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Guidelines for Designing a Ceasefire in the Russia-Ukraine War

Best Practices, Lessons Learned, and
the Role of Technology



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About This Report

This report provides a comprehensive analysis of best practices, lessons learned, and the role of technology in establishing and maintaining ceasefires, with a specific focus on the Russia-Ukraine war. We examine historical ceasefire agreements, identify key factors contributing to their success or failure, and offer recommendations for future ceasefire negotiations. We also explore the potential of remote-sensing technologies, to enhance ceasefire monitoring and compliance. By drawing on past experiences and leveraging technological advancements, we aim to provide actionable insights for policymakers and stakeholders working toward a durable peace in Ukraine.

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Summary

Issue

The Russia-Ukraine war is the largest and deadliest conflict in Europe since World War II. While an end to the fighting is not in sight at the time of this writing in June 2025, the war will eventually come to an end—and most likely through a negotiated agreement. A *ceasefire*—an accord between the belligerents to cease active hostilities and avoid their resumption—will be a key component of any negotiated end to the war.

Under any circumstances, designing, agreeing on, and implementing a ceasefire are extremely challenging tasks. The specific circumstances of the Russia-Ukraine war make doing so even more difficult. The conflict line is roughly 3,300 km long, spans land and sea, abuts multiple international borders, and crisscrosses heavily mined areas. The extremely high level of mistrust between the belligerents makes any agreement between them politically fraught. A ceasefire, in particular, will create military vulnerabilities that both sides will worry could be exploited by the other side for tactical gain. And Russia and Ukraine have had recent experience, in the 2014–2021 period, of a ceasefire—the Minsk agreements—that never achieved a sustainable end to the fighting. Both Moscow and Kyiv have stated that any new cessation agreement must be enduring, voicing nearly identical concerns that the other side could use any pause to rearm, refit, and reattack.

Such concerns point to the key challenge in finding agreements to end any war: the credible commitment problem. Belligerents have good reason to mistrust each other after fighting a war and particularly to be skeptical about the other side's stated intent to stop fighting. They might believe that the other side is a determined aggressor that will attack again once its relative capabilities improve or a fickle actor prone to change its preferences over time. Negotiating and complying with a ceasefire agreement can be an important costly signal that former belligerents can use to overcome the credible commitment problem.

It will be essential to design a ceasefire agreement carefully and deliberately to maximize the chances of achieving an enduring peace in Ukraine.

In this report, we distill guidelines for designing an effective ceasefire agreement in the Russia-Ukraine war.

Approach

To develop guidelines for a future ceasefire agreement, we pursued three lines of analysis. First, we conducted a systematic review of academic and practitioner literature on ceasefire-agreement design to identify the mechanisms that are most closely associated with enduring peace. We focused specifically on past cases of ceasefires following interstate wars. Drawing from our findings, we extrapolated how these mechanisms could be applied in a future ceasefire in the Russia-Ukraine war to increase the likelihood that the agreement endures.

Second, we examined the history of the Minsk agreements, the documents that were meant to end the 2014–2021 phase of conflict between Russia and Ukraine, to derive lessons for future efforts at achieving and maintaining a ceasefire. We reviewed the wide body of empirical research on these agreements and conducted interviews with officials involved in the negotiation process and the Organization for Security and Co-operation in Europe Special Monitoring Mission to Ukraine (SMM). We focused on understanding the lessons from the flaws in that process and recommendations for how a future ceasefire agreement might avoid them.

Third, we examined remote-sensing technology for use in monitoring a future ceasefire in Ukraine. Ukraine is the largest country in Europe; the current conflict line, by our measurements, extends more than 3,000 km. To monitor that area effectively would require hundreds of thousands of personnel—more than the total number of United Nations (UN) peacekeepers deployed globally. Therefore, remote (i.e., uncrewed) sensors will be a crucial component of any ceasefire-monitoring mission—and effective third-party monitoring has been shown to be essential for ceasefire success. To understand the potential remote-sensing requirements for a mission in Ukraine, we began by reviewing the nascent use of this technology in other efforts to monitor ceasefires, including the SMM. We assessed the ways in which such technology can contribute to ceasefire maintenance. We then turned to the geography of the current conflict and the specific remote-sensing technologies relevant to these varied environments. Next, we iden-

tified the benefits and drawbacks of a variety of remote-sensing capabilities and the platforms that could be used along the lines of the three primary domains of ceasefire monitoring: air, land, and maritime. Drawing on our analysis of the geography of the conflict, we then mapped how different remote-sensing capabilities and platforms can be deployed along the conflict line to enable more-effective monitoring.

Key Findings

In this section, we summarize the key findings of these three lines of effort. We then offer, in the next section, a consolidated list of top-line recommendations, which reflect all three sets of findings. Through our study of past interstate ceasefires and the factors that produced durable peace, we derived the following set of recommendations for a future agreement to end the hostilities in Ukraine:

- *Troop withdrawal*—Withdrawing forces away from the contact line will be an important signal of commitment to a future ceasefire. But the most peace-supporting withdrawals would need to entail ceding control of territory beyond the status quo ante bellum (i.e., ceding territory held before the conflict). To date, Russia has shown no willingness to give up any of the Ukrainian territory it has occupied since February 24, 2022. The literature suggests that the ongoing territorial dispute will prove a challenge to peace over the long term.
- *Demilitarized zone (DMZ)*—Any ceasefire agreement in Ukraine should consider including a fully demilitarized area separating troops. A DMZ in Ukraine might have to be much wider than past cases to account for advances in military capabilities. It will also have to vary in width according to the particular geography; for example, there are some population centers that abut the line of contact as of this writing that might require additional protections.
- *Confidence-building measures (CBMs)*—Research suggests that CBMs encompassing mutual military inspection, on-site verification visits, and aerial surveillance may be associated with more durable peace. The former two measures could be carried out by Russian and Ukrainian officers delegated to a potential joint commission. Such CBMs,

similar to provisions in the Treaty on Conventional Armed Forces in Europe, can enhance mutual confidence in compliance with any ceasefire agreement's stipulations. Third-party aerial surveillance (using satellites, for example) could also be helpful.

- *Dispute resolution*—Joint commissions composed of representatives from both sides appear to be the most useful method for dispute resolution. Russian and Ukrainian officers participated in a similar commission from 2015 to 2017. Such a commission should be part of any future agreement as well.
- *Agreement specificity*—More-specific agreements may be more successfully implemented than vaguer ones, as the sides are more likely to have a clear, shared understanding of what the agreement terms mean. This finding calls for agreements that are precise and well elaborated rather than general statements of principle. An agreed-on, precise ceasefire line will also be important.
- *Agreement formality*—Peace may last longer following formal agreements than informal agreements. In the Russia-Ukraine context, a ceasefire agreement should therefore be a formal document, or perhaps even a legally binding treaty, instead of an informal arrangement or unilateral measures.
- *Third-party pressure*—Pressure from external actors can help bring conflict parties to agreement. But if such pressure is a key factor in motivating Russia or Ukraine to cease hostilities, it must be maintained over the long term. In the Russia-Ukraine case, that could mean ensuring long-term Western military assistance to Ukraine because that assistance has been a key pressure point vis-à-vis Russia. If the third party's interest in maintaining the pressure is perceived by one or both of the belligerents to be fleeting, the ceasefire is more likely to collapse.
- *Third-party guarantees*—Although there are very few historical cases for comparison, our research suggests that explicit ceasefire guarantees from third parties could be helpful. Ukraine has sought such guarantees since the start of the war. To ensure an enduring peace, outside powers willing to remain involved in upholding the ceasefire should consider committing to act in the event of serious violations.

- *Peacekeeping*—Peacekeeping missions are generally associated with a longer duration of peace. Russia and Ukraine would need to agree on the composition of a peacekeeping force, and Russia's status as a permanent member of the UN Security Council may further complicate the approval of a peacekeeping operation. While the significant military capabilities of the belligerents might undermine the deterrent effect of a lightly armed peacekeeping mission, peacekeepers potential roles' go beyond deterring renewed conflict; for example, they can monitor the implementation of a ceasefire agreement.
- *Third-party monitoring*—Third-party monitoring is associated with more durable peace. A monitoring mission should be a key component of any future ceasefire agreement.

The history of the failure of the Minsk agreements offers the following important lessons for future ceasefire negotiations:

- Textual ambiguity in the agreement created space for competing interpretations and opportunities to exploit the process. The agreements lacked clarity on basic parameters for ceasefire implementation (e.g., withdrawal of heavy weapons, defined geographic coordinates for the established security zone), did not explicitly identify roles and responsibilities of all relevant actors, and did not formalize authorities for the disparate organizations involved in implementation.
- The absence of accountability mechanisms for violations undermined the agreement. The SMM had no mandate to attribute responsibility for violations, and the Minsk agreements did not include any dispute-resolution mechanisms for adjudicating incidents or sanctions for noncompliance.
- Failure to address the underlying drivers of the conflict in any significant way made an enduring cessation of hostilities much more challenging. The Minsk agreements did not directly address the core security concerns motivating Russia's military intervention into Ukraine. As a result, Moscow had little incentive to comply with the ceasefire.
- Poor planning and imperfect negotiating conditions contributed to the flawed agreements they produced. The ceasefire negotiations were

haphazard and rushed, led by political leaders rather than technical experts, and held under mounting military pressure on the battlefield.

