evidence included herein may be relevant, if combined with other potentially probative evidence from other sources at a later date, in helping to prove or disprove the other elements of this specific war crime.

1. The perpetrator directed an attack.

2. The object of the attack was one or more buildings dedicated to religion, education, art, science or charitable purposes, historic monuments, hospitals or places where the sick and wounded are collected, which were not military objectives.

3. The perpetrator intended such building or buildings dedicated to religion, education, art, science or charitable purposes, historic monuments, hospitals or places where the sick and wounded are collected, which were not military objectives, to be the object of the attack.

4. The conduct took place in the context of and was associated with an armed conflict not of an international character.

5. The perpetrator was aware of factual circumstances that established the existence of an armed conflict.[23]

N.B. "The presence in the locality of persons specially protected under the Geneva Conventions of 1949 or of police forces retained for the sole purpose of maintaining law and order does not by itself render the locality a military objective."[24]

*Specific Protections for Healthcare Facilities and Medical Personnel*
The protected status of healthcare facilities and medical personnel is a bedrock tenet of IHL. The 1949 IV Geneva Conventions explicitly prohibit either the intentional or indiscriminate targeting of healthcare infrastructure, including hospitals, clinics, and other locations engaged in the provision of medical care to civilian populations. Article 18 states without ambiguity:

> Civilian hospitals organized to give care to the wounded and sick, the infirm and maternity cases, may in no circumstances be the object of attack but shall at all times be

21. UN General Assembly. "Rome Statute of the International Criminal Court," § Article 8(2)(b)(ix), 17 July 1998. https://www.icc-cpi.int/sites/default/files/RS-Eng.pdf. Archived at: https://perma.cc/9U7U-R4GD.

22. Ibid.

23. International Criminal Court. "Elements of Crimes of the International Criminal Court," § Article 8(2)(e)(iv), 2011. https://www.icc-cpi.int/sites/default/files/NR/rdonlyres/336923D8-A6AD-40EC-AD7B-45BF9DE73D56/0/ElementsOfCrimesEng.pdf. Archived at: https://perma.cc/V42F-J84C.

24. Ibid.

> respected and protected by the Parties to the conflict.[25]

There are circumstances in which this protected status afforded to healthcare facilities by IHL can be rescinded. However, these circumstances, when they rarely occur, require the party to the conflict intending to strike the facility to meet specific obligations for such an attack to be considered lawful. Article 21 articulates the specific circumstances and actions that must be taken by a party intending to attack a healthcare facility they believe has become a legitimate military target as follows:

> The protection to which fixed establishments and mobile medical units of the Medical Service are entitled shall not cease unless they are used to commit, outside their humanitarian duties, acts harmful to the enemy. Protection may, however, cease only after a due warning has been given, naming, in all appropriate cases, a reasonable time limit and after such warning has remained unheeded.[26]

No evidence has been collected by Yale HRL indicating that healthcare facilities in the area and timeframe analyzed for this report were being utilized in a way that removed their initial protected status afforded by IHL. There is no evidence available to Yale HRL that Russia and Russia-aligned forces provided appropriate warning or exercised precaution in any of their alleged attacks on healthcare facilities documented in this report.

*Specific Protections for Educational Facilities*

Educational institutions also receive protected status under IHL. These protections mentioning educational institutions specifically include the 1949 IV Geneva Conventions and The Hague Convention (IV) respecting the Laws and Customs of War on Land and its annex: Regulations concerning the Laws and Customs of War on Land. The Hague, 18 October 1907.[27]

Educational facilities can lose their protected status when used by an armed actor for military purposes. However, the party attacking the educational facility where armed actors are allegedly present remains responsible to engage in all necessary precautions — as well as to presume that the civilian object retains its protected status when any reasonable doubt exists about how that facility is being utilized by armed actors. This responsibility is not obviated by the actions of other armed actors.[28]

It is important to note that, while the protection afforded to educational facilities is less ironclad than that provided to healthcare facilities when the two are compared to each other, their protected status is well established in IHRL as well as IHL. The Convention on the Rights of the Child, a key instrument of IHRL, prohibits attacks on schools as both a violation of a child's right to

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25. International Committee of the Red Cross (ICRC). "1949 Geneva Convention IV, relative to the Protection of Civilian Persons in Time of War," § Article 18, 12 August 1949, 75 U.N.T.S. 287. https://ihl-databases.icrc.org/ihl/INTRO/380. Archived at https://perma.cc/UF4J-GHDL.

26. International Committee of the Red Cross (ICRC). "1949 Geneva Convention I, for the Amelioration of the Condition of the Wounded and Sick in Armed Forces in the Field," § Article 21, 12 August 1949, 75 U.N.T.S. 31. https://www.un.org/en/genocideprevention/documents/atrocity-crimes/Doc.30_GC-I-EN.pdf. Archived at https://perma.cc/2AD9-MWFV.