- The agreements lacked a mechanism for adaptation or renegotiation. When implementation of the Minsk agreements did not meet deadlines or benchmarks, parties continued to go through the motions rather than revisiting the documents themselves.

Negotiators should do the following to overcome the shortcomings of the Minsk agreements:

- Be explicit in specifying roles and responsibilities, protocols, and operating procedures.
- Establish robust accountability mechanisms to adjudicate incidents, sanction violations, and deter noncompliance.
- Establish a separate negotiation track for addressing overarching geopolitical questions, held in parallel with ceasefire discussions.
- Immediately begin preparations for eventual negotiations, including by holding preliminary talks and drafting proposals for ceasefire modalities.
- Establish a timeline for iteratively assessing the ceasefire, as well as conditions (such as serial noncompliance) that would automatically trigger a process to renegotiate or adapt parts of the agreement.

We found that remote-sensing technology will play a critical role in any future third-party monitoring mission in Ukraine given the scale of the conflict line and the otherwise unachievable persistence of monitoring that remote sensing provides. Our recommendations, it should be noted, are for a third-party monitoring mission, not for the parties to implement themselves. Russia and Ukraine both deploy many of the remote-sensing technologies discussed here for warfighting intelligence, surveillance, and reconnaissance, and they will maintain many of these capabilities after any cessation of hostilities. Therefore, the role of remote-sensing technology for a third-party monitoring mission in this context is not to deliver information to the parties that they cannot otherwise obtain. Instead, it is to provide the referee with better binoculars. For a third-party monitoring mission to

serve as a neutral arbiter in a no-trust environment, it must have its own sources of information, independent of the parties.

- Based on the peacekeeper-to-kilometer ratio of past peacekeeping missions, roughly 330,000 peacekeepers could be required in Ukraine to monitor the more than 3,300-km conflict line as it currently stands—an impossibly high number. Remote-sensing technology, therefore, will be needed in addition to human monitors.
- Remote-sensing technology increases the effectiveness of monitoring, reduces the risks posed to human monitors, and expands monitoring reach while reducing in-field personnel requirements.
- While no single remote-sensing technology can be used to monitor the disparate geographies of the conflict line, a combination of remote-sensing capabilities and platforms could achieve a persistent and pervasive presence capable of responding to emergent monitoring needs. A combined and integrated suite of remote-sensing platforms would also serve to limit the drawbacks of certain platforms and prevent an overreliance on any one platform.

To monitor the conflict line comprehensively, a third-party ceasefire-monitoring mission should deploy a combined and integrated suite of the following remote-sensing technologies with capabilities and systems tailored to Ukraine's unique geographic conditions:

- On Ukraine's northern borders in the densely forested region of Polesia, tethered aerostats equipped with a variety of sensors, such as electro-optical/infrared cameras, and satellite imagery enable coverage of an environment that is not amenable to ground-based sensors. Given that the primary threat on the Ukraine-Belarus border has been the amassing of troops for the initial large-scale invasion, aerial monitoring could capture troop movements on either side of the conflict line and alert the monitoring mission of a potential impending ceasefire violation. Short- and medium-range uncrewed aerial systems (UASs) and uncrewed ground vehicles can surveil the Chernobyl Exclusion Zone to reduce human monitors' exposure to radiological hazards while preventing and deterring violations in that area.

- Along the flat steppe region on Ukraine's eastern border with Russia and the line of contact, camera-enabled long-range UASs can provide constant daytime and night-time coverage of the areas where direct fighting has been most intense while short- and medium-range UASs can be deployed to deter and document violations in hotspots and surveil heavily mined areas. Given the flat and open nature of the steppe, radars and counter-battery radars mounted on aerostats can be used to track and locate the source of violations.
- In urban and suburban environments that have seen heavy fighting, fixed cameras, acoustic sensors, and aerostats can provide persistent monitoring. In light of potential civilian sensitivities to drones, these platforms may be better suited for monitoring population centers.
- For the stretch of the conflict line that runs along the Dnipro River, long-range UASs can provide constant aerial surveillance while tethered aerostats can provide persistent coverage of the small islands located in the Dnipro River delta. Buoys embedded with cameras and radar can demarcate riverine boundaries while both capturing and deterring ceasefire violations. Camera and sensor-enabled uncrewed surface vehicles (USVs) can patrol waters for potential violations.
- On Ukraine's Black Sea coast, aerostats embedded with cameras and radar can be tethered to the coast for aerial monitoring while camera-enabled buoys can mark and monitor maritime boundaries close to shore. Camera and sensor-enabled USVs can patrol the Black Sea for potential violations and signal long-range UASs to perform aerial surveillance if needed.

To ensure that remote-sensing technology is being deployed effectively, a future ceasefire agreement should

- provide for a fusion center for data integration to analyze streams of data coming in from multiple sources. Leverage the latest advances in artificial intelligence to reduce the number of personnel needed to interpret incoming data
- establish consequences for interference with remote-sensing technology to establish new norms and deter future attempts
- include accountability mechanisms to ensure data from remote-sensing technology are used to adjudicate and sanction ceasefire violations.

Top-Line Recommendations

For policymakers and stakeholders involved in considering the details of a future ceasefire agreement in Ukraine, we offer the following seven top-line recommendations:

- Negotiate overarching geopolitical questions in parallel with, but on a separate track from, ceasefire discussions.
- Start working on the ceasefire design long before negotiations begin.
- Design a formal ceasefire agreement that clearly specifies assigned roles and responsibilities, protocols, and operating procedures.
- Ensure that the agreement includes the following key components:
 - DMZs along the frontline
 - CBMs, particularly mutual military inspection, on-site verification visits, and aerial surveillance
 - dispute-resolution mechanisms that involve the conflict parties in joint commissions
 - an extensive third-party monitoring mechanism
 - robust accountability mechanisms to identify, punish, and deter noncompliance.
- Include a robust remote-sensing infrastructure, featuring UAVs, aerostats, fixed ground sensors, satellites, buoys, and USVs.
- Ensure that the agreement treats interference with remote sensors as a violation.
- Include mechanisms that allow for political-level oversight of implementation and possibly specified conditions that would trigger renegotiation.

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Introduction

As of this writing (June 2025), the full-scale Russia-Ukraine war is well into its fourth year. It is the largest military conflict in Europe since World War II. There have been hundreds of thousands of casualties. Despite some initial moves to restart negotiations in 2025, the sides are far from an agreement to end the fighting.

But this war will eventually come to an end. Because an outright military victory is highly unlikely (at least as of this writing), that end will come in the form of a negotiated agreement or agreements. One key element of any such agreement will be a *ceasefire*: an accord that outlines the mechanisms to end the violence and ensure that hostilities do not resume.

Designing an effective ceasefire in the Russia-Ukraine war will not be a trivial task. The opposing armies are among the most capable and lethal forces on the planet. They have been engaged in a high-intensity war for a comparatively long period. The frontline between them is enormous by global standards of conflict lines, stretching, depending on how one measures, up to 3,300 km. The extremely high level of mistrust between the belligerents makes any agreements between them politically fraught. A ceasefire, in particular, will create military vulnerabilities that both sides will worry could be exploited by the other side for tactical gain. And Russia and Ukraine have had recent experience of a ceasefire—the Minsk agreements—that never achieved a sustainable end to the fighting in the 2014–2021 phase of the conflict. Both Moscow and Kyiv have stated that any new cessation agreement must be enduring, voicing nearly identical concerns that the other side will use any pause to rearm, refit, and reattack.

Such concerns point to the key challenge in finding agreements to end any war: the credible commitment problem. Belligerents have good reason to mistrust each other after fighting a war and particularly to be skepti-

cal about the other side's stated intent to stop fighting. They might believe that the other side is a determined aggressor that will attack again once its relative capabilities improve or a fickle actor prone to change its preferences over time. Negotiating and complying with a ceasefire agreement can be an important costly signal that former belligerents can use to overcome the credible commitment problem.

It will be essential to design a ceasefire agreement carefully and deliberately to maximize the chances of achieving an enduring peace in Ukraine. Of course, no agreement can function absent political will on both sides to make it work. But political will is not sufficient to ensure ceasefire success. Poorly designed agreements can, in fact, lessen political investment in a peace process. Well-designed agreements can reduce incentives to renew fighting, mitigate uncertainty, and help prevent accidents, therefore contributing to the maintenance of peace.

In this report, we draw on existing academic literature, empirical research on past attempts at cessations of hostilities in Ukraine, and, in light of the unprecedented geographic scope of this conflict, an assessment of remote-sensing technology for monitoring to develop a set of recommendations for a future ceasefire agreement. These recommendations aim to provide policymakers with concrete strategies to enable a lasting cessation of hostilities, ultimately paving the way for a political settlement to the Russia-Ukraine war.

Methodology and Structure

Rather than drafting a proto-agreement or striving to cover all possible aspects of a future ceasefire, we analyzed existing bodies of empirical evidence to develop guidelines for an agreement. Specifically, we consulted three sets of sources. First, we examined past ceasefires, focusing specifically on those that sought to end interstate wars. We reviewed the existing literature to determine which provisions of these agreements were most conducive to enduring peace and, thus, are ones to be considered in designing a Russia-Ukraine ceasefire. Second, we analyzed the Minsk agreements, the documents that were meant to end the 2014–2021 phase of the conflict, and their implementation. These agreements, though widely regarded today

as a failure, offer important lessons for a future ceasefire in Ukraine. Third, in light of the enormity of the geographic scope of the Russia-Ukraine war, we assessed how uncrewed remote-sensing technology could enable ceasefire implementation. Uncrewed systems (e.g., drones) have played a major role in the warfighting, and they could also play a role in keeping the peace. These three strands of research do not provide for a comprehensive agreement. However, because the war continues as of this writing, we took this approach to generate guidelines that could be adapted to the specific circumstances on the ground when the guns fall silent.

Chapter 2 provides a review of best practices from global ceasefire agreements based on academic and practitioner literature. Specifically, we sought to identify those elements of ceasefire agreements that are most closely associated with enduring peace. In Chapter 3, we review the history of the Minsk agreements, identify lessons learned from their shortcomings, and present recommendations based on those lessons. Chapter 4 focuses on remote-sensing technology. It offers an overview of the technological capabilities available for monitoring, an assessment of the diverse geography along the conflict line in Ukraine, and recommendations for how to deploy such capabilities in that geography. Finally, in Chapter 5, we provide a concise account of the most important recommendations derived from this study.

Ceasefire Best Practices

What elements should a future ceasefire agreement in the Russia-Ukraine war contain? In this chapter, we seek to derive the best practices from the academic and practitioner literature on past ceasefires. We begin by covering some of the key distinctions made and terms used in this literature. We then discuss the findings regarding specific ceasefire mechanisms that can contribute to a durable peace. Finally, we offer some suggestions for how these best practices can be applied in the Russia-Ukraine context.

Ceasefire Definitions

We use Bara, Clayton, and Rustad's definition of a *ceasefire* as "any arrangement in which a conflict party commits to a temporary or permanent cessation of violence."¹ However, there is no consensus definition of a ceasefire in the literature, which complicates a comparison of both the studies of relevant agreements and the agreements themselves. Practitioners often confine the term to formal agreements between parties that are monitored or verified.² While not always included in formal definitions, there is an assumption that ceasefires do not address "the underlying political, social or economic drivers around which a conflict is fought."³ Ceasefires

¹ Corinne Bara, Govinda Clayton, and Siri Aas Rustad, "Understanding Ceasefires," *International Peacekeeping*, Vol. 28, No. 3, 2021, p. 332.

² Cate Buchanan, Govinda Clayton, and Alexander Ramsbotham, *Ceasefire Monitoring: Developments and Complexities*, Conciliation Resources, June 2021, p. 6.

³ Buchanan, Clayton, and Ramsbotham, 2021, p. 6.

can be part of a broader settlement, but they are not peace agreements.⁴ Ceasefires can also be stand-alone documents. All ceasefires tend to share a primary objective—cessation of violence—but the underlying goals vary across conflicts. Examples of underlying goals include “signalling peaceful intent, building trust, establishing control of forces, reducing human suffering, creating a more favourable environment for negotiations, and preparing security arrangements for the immediate post-peace agreement period.”⁵ Ceasefires often come at the beginning of a negotiation process, frequently as a prerequisite to negotiations for a peace agreement.⁶ Peace talks have concluded successfully without a previously agreed ceasefire in some cases, while multiple rounds of ceasefires have collapsed without an ultimate peace agreement in others.⁷

Ceasefires in Interstate and Intrastate Wars

Nearly all research on war duration and termination examines either interstate *or* intrastate wars, while studies analyzing both types tend to consider each separately. The body of relevant literature from recent decades is dominated by civil war research.⁸ One driver of this trend may be data: Since 1950, “the rate at which interstate wars have ended with a formal peace treaty has declined dramatically.”⁹ Interstate conflicts have been relatively rare in the

⁴ Govinda Clayton, Laurie Nathan, and Claudia Wiehler, “Ceasefire Success: A Conceptual Framework,” *International Peacekeeping*, Vol. 28, No. 3, June 2021, p. 344.

⁵ Bara, Clayton, and Aas Rustad, 2021, p. 332.

⁶ Luc Chounet-Cambas, *Negotiating Ceasefires*, Centre for Humanitarian Dialogue, March 2011.

⁷ Chounet-Cambas, 2011.

⁸ Isabel Bramsen and Isak Svensson, “Peace Talks in the Russia-Ukraine War: When, Who, and How?” *International Negotiation*, Vol. 30, 2025.

⁹ Tanisha M. Fazal, “The Demise of Peace Treaties in Interstate War,” *International Organization*, Vol. 67, No. 4, Fall 2013.

post–World War II era,¹⁰ and they make up only 4 percent of peace agreements from 1990 to 2018 in the Peace Agreement Access Tool Database.¹¹

According to Virginia Page Fortna, the primary difference in maintaining peace after interstate wars compared with intrastate wars is the necessity of solving fundamental political issues in intrastate wars.¹² Barbara F. Walter similarly argues that intrastate wars are harder to resolve because the conflict parties must share the same state after the fighting ends.¹³ It is rare for intrastate wars to end with ceasefires that do *not* address the underlying cause(s) to some extent.¹⁴ Because of these differences, which are particularly salient in ceasefire agreement design, we largely consider the interstate conflict literature in this chapter, given the report’s focus on lessons learned for Ukraine. Some studies on civil wars can still provide useful inputs, as can practitioner literature drawing on experiences from both interstate and intrastate wars, about *how* specific mechanisms have been used in various cases. But our focus here is on how these mechanisms can contribute to the duration of peace in Ukraine, and the vast difference between the contexts of civil and interstate wars limits the applicability of insights from studies of the former.

What Makes a Ceasefire Successful?

There is no clear consensus on how to define or measure ceasefire success. Quantitative research may, for example, consider a ceasefire successful if battle deaths stay below a specific number for a specific period.¹⁵ Other

¹⁰ Marie Allansson, Erik Melander and Lotta Themnér, “Organized Violence, 1989–2016,” *Journal of Peace Research*, Vol. 54, No. 4, July 2017, p. 576.

¹¹ Robert A. Forster, “Peace Agreements,” in Scott Romaniuk and Péter Marton, eds., *The Palgrave Encyclopedia of Global Security Studies*, 2023.

¹² Virginia Page Fortna, *Peace Time: Cease-Fire Agreements and the Durability of Peace*, Princeton University Press, 2004.

¹³ Barbara F. Walter, “Bargaining Failures and Civil War,” *Annual Review of Political Science*, Vol. 12, 2009.

¹⁴ Fortna, 2004.

¹⁵ Clayton, Nathan, and Wiehler, 2021, p. 342.

factors complicate these measures. Even violated ceasefires, for example, can have a longer-term positive effect on reducing or ending violence.¹⁶ Ceasefire agreements usually do not address the underlying political drivers and therefore rarely—in themselves—mark a definitive end to a conflict, even when they do end violence.¹⁷ Some scholars propose more-flexible definitions, such as viewing ceasefire success as a spectrum instead of as a binary measure.¹⁸ This conceptualization allows the scope and indicators of ceasefire success to change over time. Most research on ceasefires tends to assume that the aim of a ceasefire is to encourage a larger peace process.¹⁹ This means that ceasefire success is often measured in relation to peacebuilding (e.g., a successful ceasefire is one that leads to an eventual peace agreement).²⁰ This is not necessarily an incorrect assumption, but its implications for research design are important to keep in mind. As a result, researchers frequently focus on peace durability, ceasefire stability, ceasefire sustainability, and encouragement of peacebuilding as measures of ceasefire success.²¹ In this report, we focus specifically on the duration of peace.

Agreement Strength and Ceasefire Success

Research on peace duration, most prominently the work of Fortna, has demonstrated that the nature of a ceasefire agreement can have a significant impact on the duration of peace. Fortna argues that “belligerents can draft cease-fire agreements that foster peace by altering the incentives to attack, by reducing uncertainty about intentions, and by preventing and controlling accidents.”²² Her research demonstrates that overall agreement

¹⁶ Clayton, Nathan, and Wiehler, 2021.

¹⁷ Bara, Clayton, and Rustad, 2021.

¹⁸ Govinda Clayton and Valerie Sticher, “The Logic of Ceasefires in Civil War,” *International Studies Quarterly*, Vol. 65, No. 3, September 2021.

¹⁹ Chounet-Cambas, 2011.

²⁰ Clayton, Nathan, and Wiehler, 2021.

²¹ Clayton, Nathan, and Wiehler, 2021, p. 345.

²² Fortna, 2004, p. 3.

strength, measured both objectively and subjectively, reduces the risk of another war.²³ Fortna's work is based on a dataset of 48 ceasefires in interstate wars ending from 1946 to 1997.²⁴ She controls for other factors theorized to affect peace duration, such as a history of conflict between parties or regime type.²⁵ Fortna cautions that her findings should be interpreted carefully because of the small sample size, lack of controlled environment, and interconnected nature of the mechanisms.²⁶ This last point is echoed by other scholars who warn that "in most cases, provisions in peace agreements are not meant to be implemented independently but in accordance with each other."²⁷

In addition to the empirical evidence in Fortna's study, key theoretical arguments suggest that ceasefire agreements help ensure that peace endures. Recent belligerents have ample reason not to believe each other's commitment to ceasing hostilities. After all, they have just fought a war. One side might believe that the other is an incorrigible aggressor; it will use any pause in fighting to rearm, refit, and attack again from a better relative position. Or one side might see the other as a fickle actor whose preference for peace in the moment could change in the future. Such *credible commitment problems* make it hard to end wars even when doing so would benefit both sides—and equally hard to keep the peace.²⁸ Mutual mistrust can also create an environment when small incidents can escalate quickly, and accidents can be misperceived as deliberate aggression.²⁹ A strong ceasefire agreement is

²³ Virginia Page Fortna, "Scraps of Paper? Agreements and the Durability of Peace," *International Organization*, Vol. 57, No. 2, April 15, 2003b, p. 354.