27. International Committee of the Red Cross (ICRC). "1949 Geneva Convention IV, relative to the Protection of Civilian Persons in Time of War," 12 August 1949, 75 U.N.T.S. 287. https://ihl-databases.icrc.org/ihl/INTRO/380. Archived at https://perma.cc/UF4J-GHDL; International Peace Conference (The Hague). "Hague Convention (IV) Respecting the Laws and Customs of War on Land and Its Annex: Regulations Concerning the Laws and Customs of War on Land," § Regulations: Article 56, 18 October 1907. https://ihl-databases.icrc.org/applic/ihl/ihl.nsf/xsp/.ibmmodres/domino/OpenAttachment/applic/ihl/ihl.nsf/4D47F92DF3966A7EC12563CD002D6788/FULLTEXT/IHL-19-EN.pdf. Archived at https://perma.cc/93EK-NW3S.

28. International Committee of the Red Cross (ICRC). "Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I)," § Article 57, 8 June 1977, 1125 U.N.T.S. 3. https://ihl-databases.icrc.org/applic/ihl/ihl.nsf/Article.xsp?action=openDocument&documentId=50FB5579FB098FAAC12563CD0051DD7C. Archived at https://perma.cc/FDW4-JA4B.

education and their right to life, liberty, and security of person, among other rights.[29] Additionally, attacks on educational facilities, according to UN Resolution 1261 (1999), is one of the "six grave breaches" that affect children during armed conflict.[30]

Ukraine under President Zelensky became a signatory to the Safe Schools Declaration in 2019. Although non-binding, this Declaration commits Ukraine to prevent the utilization of schools for military purposes during armed conflict.[31] Russia is not currently among the 114 signatories to the declaration.[32] However, as Human Rights Watch noted, accountability mechanisms for holding alleged perpetrators of attacks on educational facilities to account have not yet proven sufficient to address the problem:

> The reality is that there is no one formula for 'accountability' that is suitable to all attacks on education, all conflicts, all cultures, all countries. At different times and in different settings, the same act of planting a bomb beneath a school desk might amount to a crime of arson under domestic law, a war crime under international law, and a violation of children's rights to education.[33]

## METHODOLOGY AND LIMITATIONS

### METHODOLOGY

The investigative methodology for this report combines very high resolution (VHR) satellite imagery analysis and open source investigation (*see* Appendix II for detailed methodology). The VHR imagery used to support this investigation was commercially available and unclassified imagery captured by Maxar Technologies. The high level of spatial and temporal resolution in this imagery allowed analysts to assess changes in infrastructure and the natural environment, both of which often visibly reveal the damage caused by heavy weapons and some small arms commonly utilized in armed conflict.

This report focuses on Sievierodonetsk raion as defined by the boundaries set in 2020, when the Ukrainian government restructured administrative districts, consolidating Luhansk oblast to 8 raions.[34] One of these is Sievierodonetsk raion (population 369,421 per Ukraine's 2021 census) with the administrative center in the city of Sievierodonetsk. Given timing and satellite coverage constraints, this report covers the four largest cities in the raion: Sievierodonetsk (2021 census population 101,135), Lysychansk (2021 census population 95,031), Rubizhne (2021 census population 56,066), and Popasna (2021 census population 19,672).[35]

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29. UN General Assembly. "Convention on the Rights of the Child," 20 November 1989, 1577 U.N.T.S. 3. https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-rights-child. Archived at https://perma.cc/P4YX-MV2R.

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The general methodological approach of this research included multiple levels of engagement by both the open source investigative team and the geospatial analysis team. To confirm findings with high confidence, each step included two- to three-person concurrence. Where analysts disagreed, no high confidence rating was issued. The steps are outlined below:

1. Location Identification: Identification of education and healthcare sites in the four cities and identification of incidents in high-credibility open source reporting.
2. Geospatial analysis: Review of satellite imagery for every location identified to establish visible damage over the period in question, within a radius of 400 meters from the facility's coordinates.
3. Open source investigative analysis: Review of open source reporting on incidents where satellite imagery identified damage to corroborate findings and establish confidence levels. High credibility reports advanced for further review and verification.
4. Cross-corroboration: While steps two (2) and three (3) are conducted simultaneously, the final stage of analysis involves the cross-corroboration of incidents identified by the geospatial and open source teams, respectively.

Healthcare facilities and public primary and secondary schools in the four cities in Sievierodonetsk raion were identified using open source datasets and map products. Specific alleged incidents of bombardment were identified using photographic and videographic evidence from open sources, primarily user-generated content from social media. This methodology also relied on identifying, re-verifying, and citing the work of other open source investigative groups whose fact-checking practices were clearly documented. Analysis utilized current best practice standards in open source geolocation consistent with training by the Human Rights Center at UC Berkeley School of Law, including the use of specific visual identifiers, building features, and other visually evident data (and available metadata) across multiple media sources to confirm the precise coordinates of a site and its function as a medical facility or school.[36] Every facility identified and verified through open source documentation was then assessed via satellite imagery analysis.

This report classifies damage by assigning each facility one of four levels based on available satellite imagery at the time of analysis: total damage, partial damage, minimal damage, and no visible damage. Each facility may be a single building or multiple structures: for example, a single identified school ("facility") could be one made up of one school building or multiple school buildings. The damage classification was assigned based on the holistic level of damage observed to all the facility buildings. This means that if one of two school buildings was observed to have minimal damage but the other experienced total damage, collectively the school facility would be assigned partial damage.