²⁴ Fortna, 2004, p. 45.

²⁵ Fortna, 2003b.

²⁶ Fortna, 2004, p. 174.

²⁷ Angelika Rettberg and Federico Dupont, "Implementación de acuerdos de paz: ¿de qué depende? Una revisión de la literatura académica" ["Peace Agreement Implementation (PAI): What Matters? A Review of the Literature"], *Colombia Internacional [Colombia International]*, Vol. 113, January–March 2023, p. 208.

²⁸ Dan Reiter, *How Wars End*, Princeton University Press, 2009, pp. 166–174.

²⁹ Robert Jervis, "War and Misperception," *Journal of Interdisciplinary History*, Vol. 18, No. 4, Spring 1988.

an important costly signal that former belligerents can use to overcome the commitment problem and minimize the chances of misperception.

Fortna argues that strong agreements can reduce the incentive to renew violence. Conflict parties can agree to raise the costs of breaking a ceasefire with physical obstacles, such as demilitarized zones (DMZs); arms control agreements; withdrawal from the front lines; or by risking reputational costs by publicly agreeing to a ceasefire.³⁰ External actors can raise these costs by deploying peacekeepers as a buffer or using peacekeepers to take “on some of the responsibility for retaliation in the event of defection.”³¹ Agreements can also minimize uncertainty. For example, they can precisely mark the ceasefire line to preclude parties from using *salami tactics* (i.e., a series of small-scale encroachments) to gain an advantage.³² Verification and monitoring mechanisms can ensure violations do not go undetected, which can create audience costs and reduce fears of unexpected attack.³³ If the conflict parties are willing to accept cost-raising measures, that can serve as a credible signal of “benign intent.”³⁴ Finally, ceasefire agreements can prevent or control accidental violations. Dispute-resolution mechanisms and ongoing negotiations can help de-escalate incidents.³⁵ Confidence-building measures (CBMs) can similarly encourage less suspicion between parties.³⁶ Physical cost-raising measures can also help prevent violations from occurring. Agreements with provisions for internal control, or ones that hold each side responsible for any violations, may reduce the ability of parties to deflect blame for violence.³⁷

It is important to note that there is no scholarly consensus that the content of ceasefire agreements is the key to determining how long peace lasts.

³⁰ Fortna, 2003b.

³¹ Fortna, 2003b, p. 343.

³² Thomas C. Schelling, *Arms and Influence*, Yale University Press, 1966, pp. 66 ff.

³³ Fortna, 2003b.

³⁴ Fortna, 2003b, p. 344.

³⁵ Fortna, 2003b.

³⁶ Fortna, 2003b.

³⁷ Fortna, 2003b.

For example, Suzanne Werner and Amy Yuen found that agreement design alone cannot prevent a belligerent from returning to fighting to “renegotiate the terms” by force if it believes “a renewed war can lead to better terms.”³⁸ In an earlier study, using a more expansive definition of peace (specifically, the absence of any militarized interstate dispute), Werner found no effect of formal agreements on the recurrence of such disputes.³⁹ Other researchers, using a larger dataset than Fortna’s (covering 1914–2001 versus 1946–1997), showed that an aggregated variable of agreement strength had no effect on peace duration.⁴⁰

Our aim in this report is not to resolve this debate. When the Russia-Ukraine war comes to an end, policymakers will be faced with the dilemma of how to design an agreement to end the fighting. There is ample empirical and theoretical grounding for them to try to forge a well-designed agreement, regardless of whether such agreements were *the* key to enduring peace in past conflicts. Moreover, both Fortna’s work and that of other scholars in the field offer important insights into *which* ceasefire agreement provisions might have the most effect on peace duration. In short, we make no claims that agreement strength will be the decisive factor in determining the success of any ceasefire in Ukraine. Instead, we seek to leverage scholarly insights to aid those designing a ceasefire to choose those agreement provisions for which there is the most evidence of a positive effect on peace duration.

³⁸ Suzanne Werner and Amy Yuen, “Making and Keeping Peace,” *International Organization*, Vol. 59, No. 2, Spring 2005, p. 261. Werner and Yuen used Fortna’s dataset of interstate wars ending from 1946 to 1997.

³⁹ Suzanne Werner, “The Precarious Nature of Peace: Resolving the Issues, Enforcing the Settlement, and Renegotiating the Terms,” *American Journal of Political Science*, Vol. 43, No. 3, July 1999. Werner examined a dataset of interstate dyads formerly at war from 1816 to 1992.

⁴⁰ Nigel Lo, Barry Hashimoto, and Dan Reiter, “Ensuring Peace: Foreign-Imposed Regime Change and Postwar Peace Duration, 1914–2001,” *International Organization*, Vol. 62, No. 4, Fall 2008. The authors added to Fortna’s dataset of 48 ceasefires to create an expanded dataset of 188 ceasefire cases; the discrepancy in findings may be the result of the expanded dataset.

Political Will

In addition to the empirical question of the impact of agreement strength on peace historically, some scholars and practitioners have made the case that agreements themselves are *epiphenomenal*—that they are essentially reflections of the parties' intentions and have no independent effect on parties' behavior. In other words, only states already committed to peace would sign a strong ceasefire agreement. They argue that agreement mechanisms will "often be inadequate" if the conflict parties lack political commitment to a ceasefire.⁴¹ The substance of a ceasefire agreement itself tends to "reflect the political will of the parties,"⁴² as each party's willingness to comply with a ceasefire is shaped by the factors driving them to negotiate a ceasefire.⁴³ However, political will is a difficult concept to define or measure. Because it cannot be observed by the parties, in itself it cannot resolve commitment problems. The more salient question for ceasefire-related research is what factors *create* or *undermine* political will, not the presence or absence of it as a driver of peace duration. A well-designed agreement may help create or maintain political will.⁴⁴ And an agreement's success can alter the parties' pre-existing incentive structure and help them overcome the credible commitment problem.

Assessment of Specific Ceasefire Mechanisms

In this section, we examine the evidence from studies of past ceasefires to determine which elements of such agreements are most conducive to enduring peace.⁴⁵

⁴¹ Werner and Yuen, 2005, p. 261.

⁴² Govinda Clayton, Håvard Mogleiv Nygård, Siri Aas Rustad, and Håvard Strand, "Ceasefires in Civil Conflict: A Research Agenda," *Journal of Conflict Resolution*, Vol. 67, No. 7–8, 2022, p. 1285.

⁴³ Valerie Sticher, "Ceasefire Violations: Why They Occur and How They Relate to Strategic Decision-Making Processes," *International Studies Review*, Vol. 24, No. 4, December 2022, pp. 2–3.

⁴⁴ Fortna, 2004.

⁴⁵ Fortna, 2004, pp. 209–210.

Troop Withdrawal

Research suggests that *troop withdrawal*—defined as both the withdrawal of forces and conceding the territory on which those forces are located—can encourage durable peace.⁴⁶ For example, Michaela Mattes cites the 1989 agreement between Chad and Libya to withdraw their forces “from the positions they currently occupy.”⁴⁷ Such a withdrawal can increase the cost of attacking again. Fortna breaks down her analysis by level of withdrawal. She finds that troop withdrawal *to* the status quo ante bellum is “associated with unstable peace.”⁴⁸ Examples include Israel and Egypt, which fought again following Israel’s 1956 withdrawal from Sinai, and to India and Pakistan, which fought again following their withdrawal to pre-1965 lines.⁴⁹ Withdrawal *beyond* the status quo ante bellum (i.e., ceding territory held before the conflict) is associated with durable peace in all cases.⁵⁰ Such action is likely seen as a strong indication of commitment. In 1962, China withdrew an additional 20 km from its prewar line with India.⁵¹ Peace was unstable in cases in which one side did not cede territory taken during the war.⁵² This is seen in the “ongoing strife over territories occupied by Israel in the Six-Day War in 1967.”⁵³

Fortna also cautions that territorial issues are difficult to address in ceasefires: “[O]ften such a withdrawal is inseparable from political settlement of

⁴⁶ Fortna, 2004; Michaela Mattes, “The Effect of Changing Conditions and Agreement Provisions on Conflict and Renegotiation Between States with Competing Claims,” *International Studies Quarterly*, Vol. 52, No. 2, June 2008. Mattes uses a dataset of 125 cases of interstate territorial disputes in Europe, the Middle East, and the Americas from 1919 to 1995. All claims between the same pair of states are aggregated into one.

⁴⁷ Mattes, 2008, p. 332.

⁴⁸ Fortna, 2004, p. 175.

⁴⁹ Fortna, 2004, p. 175.

⁵⁰ Fortna, 2004, p. 177.

⁵¹ Fortna, 2004, p. 177.

⁵² Fortna, 2004, p. 175.

⁵³ Fortna, 2004, p. 175.

the underlying dispute. It is not a mechanism that deadly enemies can easily use to prevent war while they continue to disagree over the fundamentals.”⁵⁴

Demilitarized Zones

Both Fortna and Mattes find that DMZs are often associated with stable peace.⁵⁵ DMZs are effective at de-escalating and distancing troops, which raises the cost of attack. Peace almost always lasted in cases in which troops were separated by 2 km or more, such as after the 1969 Football War between El Salvador and Honduras or the 1962 Sino-Indian War.⁵⁶ Fortna’s analysis found that peace broke down in all cases with a limited or partial DMZ, however. Following the second India-Pakistan ceasefire in 1965, troops were separated by less than 30 yards in some places; fighting inevitably resumed given this proximity.⁵⁷

Confidence-Building Measures

Research shows mixed results on the importance of CBMs, which Fortna defines as mechanisms to “provide information about or regulate military activities . . . that are likely to cause tensions between deadly enemies.”⁵⁸ Fortna finds that there are insufficient data to draw conclusions about CBMs; only around one in four ceasefire agreements contain them.⁵⁹ Mattes’s work demonstrated that provisions for “military inspections between the claimants” were effective.⁶⁰ Other research finds that on-site verification and aerial surveillance had a statistically significant effect on peace duration.⁶¹

⁵⁴ Fortna, 2004, p. 179.

⁵⁵ Fortna, 2004; Mattes, 2008.

⁵⁶ Fortna, 2004, p. 181.

⁵⁷ Fortna, 2004, p. 180.

⁵⁸ Fortna, 2004, p. 193.

⁵⁹ Fortna, 2004, p. 194.

⁶⁰ Mattes, 2008, p. 322.

⁶¹ Lo, Hashimoto, and Reiter, 2008, p. 733.

Dispute Resolution

Fortna examines two types of communication channels for dispute resolution: ongoing negotiations and joint commissions. Ongoing negotiations, mediated by a third party, are not an effective peace-reinforcing measure; “ongoing mediation is actually associated with a higher risk of another war.”⁶² Examples include continued negotiations after the first ceasefires in the Turkey-Cyprus war and the Armenia-Azerbaijan war, both of which rapidly devolved into fighting.⁶³ By contrast, joint commissions, whether civilian or military, that involve the parties themselves are a successful dispute-resolution mechanism associated with durable peace.⁶⁴ Parties’ cooperation with joint commissions can be a useful signaling tool. For example, one important factor in maintaining peace between Honduras and El Salvador was the establishment of a detailed commission to resolve a disputed boundary in 1980.⁶⁵ Engagement in these joint efforts can serve as a positive commitment signal, while a lack of engagement also shows intent.⁶⁶

Agreement Specificity

In her quantitative analysis, Fortna finds evidence that more-specific agreements are more durable than less-specific ones, all else being equal.⁶⁷ (She uses agreement length as a proxy for specificity.⁶⁸) This effect remains even when controlling for other mechanisms, such as DMZs, that are more likely to be contained in highly specific agreements.⁶⁹ In her discussion of particular cases, she finds that agreements that provide a detailed demarca-

⁶² Fortna, 2004, p. 195.

⁶³ Fortna, 2004, p. 195.

⁶⁴ Fortna, 2004, p. 195.

⁶⁵ Fortna, 2004, p. 197.

⁶⁶ Fortna, 2004.

⁶⁷ Fortna, 2004, p. 198.

⁶⁸ Fortna, 2004.

⁶⁹ Fortna, 2004.

tion of the ceasefire line help prevent salami tactics.⁷⁰ This was seen in the agreements that followed the India-Pakistan and Israel-Syria conflicts in which bouts of violence decreased after clear and codified demarcation of the ceasefire line.⁷¹

Practitioner literature tends to echo Fortna's findings: Clear and specific ceasefire agreements tend to be more durable than unclear or vague ceasefire agreements.⁷² If certain issues are left out of a ceasefire agreement because they are deemed too sensitive or controversial, they are likely to reemerge as larger problems during implementation.⁷³ Both sides need to have the same understanding of the agreement, especially regarding timelines and geography.⁷⁴ For example, problems may arise if a deadline for force withdrawal is interpreted by one side as when they *begin* withdrawing forces and by the other side as when they *finish* withdrawing forces. Ceasefires often depend on geography-based provisions, such as demilitarized areas or zones for the deployment of monitors, which should be clearly marked on high-quality maps.⁷⁵ Because disagreements over geography are common in ceasefire implementation, some experts recommend that ceasefires include a proactive plan for handling such issues.⁷⁶

Agreement Formality

Fortna's analysis finds that peace tends to last longer following formal agreements than following informal, tacit, or unilateral ceasefires.⁷⁷ She hypoth-

⁷⁰ Fortna, 2004.

⁷¹ Fortna, 2004, p. 198.

⁷² Nicholas Haysom and Julian Hottinger, *Do's and Don'ts of Sustainable Ceasefire Agreements*, UN Peacemaker, 2010; Fortna, 2004; Chounet-Cambas, 2011.

⁷³ Haysom and Hottinger, 2010.

⁷⁴ Haysom and Hottinger, 2010.

⁷⁵ Haysom and Hottinger, 2010.

⁷⁶ Haysom and Hottinger, 2010.

⁷⁷ Fortna, 2004, p. 199.

esizes that ceasefire formality may contribute to peace duration by invoking international law and audience costs if the agreement is violated.⁷⁸

Third-Party Pressure

Multiple authors examining interstate wars argue that ceasefires resulting from external pressure are more likely to fail.⁷⁹ These ceasefires may not reflect the perceived balance of military power between the conflict parties: “In such instances, although the belligerents may agree to the ceasefire temporarily to appease powerful third parties, at least one of the belligerents is going to resist pressures to institutionalize the peace.”⁸⁰ The fundamental problem, the authors argue, is that a third party might “make peace” in such a way that differs from the belligerents’ expectations about how the war would have ended if there had not been that external intervention. (They distinguish such interventions from efforts to “keep peace” after the belligerents themselves have agreed to end the fighting; these tend to be more successful.) Ceasefires pushed by external actors may also collapse due to a lack of organic willingness from the conflict parties. There may also be “considerable uncertainty about the consequences of continued fighting” following ceasefires imposed by third parties.⁸¹ That uncertainty stems, in large part, from the often fickle nature of third-party pressure to end fighting: It usually wanes over time. And in the absence of such pressure, one or both of the parties no longer finds the agreement to cease hostilities acceptable. This finding implies that for third-party pressure to be useful, it must be somehow institutionalized in the agreements to end the fighting. Otherwise, peace is unlikely to endure.

Third-Party Guarantees

Explicit third-party guarantees of ceasefire agreements may be associated with lasting peace, but such guarantees are rare in interstate conflicts, so

⁷⁸ Fortna, 2004, p. 205.

⁷⁹ Werner and Yuen, 2005; Buchanan, Clayton, and Ramsbotham, 2021.

⁸⁰ Werner and Yuen, 2005, p. 289.

⁸¹ Werner and Yuen, 2005, p. 262.

there are very few cases to consider. Guarantees are also difficult to define and may be included in broader negotiations instead of specified in the ceasefire agreement itself. Examples include the United States-South Korea Mutual Defense Treaty, signed two months after the Korean Armistice Agreement.⁸² A more relevant case for Ukraine might be the United States-Israel memorandum of agreement, signed two years after the initial Israel-Egypt ceasefire and four years before the Israel-Egypt peace agreement.⁸³ In that document, the United States, even though it was not a belligerent (as it was in Korea), committed to undertake “remedial action” if Egypt were to violate the ceasefire. Another relevant case may be the 1831 and 1839 agreements signed by the Concert of Europe—and guaranteed by its members Austria, Prussia, the United Kingdom, France, and Russia—to make Belgium an independent and neutral state.⁸⁴ In a sense, this document also was a ceasefire, at least between the rebellious Belgians and their former Dutch rulers, but it was also meant to avoid great-power conflict. Peace lasted for 75 years before Belgium was invaded by Germany; the United Kingdom joined World War I against Germany to uphold its guarantee of Belgium’s independence and neutrality.⁸⁵ These examples suggest that third-party guarantees, broadly defined and not necessarily part of the ceasefire agreement itself, may be useful mechanisms to support a lasting peace.

Peacekeeping

Research on peacekeeping’s role in maintaining peace after interstate conflicts shows it to be an effective tool. Accepting a peacekeeping operation is a highly visible signal from a conflict party of its commitment to peace.

⁸² Mutual Defense Treaty Between the United States and the Republic of Korea, October 1, 1953.

⁸³ Memorandum of Agreement Between the Governments of Israel and the United States, in Adam M. Howard, ed., *Foreign Relations of the United States, 1969–1976*: Vol. XXVI, *Arab-Israeli Dispute, 1974–1976*, Office of the Historian, Foreign Service Institute, U.S. Department of State, Document 227, September 1, 1975.

⁸⁴ Samuel Charap, “Ukraine’s Best Chance for Peace: How Neutrality Can Bring Security—and Satisfy Both Russia and the West,” *Foreign Affairs*, June 1, 2022.

⁸⁵ Charap, 2022.