Archived at https://perma.cc/5W9A-VLVN. Although all cities cited here were under the control of the Ukrainian government at the time of the 2021 census, there have been discrepancies in the population count on the national and regional level in Luhansk oblast due to a portion of the population living in the territory of the so-called Luhansk People's Republic and the difficulties in accurately counting the number of internally displaced persons in the region. See: Bukhtiyarov, Ivan. "У Луганській області мешкає менше людей, ніж показав електронний перепис населення — голова ОДА | Громадське телебачення." Hromadske, January 28, 2020. https://hromadske.ua/posts/u-luganskij-oblasti-meshkaye-menshe-ly-udej-nizh-pokazav-elektronnij-perepis-naselennya-golova-oda. Archived at https://perma.cc/DUN7-3MJ8.

36. Dubberley, Sam, Alexa Koenig, and Daragh Murray. *Digital Witness: Using Open Source Information for Human Rights Investigation, Documentation, and Accountability.* Oxford University Press, 2020.

Table 4: Facility Damage Assessment Classification

| YALE HRL BUILDING DAMAGE ASSESSMENT CLASSIFICATION | |
|---|---|
| CLASSIFICATION | DESCRIPTION |
| Total | All facility structures collectively appear to have little to no structural integrity; roof absent, clearly visible foundation and/or lack of standing structure. |
| Partial Damage[37] | Substantial damage to roof and/or vertical walls is visible, facility structure(s) appears to still stand; can include total damage to smaller structures within a facility (e.g., a gatehouse.); moderate to extensive debris (debris indicative of damage deeper than surface level; discrete and discernible chunks consistent with stone, brick, wood, or other structure materials may be visible on satellite imagery). |
| Minimal Damage | Limited surface damage to roof and/or vertical wall (if visible); can include missing roof tiles and/or light debris (visible but surface-level depth; no discernibly large chunks of stone, brick, wood, or other structures materials visible in satellite imagery). |
| No Visible Damage | No visible debris on roof or around vertical walls, no missing roof sections or tiles (not including roofs that may be under construction). |

Yale HRL reviewed satellite imagery to assess visible damage based on the timeline and location of incidents identified. Multiple geospatial analysts analyzed available satellite imagery for each facility across a range of pre- and post-incident dates. The analysts assessed the imagery and noted if the facility or its surroundings were visibly damaged and to what extent, while also noting any limitations related to image quality, availability, obscuration by trees or clouds, and angle of capture.

The satellite imagery that presented characteristics consistent with damage were captured as follows:

1. Imagery before evidence of damage; includes a wide shot for context and if needed, a zoomed-in image for comparison to damage at later date;
2. Imagery capturing evidence of damage after an initial incident and additional instances of damage thereafter; and
3. Metadata of all imagery captured, including detailed sensor and imagery characteristics.

If there is no/low visibility due to clouds, the next closest available date to the initial incident is also acquired. Images captured the day of a reported event may not show damage depending on

37. This report uses a 4-point scale, rather than a 5-point scale used in the previous report. This is intended to reduce subjectivity of the damage assessment as visible damage during this round of analysis varied widely. It remains important to note that the range of "partial damage" is broad.

the precise time of capture and incident; in these cases, the next available date is also acquired and analyzed. If no images are available or if only low-quality images are available following the date of a reported incident, satellite verification is not possible. The team maintained a detailed log of the quality and availability of imagery and regularly reviewed the availability of new imagery. Open source investigation provided additional verification of incidents using publicly available materials.

## LIMITATIONS

It is not possible at this time to determine to a reasonable standard whether an individual incident of a facility being bombarded is the result of indiscriminate fire or intentional targeting. This decision was made due to the lack of consistently robust time progressions of VHR satellite imagery across all Areas of Interest (AOIs) and a limited amount of open source online information being generated from inside the bombarded areas.

Of the locations identified to have sustained damage by Yale HRL analysts, only 14 could be sufficiently supported by open source, user-generated imagery gathered from social media, journalists, or state media. The lack of open source evidence could be explained by either a (1) lack of population still present in the region to document new damage, or (2) lack of open source sharing of footage related to damage. Yale HRL was unable to give either explanation a high confidence rating at this time.

Building damage assessments conducted primarily using satellite imagery limit what is visible to analysts and may not always show damage, even extensive damage, to a structure's sides and interior. However, off-nadir satellite imagery can mitigate this effect by providing more pronounced angles that can aid assessment of taller buildings. This approach, though, degrades the quality of the image. Other typical limitations of satellite imagery analysis include the presence of cloud cover or other environmental interference (such as ground mist from rain, trees, shadows, and snow). These limitations make damage harder to identify, particularly to vertical surfaces (such as exterior walls). This report provides a conservative estimate of damage at the sites identified, especially those where the factors above were present.

## III. EXPANDED FINDINGS

Presented below are key findings by region. Table 5 describes the extent of cross-corroboration between satellite imagery and open source data. The table demonstrates the expansiveness of satellite imagery used to identify healthcare facilities and public primary and secondary schools in Sievierodonetsk, Lysychansk, Rubizhne, and Popasna which were damaged by evident bombardment.