The presence of peacekeepers can also serve as a deterrent to renewed violence. Fortna's analysis of interstate and intrastate wars from 1947 to 1997 finds that, "in general, peace lasts longer when peacekeepers are present than when belligerents are left to their own devices."⁸⁶ The relationship between conflict context and peacekeeping success is critical. If peacekeepers are sent to "easy" conflicts, their rate of success would be artificially inflated; if they are sent to the most complex conflicts, their rate of failure would be exaggerated.⁸⁷ Controlling for the "degree of difficulty," the presence of peacekeepers has a positive effect on peace duration for both types of wars.⁸⁸ Subsequent research, while focused on civil wars, has largely echoed these findings on the positive effect of peacekeeping.⁸⁹ Two of Fortna's control variables are particularly relevant for the Russia-Ukraine context: the involvement of powerful states and the involvement of a permanent member of the United Nations (UN) Security Council (or P5). Research suggests that peacekeeping operations are rarer when a conflict is between "large powerful states."⁹⁰ She predicts a similar effect when a P5 member is involved, given their UN Security Council veto power.

Fortna's work also suggests that peace is more likely to last with the presence of peacekeepers "but that their effectiveness is easily undermined" once a mission has failed (i.e., if war has broken out while peacekeepers are deployed).⁹¹ It is thus important to differentiate between new peacekeeping operations launched after a ceasefire and existing peacekeeping operations from before the war. New operations may be helpful; failed existing ones are discredited.⁹² The host country, or countries, may be restrained by

⁸⁶ Virginia Page Fortna, "Inside and Out: Peacekeeping and the Duration of Peace after Civil and Interstate Wars," *International Studies Review*, Vol. 5, No. 4, 2003a, p. 111.

⁸⁷ Fortna, 2003a, p. 101.

⁸⁸ Fortna, 2003a, p. 112.

⁸⁹ See, for example, Barbara F. Walter, Lise Morje Howard, and V. Page Fortna, "The Extraordinary Relationship Between Peacekeeping and Peace," *British Journal of Political Science*, Vol. 51, No. 4, 2021.

⁹⁰ Fortna, 2003a, p. 102.

⁹¹ Fortna, 2004, p. 189.

⁹² Fortna, 2004.

the presence of peacekeepers but retain the ability to expel them—another highly visible signal.⁹³

It should be noted that mandates for peacekeeping operations vary significantly. A 2024 UN-commissioned study identified 30 models of peacekeeping missions, ranging from security sector reform to maritime security.⁹⁴ Several of those 30 functions could be categorized as ceasefire monitoring or post-conflict reconstruction rather than peacekeeping.

Third-Party Monitoring

Third-party monitoring in a ceasefire agreement is consistently found to have a positive effect on ceasefire success, although the literature diverges on the independence of this effect and how it is achieved.⁹⁵ In general, ceasefire agreements with monitoring mechanisms are more likely to hold in both intrastate and interstate conflicts.⁹⁶ Monitoring can increase the reputational cost of ceasefire violations by enabling attribution, de-escalate tensions by differentiating between violations and incidents, and create transparency that prevents conflict parties from “cheating” the ceasefire for military advantage.⁹⁷ Experts agree that “in the absence of effective means for monitoring and verification, ceasefires can rarely be expected to hold.”⁹⁸

Third-party monitoring is also useful as a credible and impartial arbiter of alleged violations. Without such an arbiter, it is easy for one party to claim a violation by the other side as pretext for its own violations. Politi-

⁹³ Fortna, 2004.

⁹⁴ El-Ghassim Wane, Paul D. Williams, and Ai Kihara-Hunt, *The Future of Peacekeeping, New Models, and Related Capabilities*, United Nations Department of Peace Operations, October 2024.

⁹⁵ It should be noted that there is not a clear distinction between third-party monitoring and peacekeeping in practice.

⁹⁶ Clayton and Sticher, 2021; Buchanan, Clayton, and Ramsbotham, 2021; Bara, Clayton, and Rustad, 2021; Sticher, 2022; Mattes, 2008.

⁹⁷ Clayton and Sticher, 2021.

⁹⁸ Antonia Potter, “Ceasefire Monitoring and Verification: Identifying Best Practice,” Centre for Humanitarian Dialogue, June 10, 2004, p. 1.

cally, a monitor's validation of a party's complaint offers an alternative to retaliation and, thus, can help avoid a tit-for-tat escalatory spiral.

Ceasefires can fail because of a lack of accountability even if monitoring missions reduce uncertainty. Third parties may be unwilling or unable to impose costs for ceasefire violations regardless of the information provided by monitoring.⁹⁹ The views of convened experts on this subject were summarized as follows:

To shift the behaviour of conflict parties, information provided by monitors is often insufficient on its own and needs to translate into some political, economic, or reputational costs associated with non-compliance that outweigh any benefits that might be gained from violating a ceasefire.¹⁰⁰

These experts also noted the need for flexible mandates and an iterative approach to mission design because of the ever-evolving nature of conflict dynamics.¹⁰¹

Monitoring also has costs that must be factored into agreement design. Monitoring missions require significant resource investment and commitment from the states responsible for the mission, especially in situations in which belligerents oppose monitoring or there is a "high degree of uncertainty about whether the parties will stick to an agreement."¹⁰² Monitoring may not always be feasible, such as in situations with temporary agreements or ones lacking sufficient resources for a monitoring mission.¹⁰³

Some scholars note that "flawed" monitoring can be harmful.¹⁰⁴ Biased monitoring, real or perceived, can undermine trust in the ceasefire itself.¹⁰⁵

⁹⁹ Valerie Sticher and Aly Verjee, "Do Eyes in the Sky Ensure Peace on the Ground? The Uncertain Contributions of Remote Sensing to Ceasefire Compliance," *International Studies Review*, Vol. 25, No. 3, September 2023, p. 5.

¹⁰⁰ Buchanan, Clayton, and Ramsbotham, 2021, p. 8.

¹⁰¹ Buchanan, Clayton, and Ramsbotham, 2021, pp. 9–11.

¹⁰² Clayton and Sticher, 2021, p. 4.

¹⁰³ Buchanan, Clayton, and Ramsbotham, 2021, p. 9.

¹⁰⁴ Sticher and Verjee, 2023, p. 5.

¹⁰⁵ Sticher and Verjee, 2023, p. 5.

Inaccurate, delayed, interrupted, or surface-level monitoring reports risk creating a skewed picture of conflict dynamics.¹⁰⁶ Monitoring may also inadvertently create incentives for noncompliance. Conflict parties may use noncompliance to signal intent to other parties (knowing that monitoring will ensure that noncompliance gets noticed), influence the monitor(s), or test the reaction to noncompliance as an indicator of likely costs if they were to return to fighting.¹⁰⁷

Summary

Academic research on the impact of ceasefire agreement design on the durability of peace after interstate wars is limited by a small sample size, unique conflict environments, and the interconnected nature of agreement mechanisms. But the existing literature suggests that certain agreement design elements should be considered in any discussion of a cessation of hostilities in the Russia-Ukraine war to ensure it is a lasting one. These elements are summarized in Table 2.1.

Implications for Designing a Ceasefire in the Russia-Ukraine War

It bears repeating that even the best-designed agreement will not stop a determined aggressor. An extremely effective monitoring mechanism, for example, cannot prevent such an aggressor from renewing conflict; information about the other side's intentions is likely irrelevant.¹⁰⁸ In such a case, even "legions of monitors and troops may fail."¹⁰⁹ But a well-designed agreement can help parties signal their intentions, raise the costs of a return to hostilities, reduce uncertainty, and minimize the risks of accidental ceasefire violations. We have highlighted the mechanisms most closely associated

¹⁰⁶ Sticher and Verjee, 2023, p. 5.

¹⁰⁷ Aly Verjee, "Theorizing Conflict Opponent Noncompliance from Ceasefire Monitoring," *Cooperation and Conflict*, January 25, 2025, p. 4.

¹⁰⁸ Sticher and Verjee, 2023, p. 5.

¹⁰⁹ Potter, 2004, p. 2.

TABLE 2.1

Mechanisms Associated with Durable Peace in Interstate Ceasefires

Mechanism	Research Findings
Troop withdrawal	- Increases cost of attack; a costly signal of peaceful intentions - Some indication that only withdrawal beyond status quo ante bellum is associated with durable peace
DMZs	- Increases cost of attack; a costly signal of peaceful intentions - Research suggests that peace is more durable when troops are separated by at least 2 km.
CBMs	Evidence that only certain CBMs support durable peace: mutual military inspection, on-site verification, and aerial surveillance
Dispute resolution	- Joint commissions involving all sides have proven effective. - Parties' cooperation with joint commissions can be a useful signaling mechanism.
Agreement specificity	- Demarcation of the ceasefire line helps prevent salami tactics. - Specificity precludes disputes over the terms.
Agreement formality	- Longer peace duration after formal agreements than informal or unilateral ones - Formal agreements increase reputational costs for violations.
Third-party pressure	If applied to compel a ceasefire, third-party pressure must be institutionalized to ensure that peace endures.
Third-party guarantees	Explicit third-party guarantees can raise the cost of renewed aggression.
Peacekeeping	Accepting a peacekeeping operation is a highly visible signal from a conflict party.
Third-party monitoring	Can increase the reputational cost of violations, de-escalate tensions, and create transparency

with durable peace in Table 2.1. Below, we extrapolate how these mechanisms could be applied in the context of a future ceasefire agreement in the Russia-Ukraine war:

- *Troop withdrawal*—Withdrawing forces away from the contact line will be an important signal of commitment to a future ceasefire. But

the most peace-supporting withdrawals would need to entail ceding control of territory beyond the status quo ante bellum. To date, Russia has shown no willingness to give up any of the Ukrainian territory that it has occupied since February 24, 2022. The literature suggests that the ongoing territorial dispute will prove a challenge to peace over the long term.