Table 5. Evidence Sources

| CITY | N°. LOCATIONS W/ DIRECT IMPACT REGISTERED | IMPACT INSTANCES REGISTERED BY IMAGERY ONLY | IMPACT INSTANCES REGISTERED BY NON-IMAGERY OPEN SOURCE ONLY | IMPACT INSTANCES REGISTERED BY IMAGERY & OPEN SOURCE DATA |
|---|---|---|---|---|
| Sievierodonetsk | 28 | 24 | 0 | 4 |
| Lysychansk | 5 | 3 | 0 | 2 |
| Rubizhne | 11 | 5 | 0 | 6 |
| Popasna | 7 | 0 | 0 | 7 |
| Total | 51 | 32 | 0 | 19 |

Tables 6a and 6b describe the extent of damage to healthcare facilities and public primary and secondary schools in the cities of Sievierodonetsk, Lysychansk, Rubizhne, and Popasna in Sievierodonetsk raion. These facilities were damaged by evident bombardment visible in satellite imagery captured between 24 February and 13 June 2022. The damage levels are tallied according to the level of damage observed on the last available satellite image dated 13 June 2022 or prior.

Table 6a: Damage Sustained to Healthcare Facilities

| CITY | TOTAL DAMAGE | PARTIAL | MINIMAL | NOT VISIBLE | N°. W/ DAMAGE | N°. FACILITIES |
|---|---|---|---|---|---|---|
| Sievierodonetsk | 3 | 4 | 4 | 1 | 11 | 12 |
| Lysychansk | 1 | 1 | 0 | 7 | 2 | 9 |
| Rubizhne | 0 | 2 | 4 | 1 | 6 | 7 |
| Popasna | 1 | 1 | 0 | 0 | 2 | 2 |
| Total | 5 | 8 | 8 | 9 | 21 | 30 |

Table 6b: Damage Sustained to Primary and Secondary Schools

| CITY | TOTAL DAMAGE | PARTIAL | MINIMAL | NOT VISIBLE | N°. W/ DAMAGE | N°. FACILITIES |
|---|---|---|---|---|---|---|
| Sievierodonetsk | 0 | 7 | 10 | 7 | 17 | 24 |
| Lysychansk | 1 | 2 | 0 | 18 | 3 | 21 |
| Rubizhne | 0 | 4 | 1 | 4 | 5 | 9 |
| Popasna | 2 | 3 | 0 | 0 | 5 | 5 |
| Total | 3 | 16 | 11 | 29 | 30 | 59 |

Tables 7a and 7b describe multiple waves of damage to healthcare facilities and public primary and secondary schools in the cities of Sievierodonetsk, Lysychansk, Rubizhne, and Popasna in Sievierodonetsk raion visible in satellite imagery captured between 24 February and 13 June 2022.

Table 7a: Evident Waves of Attack Affecting Healthcare Facilities

| CITY | AT LEAST ONE WAVE | AT LEAST TWO WAVES | THREE OR MORE WAVES | Nº. OF LOCATIONS WITH DIRECT IMPACT REGISTERED |
|---|---|---|---|---|
| Sievierodonetsk | 6 | 3 | 2 | 11 |
| Lysychansk | 2 | 0 | 0 | 2 |
| Rubizhne | 6 | 0 | 0 | 6 |
| Popasna | 1 | 0 | 1 | 2 |
| Total | 15 | 3 | 3 | 21 |

Table 7b: Evident Waves of Attack Affecting Primary and Secondary Schools

| CITY | AT LEAST ONE WAVE | AT LEAST TWO WAVES | THREE OR MORE WAVES | Nº. OF LOCATIONS WITH DIRECT IMPACT REGISTERED |
|---|---|---|---|---|
| Sievierodonetsk | 9 | 7 | 1 | 17 |
| Lysychansk | 3 | 0 | 0 | 3 |
| Rubizhne | 2 | 2 | 1 | 5 |
| Popasna | 0 | 3 | 2 | 5 |
| Total | 14 | 12 | 4 | 30 |

# APPENDIX I: IMAGERY EXAMPLES

## DAMAGE SCALE EXAMPLES

Table 1 compares Yale HRL's building damage assessment classification scale to other common building damage assessment classifications. Yale HRL uses a four-point scale that includes "no visible damage," "minimal damage," "partial damage," and "total damage" which is based on and closely aligns with the classification proposed by the International Working Group on Satellite-based Emergency Mapping (IWG-SEM).[38]