- *DMZs*—Any ceasefire agreement in Ukraine should consider including a fully demilitarized area separating troops. Fortna’s work suggests that such a DMZ be at least 2 km wide. However, that estimate does not reflect recent advances in military capabilities, particularly in long-range strike and uncrewed aerial vehicles (UAVs). Therefore, a DMZ in Ukraine might need to be much wider. It will also have to vary in width according to the particular geography; for example, there are some population centers that abut the line of contact as of this writing, and they might require additional protections.
- *CBMs*—Research suggests that CBMs encompassing mutual military inspection, on-site verification visits, and aerial surveillance may be associated with more durable peace. The former two measures could be carried out by Russian and Ukrainian officers delegated to a potential joint commission. Such CBMs, similar to provisions in the Treaty on Conventional Armed Forces in Europe, may enhance mutual confidence in compliance with any ceasefire agreement’s stipulations. Third-party aerial surveillance, perhaps via satellite imagery, could also be helpful.
- *Dispute resolution*—Joint commissions composed of representatives from both sides appear to be the most useful method for dispute resolution. Russian and Ukrainian officers participated in a similar commission from 2015 to 2017 as discussed in Chapter 3. Such a commission should be part of any future agreement as well.
- *Agreement specificity*—More-specific agreements may be more successfully implemented than vaguer ones, as the sides are more likely to have a clear, shared understanding of what the agreement terms mean. This finding calls for agreements that are precise and well elaborated rather than general statements of principle. An agreed-on, precise ceasefire line will also be important.

- *Agreement formality*—Peace may last longer following formal agreements than informal agreements. In the Russia-Ukraine context, a ceasefire agreement should therefore be a formal document, or perhaps even a legally binding treaty, instead of an informal arrangement or unilateral measures.
- *Third-party pressure*—Pressure from external actors can help bring conflict parties to agreement. But if such pressure is a key factor in motivating Russia or Ukraine to cease hostilities, it must be maintained over the long term. In the Russia-Ukraine case, that could mean ensuring long-term Western military assistance to Ukraine because that assistance has been a key pressure point vis-à-vis Russia. If the third party's interest in maintaining the pressure is perceived by one or both of the belligerents to be fleeting, the ceasefire is more likely to collapse.
- *Third-party guarantees*—Although there are very few historical cases for comparison, our research suggests that explicit ceasefire guarantees from third parties could be helpful. Ukraine has sought such guarantees since the start of the war. To ensure an enduring peace, outside powers willing to remain involved in upholding the ceasefire should consider committing to take action in the event of serious violations.
- *Peacekeeping*—Peacekeeping missions are generally associated with a longer duration of peace. Russia and Ukraine would need to agree on the composition of a peacekeeping force, and Russia's status as a permanent member of the UN Security Council may further complicate the approval of a peacekeeping operation. While the significant military capabilities of the belligerents might undermine the deterrent effect of a lightly armed peacekeeping mission, peacekeepers' potential roles go beyond deterring renewed conflict; for example, they can monitor implementation of a ceasefire agreement.
- *Third-party monitoring*—Third-party monitoring is associated with more durable peace. A monitoring mission should be a key component of any future ceasefire agreement.

Lessons Learned from the Minsk Agreements

Before Russia launched its full-scale invasion of Ukraine in February 2022, the two countries had been mired in conflict for eight years. Accords meant to resolve that conflict—documents that came to be known as the Minsk agreements for the city in which they were signed—were concluded in 2014–2015, but they failed to stop the fighting or resolve the underlying political disputes. The process left the conflict simmering and unresolved, with a death toll surpassing 14,000.¹ To avoid repeating such an outcome, we examine the history of the Minsk agreements in this chapter to derive lessons applicable to any future ceasefire in Ukraine.

To that end, we analyze these documents and the associated consultation processes. We first provide a general overview of the diplomatic developments that led to the agreements, followed by a textual overview of one of the core documents (the February 2015 accord known as Minsk-2). Finally, we identify critical lessons learned for any future ceasefire in Ukraine, offering recommendations for how the architects of a future agreement might apply them in support of a more robust and durable peace. While other projects have sought to enumerate a toolbox of concrete policy ideas to incorporate into a future ceasefire,² this chapter instead highlights overarching principles and best practices that can inform policymakers as they negotiate and codify such a document.

¹ “Ukraine Crisis: UN Political Affairs Chief Calls for ‘Maximum Restraint,’” *UN News*, February 17, 2022.

² Walter Kemp, *Drawing a Line: A ‘Swiss Army Knife’ of Options for Achieving a Sustainable Ceasefire in Ukraine*, Geneva Centre for Security Policy, February 2025.

Background

Following Ukraine's 2014 Maidan Revolution that ousted a Russia-friendly president and brought a pro-Western government to power, the Kremlin launched a series of military and political operations against Ukraine. In addition to annexing Crimea, Moscow stoked and supported a separatist uprising in Ukraine's eastern Donbas region, capitalizing on discontent there with the political changes underway in the capital. Protests against the new government in Kyiv escalated as Russian-backed rebels took up arms, occupied government buildings, and declared two new independent states, the Donetsk People's Republic and the Luhansk People's Republic (DNR and LNR, respectively). In response, interim President Oleksandr Turchynov began a military campaign, referred to officially as an "anti-terrorist operation," to reestablish Ukrainian control over its territory.³

As this chaos and discord were still unfolding, the Organization for Security and Co-operation in Europe (OSCE), of which Ukraine and Russia are both members, agreed to send a Special Monitoring Mission to Ukraine (SMM) to promote peace and stability. The organization's 57 participating states adopted a two-page mandate establishing the SMM on March 21, 2014. This mandate tasked the monitors with, inter alia, gathering information on security developments, reporting any violations of OSCE principles, and facilitating dialogue to "reduce tensions and promote normalization of the situation."⁴ Initially, 100 monitors were authorized for a six-month mission; the ensuing war in the Donbas led the OSCE to regularly extend this mandate and increase the SMM's personnel, which had reached 689 monitors by the time its mandate ended in February 2022.⁵

While the SMM was authorized to monitor the situation on the ground throughout the country, it had no mandate to restore order in the Donbas. The diplomatic effort to end hostilities and reach a political settlement took several forms over the course of 2014 and early 2015. The first major push

³ "Ukraine Says Donetsk 'Anti-Terror Operation' Under Way," BBC, April 16, 2014.

⁴ Organization for Security and Co-operation in Europe Permanent Council, *Decision No. 1117: Deployment of an OSCE Special Monitoring Mission to Ukraine*, PC.DEC/1117, March 21, 2014.

⁵ SMM, *As of 7 February 2022 Status Report*, February 15, 2022b.

came in April 2014, when the top diplomats from Ukraine, Russia, the United States, and the European Union met in Geneva. These talks concluded with a joint statement affirming the principles of reconciliation, ending violence, disarming and withdrawing illegal armed groups, amnesty for non-capital offenses, and constitutional reform. The SMM was asked to “play a leading role in assisting Ukrainian authorities and local communities in the immediate implementation of these de-escalation measures wherever they are needed most.”⁶ This format, however, failed to end the conflict, in part because the separatists rejected an agreement that they themselves had no role in negotiating.⁷

Two months later, on the margins of the 70th anniversary celebration of D-Day in Normandy, France, the leaders of Ukraine, Russia, Germany, and France met, and that grouping became a regular format for diplomatic engagements right up until the full-scale invasion. In addition to conducting high-level political meetings, the Normandy Format (also known as the Normandy Four) soon established an additional body, the Trilateral Contact Group (TCG)—composed of Ukraine, Russia, and the OSCE—to serve as a platform for technical consultations to develop a ceasefire and peace plan.⁸

The first peace plan emerged in autumn. A successful summer offensive by the Ukrainian military was met with an increase in Russian support for the separatists, who inflicted major losses in both territory and lives.⁹ Faced with the increasingly clear reality that military victory was unachievable, then-Ukrainian President Petro Poroshenko negotiated the principles of a settlement over a series of phone calls with Russian President Vladimir Putin, who had unveiled his own draft plan on September 3, 2014. The

⁶ “Joint Geneva Statement on Ukraine from April 17: The Full Text,” *Washington Post*, April 17, 2014.

⁷ Laura Smith-Spark, Greg Botelho, and Phil Black, “Pro-Russia Separatists in Ukraine Defiant Despite International Deal, Call for Unity,” CNN, April 18, 2014.

⁸ Fred Tanner, Hilde Haug, Tjasa Vendramin, Michael Raith, Małgorzata Twardowska, and Aniek van Beijsterveldt, *A Peaceful Presence: The First Five Years of the OSCE Special Monitoring Mission to Ukraine*, ed. by Heather Cantin, Walter Kemp, Richard Murphy, and Nicholas J. Stewart, OSCE Conflict Prevention Centre, 2021, p. 26.