Table 1: Building Damage Assessment Classification[39]

| BUILDING DAMAGE ASSESSMENT CLASSIFICATION | | | |
|---|---|---|---|
| Copernicus (<~2018) | UNOSAT: complex emergencies | BAR | HRL |
| Destroyed | Destroyed | Critical Visible Damage | Total Damage<br>Structure appears to have little to no structural integrity; roof absent, clearly visible foundation and/or lack of standing structure. |
| Highly Damaged | Severe Damage | Significant Visible Damage | Partial Damage[40]<br>Substantial damage to roof and/or vertical walls is visible, facility structure(s) appears to still stand; can include total damage to smaller structures within a facility (e.g., a gatehouse); moderate to extensive debris. |
| Moderately Damaged | Moderate Damage | | |
| Negligible to Slight Damage | Possible Damage | Minimal Visible Damage | Minimal Damage<br>Limited surface damage is visible; roof tiles missing and/or light debris is visible; (visible but surface-level depth; no discernibly large chunks consistent with stone, brick, wood, or other structures materials visible in satellite imagery). |
| Not Affected | No Visible Damage | No Visible Damage | No Visible Damage<br>No visible debris on roof or around vertical walls, no missing roof sections or tiles (not including roofs that may be under construction). |

38. International Working Group on Satellite-based Emergency Mapping (IWG-SEM) "Emergency Mapping Guidelines: Building Damage Assessment Chapter," Working Paper. Version 1.0, September 2018. https://www.un-spider.org/sites/default/files/IWG_SEM_Guidelines_Building%20Damage%20Assessment_v1.0.pdf. Archived at https://perma.cc/B6YT-CYRY.

39. Informed by the International Working Group on Satellite-based Emergency Mapping (IWG-SEM) "Emergency Mapping Guidelines: Building Damage Assessment Chapter," Working Paper. Version 1.0, September 2018. https://www.unspider.org/sites/default/files/IWG_SEM_Guidelines_Building%20Damage%20Assessment_v1.0.pdf Archived at https://perma.cc/B6YT-CYRY.

40. This report uses a 4-point scale, rather than a 5-point scale used in the previous report. The range of "partial damage" is broad.

Figure 1: Observable Waves of Damage


29 March 2022 | No visible damage 16 May 2022 | Partial damage 30 May 2022 | Additional partial damage

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The first image (left) was captured on 29 March 2022 (no visible damage), the second image (center) was captured on 16 May 2022 and shows partial damage, and the third image (right) was captured on 30 May 2022 and shows additional partial damage. These images are of the same facility and multiple iterations of damage are clearly visible.

The above images were captured on 29 March 2022, 16 May 2022, and 30 May 2022, respectively (left to right). These images demonstrate the incremental increase in damage to the roof of the facility. This indicates that the facility incurred damage on at least two separate occasions. It is not possible to conclude exactly how many separate instances of damage occurred to a facility given two images separated by an extended time period. However, the chronological analysis of available imagery for the reporting period indicates the minimum number of occasions on which an identified location incurred damage. Analysts were able to conclude that this facility incurred damage on at least one occasion between 29 March 2022 and 16 May 2022 and on at least occasion between 16 May 2022 and 30 May 2022; meaning that it sustained at least two waves of damage.

For facilities consisting of more than one building, this report defines the number of minimum "waves" of damage at a facility by the number of times satellite imagery captures any change in damage to at least one building within that facility. In short, a building in a facility at which there were at least two waves of damage may not necessarily have been hit at least two times. Rather, a building in a facility at which there were at least two waves of damage may have incurred damage two, one, or no times; if a satellite image captures increased damage to at least one building within a facility compared to previously available imagery, a wave of damage is counted.

# INTERSCHOOL RESOURCE CENTER | СЄВЄРОДОНЕЦЬКИЙ МІЖШКІЛЬНИЙ РЕСУРСНИЙ ЦЕНТР
## SIEVIERODONETSK

Date: 2022.03.29
Source: WV03
Ground Sampling Distance: 34 cm
Off-Nadir: 17.4842°

Image from 2022.03.29 shows the roofs of the resource center without visible damage. Other nearby buildings appear intact.


No Visible Damage

Date: 2022.05.30
Source: GEO1
Ground Sampling Distance: 44 cm
Off-Nadir: 14.8564°

Image from 2022.05.30 shows visible changes consistent with impact to the roof.


Minimal Damage

Satellite imagery

# LYCEUM “COLLEGIUM” | ЛІЦЕЙ “КОЛЕГІУМ”
## SIEVIERODONETSK

Date: 2022.03.29
Source: WV03
Ground Sampling Distance: 34 cm
Off-Nadir: 17.4842°

Image from 2022.03.29 shows the lyceum without visible damage. Other nearby buildings appear intact.


No Visible Damage

Date: 2022.05.30
Source: GEO1
Ground Sampling Distance: 44 cm
Off-Nadir: 14.8564°

Image from 2022.06.06 shows visible indicators of impact consistent with bombardment and clustered damage to a significant portion of the central lyceum structure’s roof.


Partial Damage

Satellite imagery

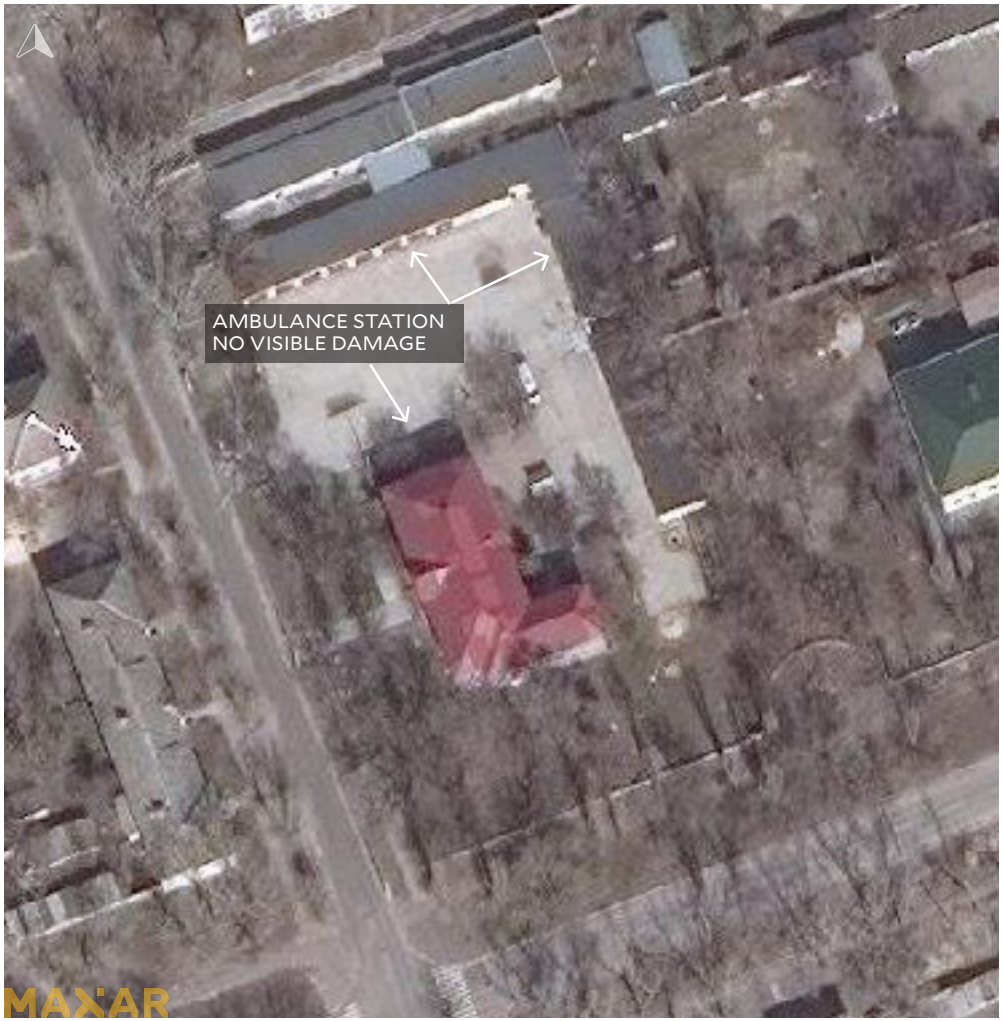
# AMBULANCE STATION | СТАНЦІЯ ШВИДКОЇ МЕДИЧНОЇ ДОПОМОГИ
## SIEVIERODONETSK

Date: 2022.03.29
Source: WV03
Ground Sampling Distance: 34 cm
Off-Nadir: 17.4842°

Image from 2022.03.29 shows the roof of the ambulance station without visible damage. Other nearby buildings appear intact.

Date: 2022.06.06
Source: WV03
Ground Sampling Distance: 39 cm
Off-Nadir: 28.9469°

Image from 2022.06.06 shows that the main station structure no longer has a roof, leaving its interior exposed. Nearby buildings have visible roof damage or are missing roofs.




No Visible Damage


Total Damage

Satellite imagery

## APPENDIX II: DETAILED METHODOLOGY

The investigative methodology for this report combines very high resolution (VHR) satellite imagery analysis and open source investigation. The VHR imagery used to support this report is commercially available unclassified imagery captured by Maxar Technologies. The imagery typically has a spatial resolution between 38 and 50 cm which allows analysts to identify natural and manmade landscape features including individual buildings, vehicles, trees and more. Such high-resolution imagery is captured repeatedly across time (though temporal resolution differs based mostly on satellite revisit rates, satellite tasking, and atmospheric conditions), allowing analysts to monitor changes in feature characteristics in any given landscape where satellite imagery is available. This high level of spatial and temporal resolution allows analysts to closely analyze changes in infrastructure and the natural environment, both of which often visibly bear the brunt of war. Repeating indicators of damage to infrastructure, for example, includes changes in feature coloration, texture, and pattern as seen from above.

Prioritization for areas of interest and imagery assessment was based on existing reports of attacks on healthcare and educational facilities with the goal of understanding how a targeted area was being attacked. Exclusion criteria are described below regarding imagery quality, open source data integrity and degree of corroboration, as well as HRL's processes for review and consensus of available data at the time of reporting. Findings in this report should not be considered conclusive of all possible evidence relevant to these areas of interest and facilities, but rather representative of these research methods, data sources, and their limitations.

### METHODOLOGICAL PRINCIPLES

These findings are verified by the research team with both geospatial imagery analysis and highly credible open source investigative evidence.

This approach produces findings in three categories of verification:

1. Dually verified (open source investigative and geospatial imagery analysis) incidents;
2. Open source investigative evidence with credible third party verification (e.g., Associated Press, New York Times Visual Investigations, or Washington Post), but no geospatial imagery analysis verification available; and
3. Geospatial imagery evidence without open source investigative evidence or verification.

To ensure that this report is easily cross-referenced with other available open source data and reporting, the investigative case files in the full dossier clearly state where and why geospatial imagery analysis or open source investigative evidence may have been unavailable or insufficient based on this research team's criteria. The case files may be released upon request by Yale HRL and the Conflict Observatory to support future judicial proceedings, law enforcement investigations, and public health research.

Every assessment on geospatial imagery analysis and open source investigative evidence is rated by confidence level. Confidence level relates to an analyst's finding (i.e., result of the analysis and indicative of, but not a rating of, the data sources used to establish the finding). High confidence reflects a finding based on diverse, robust, and independently verifiable data corroborated by multiple sources; the data set has been assessed and consistently interpreted by multiple analysts. Where one team's findings are not assessed to be high confidence, that incident is only considered verified by the team whose finding merited high confidence.

### IMAGERY DAMAGE ASSESSMENT SCALE

Yale HRL classified the evidence of damage to healthcare facilities through satellite imagery on a four point scale: "not visible," "minimal," "partial," and "total" damage. This report condenses

the damage scale used in previous HRL analysis and closely aligns with the damage classification proposed by the International Working Group on Satellite-based Emergency Mapping (IWG-SEM). The condensed damage scale minimizes subjectivity introduced by the geospatial analysts (*see* Appendix I for more details).

## GENERAL METHODOLOGICAL APPROACH

The general methodological approach of this research included multiple levels of engagement by both the open source investigative team and the geospatial analysis team. In order to confirm high confidence, each step included two- to three-person verification of the findings. Where analysts disagreed, no high confidence rating was issued.

## LOCATION METHODOLOGY

This report investigates damage to healthcare facilities and public primary and secondary schools consistent with bombardment in the cities of Sievierodonetsk, Lysychansk, Rubizhne, and Popasna in Sievierodonetsk raion. Healthcare facilities and public primary and secondary schools were defined as those identified in (pre-invasion) Ukrainian Ministry of Health and Ukrainian Ministry of Education databases, respectively. These healthcare and educational facilities were then cross-referenced and further verified using open source records to determine their operational status. For example, if a facility could be determined to have been shut down or abandoned before 24 February, it was excluded from this report's analysis.

Each facility identified was given a location identifier (ID) with a numbering system that indicates if a structure is part of a larger campus or complex. Latitude/longitude, name in English and Ukrainian, and other identifying features were recorded.

Open source reporting related to healthcare and education infrastructure was reviewed and matched with the geospatial areas of interest. If any alleged incident was identified in a region of interest, the location was marked for review by geospatial imagery analysis and open source investigative teams.

## OPEN SOURCE METHODOLOGY

The open source team reviewed public reporting on the alleged incident as well as associated photographic and videographic evidence. Rather than building a standalone archive of user-generated content related to identified incidents, this rapid response methodology relied on identifying, re-verifying and citing the work of other highly credible open source investigative groups whose fact-checking practices were clearly documented. Following an assessment of source credibility and documentation (and metadata) veracity where available, open source evidence informed the confidence level assigned to the incident. Findings were then documented. The team utilized current best practice standards in open source geolocation consistent with training by the Human Rights Center at UC Berkeley School of Law, including the use of specific visual identifiers, building features, and other visually evident data (and available metadata) across multiple media sources to confirm the precise geo coordinates of a site and its function as a medical facility.

## GEOSPATIAL METHODOLOGY

Once the location team compiled and geolocated a comprehensive list of the healthcare facilities and public primary and secondary schools in Sievierodonetsk raion's cities of Sievierodonetsk, Lysychansk, Popasna, and Rubizhne, at least two geospatial analysts analyzed each facility through available satellite imagery across a range of pre- and post-incident dates. The analysts reviewed the imagery from each available date, noting if the facility and/or its surroundings were visibly damaged and to what extent, while also commenting on any limitations related to image quality, limited availability, obscuration by trees or clouds, and angle of capture. Once two to three analysts agreed on the visual damage indicators present in the imagery, the location was flagged as either 1) visibly presenting characteristics consistent with structural damage or 2) not visibly presenting

characteristics consistent with damage. Damage was assessed using the scale described in Appendix I. This process was repeated for all available imagery during the period between 24 February 2022 and 13 June 2022 to capture any additional visible damage to analyzed structures.

It should be noted that the presence or absence of characteristics consistent with structural damage evident in satellite imagery on these dates, using the tools available to these analysts, is not conclusive of the total presence or absence of structural damage to the site in question at that time.

The imagery scenes that presented characteristics consistent with damage were captured as follows:

1. Imagery before evidence of damage; includes a wide shot for context and if needed, a zoomed-in image for comparison to damage at later date;
2. Imagery capturing evidence of damage, after an initial incident and additional instances of damage thereafter; and
3. Metadata of all imagery captured; includes detailed sensor and imagery characteristics.

All images captured are taken from the closest possible date of an initial incident. If there is no/low visibility due to clouds, the next closest available date to the initial incident is also captured. Note that images captured the day of a reported event may not show damage depending on the precise time of capture and attack; in these cases, the next available date is also captured. If no images are available or if only low-quality images are available following the date of a reported event, satellite verification is not possible. It is important to note that the team maintained a detailed log of the quality and availability of imagery and regularly reviewed the availability of new imagery. All damage that was visible in satellite imagery on or before 13 June is included in the analysis for this report. Variation in image coloration (multispectral color vs panchromatic) is due to the satellite sensors' respective capabilities. For this work, multispectral (true color imagery) is optimal for damage assessments because of the associated color contrast while panchromatic, or black and white imagery, reduces contrast clarity. Both types of imagery were used, depending on availability.

A significant number of facilities sustained multiple iterations of damage consistent with bombardment during the period between 24 February to 13 June 2022. Damage was noted and classified for each iteration of damage consistent with bombardment. The damage scales used denote the status of the facility as of 13 June 2022. The first image taken after 24 February showing a facility damaged caused the facility to be recorded as "damaged". If that healthcare facility were to have sustained additional damage consistent with bombardment at a later date, then that imagery would be noted, annotated, and its status would be updated accordingly. Any additional damage that significantly altered its damage classification was immediately noted. Additional waves of damage were similarly captured — even if the damage status of the facility did not measurably change.

## Challenges, Limitations, & Mitigation

There are some specific methodological challenges associated with open source research and geospatial imagery analysis. There are also methodological challenges unique to the healthcare infrastructure in Ukraine. These include:

- LIMITED OPEN SOURCE DATA | The open source verification process was hampered by a lack of available sources. There were only 14 cases where open source material could corroborate satellite findings during this investigation. The low quantity of open source material could be explained by several reasons. For example, mass displacement of the population in the region around the time of the attacks may have resulted in fewer images/videos being taken. Additionally, change in connectivity within the area and/or a rapidly deteriorating security situation could reduce the capability and willingness of people remaining in the area to post content to open source platforms. There is not enough information available currently to determine which of these dynamics was present and to what degree.
- CAMPUS MEDICAL FACILITIES | Many healthcare facilities in Ukraine are arranged in a campus structure. This means that multiple facilities may be damaged from one strike. Depending on the specifics of each incident, some damage may be verifiable by either open source or geospatial analysis (or both) and some may not be verifiable by either at the time of this team's report. This limitation can only be mitigated by thorough review and analysis to properly identify each facility at the campus and determine impact based on available imagery and reporting. Though many Ukrainian education facilities are also grouped into large campuses, due to this report's focus on primary and secondary schools (thus excluding kindergarten and tertiary facilities), the only buildings analyzed were those specifically relevant to primary and secondary schools, rather than an entire campus. There were some instances where what was believed to be a kindergarten or vocational schools (tertiary) shared the same campus as a primary or secondary school. However, because those were outside the scope of this report, damage to those facilities were not included.
- SURROUNDING DAMAGE | The primary objective of this report was to identify and document damage sustained by educational and healthcare facilities. Yale HRL's first submission to the OSCE Moscow Mechanism, "Evidence of Widespread and Systematic Bombardment of Ukrainian Healthcare Facilities," included instances of surrounding damage within 400 meters of structures of interest. While the same analysis methodology was used in this second phase — accounting for and documenting damage to all 89 facilities' surroundings — given the high level of visible damage to the facilities themselves, such instances of nearby damage were assessed and noted for this report.
- SIMPLIFIED DAMAGE SCALE | The geospatial analysis in this report uses a 4-point damage scale rather than a 5-point damage scale that was previously used for the analysis presented to the OSCE Moscow Mechanism in April 2022.
- LIMITED IMAGERY | In more rural parts of Sievierodonetsk raion, outside of the metropolitan area, there often is less available satellite imagery, which may result in large time gaps from one set of imagery to another. Further there was highly limited clear imagery available for a pre- and post-incident comparison. This limitation can only be mitigated by tasking satellites to capture recent and regular imagery in these locations.
- TYPICAL LIMITATIONS OF SATELLITE IMAGERY ANALYSIS | Typical limitations of satellite imagery analysis include the presence of cloud cover or other environmental interference (such as ground mist from rain, trees and shadows, snow), as well as angle of imagery capture. These limitations mean that damage is harder to identify, particularly to vertical surfaces (such as exterior walls). Examples are also included below. These limitations were mitigated by secondary verification with ground-imagery via open source investigative evidence and the presence of images captured at lower angles (off-nadir) supported verification of damage to vertical surfaces, when available.

Table 1: Obstructive Factors: Image Analysis

| OBSTRUCTIVE FACTORS \| IMAGE ANALYSIS | |
|---|---|
| Type | Effect |
| Cloud cover | Partial/complete obstruction of image |
| Ground fog/mist/smog | Image blurring |
| Snow fall | Masking damage |
| Varying angles of capture | Difficulty comparing tiles; damage obscured by shadows; only coverage of one side of buildings |
| Deciduous trees & other vegetation | Difficulty comparing tiles |

Figure 1: Examples of Low Visibility


8 April 2022 | Haze


5 April 2022 | Cloud cover


11 June 2022 | Poor contrast