⁹ Vincent L. Morelli, *Ukraine: Current Issues and U.S. Policy*, Congressional Research Service, RL33460, January 3, 2017.

principles negotiated between the two leaders were then formalized by the TCG in Minsk.¹⁰ Two documents emerged from these discussions, a protocol on September 5 that laid out general principles for the peace process and a follow-up memorandum on September 19 that provided some specifics for the military de-escalation. Collectively, these agreements became known as Minsk-1. That same month, Ukraine and Russia bilaterally established the Joint Center for Control and Coordination (JCCC), a body of military officers from each side assigned to support the agreements' implementation.¹¹

Minsk-1 failed to hold. Over the following five months, the tenuous ceasefire agreement suffered numerous violations before entirely collapsing with the full resumption of war in the Donbas. In mid-January 2015, Russian and Russian-backed forces began a major military offensive against Ukrainian-held territory, including the strategic cities of Mariupol and Debaltseve.¹² On January 24, Ukraine's defense minister admitted that "the situation has worsened along the whole front" and that "illegal armed groups are on the attack everywhere."¹³

As the conflict continued to escalate, especially around Debaltseve, the leaders of the Normandy Four reconvened in Minsk in February for new peace negotiations. After a 16-hour night of marathon negotiations, the participants produced a new agreement on February 12, 2015. Although negotiated by the Normandy Four leaders, the agreement was signed by representatives of the TCG—OSCE Ambassador Heidi Tagliavini, former Ukrainian President Leonid Kuchma, Russian Ambassador Mikhail Zurabov—as well as the rebel leaders of the LNR and DNR, Aleksandr Zakharchenko and Igor Plotnitsky, respectively, although their titles are not acknowledged in the text. The new document, officially called Package of Measures for the Implementation of the Minsk Agreements, was meant to update, clarify,

¹⁰ "Russia and Eurasia," *Strategic Survey*, Vol. 115, No. 1, 2015, p. 165.

¹¹ Tanner et al., 2021, p. 34.

¹² Alan Cullison, "Deadly Rebel Attack in Ukraine Signals Escalation," *Wall Street Journal*, January 25, 2015.

¹³ Tom Parfitt, "Tank Troops Fight to Contain Rebel Expansion in Eastern Ukraine," *The Telegraph*, January 24, 2015.

and reaffirm the original peace process outlined in September 2014.¹⁴ The UN Security Council promptly endorsed the agreement, which came to be known as Minsk-2.¹⁵

Minsk-2

The full text of Minsk-2 is about 1,000 words, including a footnote. Its 13 provisions can be broken into four broad categories: security, political, economic, and humanitarian. On security matters, Minsk-2 stipulated an immediate and comprehensive ceasefire, followed by the withdrawal of all heavy weapons and foreign and illegal military forces, and the reestablishment of Ukrainian control over its border with Russia. The SMM, already established in Ukraine, was called on to “ensure effective monitoring and verification of the ceasefire regime . . . using all technical equipment necessary, including satellites, drones, radar equipment, etc.”¹⁶

Minsk-2 called for various changes to Ukraine’s legal and constitutional order. The separatist regions were to be reincorporated under Ukrainian sovereignty, but some political power was to be devolved to the regions. Ukraine’s parliament would pass legislation granting temporary special status to “certain areas of the Donetsk and Luhansk regions,” including the rights to linguistic self-determination, control over appointments in prosecutors’ offices and courts, and the creation of local people’s militia (i.e., police forces). These powers would then be enshrined in permanent legislation and “a new constitution,” to be enacted by the end of 2015. Finally, all militants would be pardoned, facilitating the reintegration of the separatists into Ukrainian society.¹⁷

While the sequencing of Minsk-2’s security and political stipulations became a major point of contention, the document’s text provides a general

¹⁴ Package of Measures for the Implementation of the Minsk Agreements, Organization for Security and Co-operation in Europe, February 12, 2015.

¹⁵ UN Security Council Resolution 2202, S/RES/2202, United Nations, February 17, 2015.

¹⁶ Package of Measures, 2015.

¹⁷ Package of Measures, 2015.

timeline, unlike the Minsk-1 agreement. According to the new document, a comprehensive ceasefire was to begin within three days of signing, followed by a military withdrawal from the contract line, followed by the aforementioned political reforms and local elections in the Donbas, and concluding with the restoration of full Ukrainian sovereignty over its border with Russia.

The remaining economic and humanitarian stipulations of the agreement included hostage and prisoner-of-war exchanges, amnesty laws for militants involved in the conflict, humanitarian access, and the normalization of economic relations between the Donbas and the rest of the country. The 13th and final point called for the TCG to intensify its work, including through the establishment of new working groups “on the implementation of relevant aspects of the Minsk agreements.”¹⁸

Minsk-2 did dramatically reduce the intensity of the fighting. But it was never fully implemented. Over the next eight years, the SMM reported virtually daily ceasefire violations while political reforms stalled. The JCCC, established to provide bilateral military support to the ceasefire, faded into irrelevance as Russian and Ukrainian officers stopped coordinating, proved unable to prevent periodic upticks in violence, and effectively disbanded when the Russian contingent left the commission in December 2017.¹⁹

The TCG—along with its newly created working groups on security, political, humanitarian, and economic and social issues—met regularly in Minsk and produced multiple supplemental documents to support implementation. These included a March 2016 agreement on demining in the conflict zone and a September 2016 framework for disengaging forces and military assets. This process, monitored by the SMM, was set to begin in three pilot areas: Zolote, Petrivske, and Stanytsia Luhanska. The first two sites saw temporary success, although this progress was eventually reversed and the two sides reengaged militarily. Stanytsia Luhanska, meanwhile, saw no progress until 2019, when newly elected President Volodymyr Zelenskyy sought to recommit to the disengagement process. The militaries disengaged and pursued an initiative to repair a critical pedestrian bridge

¹⁸ Package of Measures, 2015.

¹⁹ Tanner et al., 2021, p. 34.

across the line of contact. Representatives of Zelenskyy's government also announced plans for a full disengagement along the entire front, although these plans fell apart amid pushback from activists in Kyiv.

The leaders, foreign ministers, and national security advisers of the Normandy Four also met regularly until the full-scale invasion. Their last leader-level meeting, held in Paris in December 2019, produced a statement reaffirming all sides' commitment to the implementation of the Minsk agreements and laying out measures to stabilize the frontlines and implement the political provisions.²⁰ The format's final meetings were held in the opening weeks of 2022, as Russian forces began amassing at the Ukrainian border. In late January and early February of that year, foreign ministers and security advisers met multiple times to salvage the peace process.²¹ The Minsk framework officially collapsed with Moscow's recognition of the DNR and LNR's independence on February 21, 2022, followed three days later by Russia's full-scale invasion of Ukraine.²²

From the beginning, Minsk-2 was not implemented as written. While the agreement did dramatically reduce the level of violence, a complete cessation of hostilities never took hold, and progress on the political settlement quickly stalled.²³ Both sides accused the other of acting in bad faith, professing nominal commitment to the agreement while refusing to execute its terms. Western analysts have argued that Russia intentionally kept the conflict at a low-level simmer, periodically increasing its intensity through both military and nonmilitary measures, to pressure Ukraine and undermine its consolidation as a stable Western-aligned democracy.²⁴ Russian experts

²⁰ Official Website of the President of France, "Paris 'Normandie' Summit," December 9, 2019.

²¹ David R. Cameron, "After Flurry of High-Level Diplomacy and Another Long Normandy Format Meeting, Threat of War in Ukraine Continues," MacMillan Center for International and Area Studies at Yale, February 11, 2022.

²² Lidia Powirska, "Through the Ashes of the Minsk Agreements," *Epicenter*, May 18, 2022.

²³ Marie Dumoulin, "Ukraine, Russia, and the Minsk Agreements: A Post-Mortem," European Council on Foreign Relations, February 19, 2024.

²⁴ See Duncan Allan, "The Minsk Conundrum: Western Policy and Russia's War in Eastern Ukraine," Chatham House, December 17, 2020; Mykhailo Soldatenko, "In the

have written that Kyiv never intended to carry out the political reforms it agreed to, exploiting the ceasefire to develop its military capabilities before eventually reestablishing control over the Donbas.²⁵

In short, neither Russia nor Ukraine acted as though it felt compelled to make concessions, and both seemed to believe that the other side would continue to shirk its own obligations. The agreement itself—or rather, the lack of progress toward its implementation—contributed to this commitment problem, whereby neither side could credibly commit to fulfilling its promises.²⁶ Design flaws in the document allowed the parties to exploit and compromise the process, undermining any mutual confidence that could have fostered political will.

Analysts and scholars have identified various factors that contributed to, or that can help explain, the failures of the Minsk process. These included the absence of third-party guarantors,²⁷ the OSCE's institutional

Shadow of the Minsk Agreements: Lessons for a Potential Ukraine-Russia Armistice,” Carnegie Endowment for International Peace, February 10, 2025; Samuel Charap, “Moscow’s Calibrated Coercion in Ukraine and Russian Strategic Culture,” George C. Marshall European Center for Security Studies, September 2020; Tatyana Malyarenko and Stefan Wolff, “The Logic of Competitive Influence-Seeking: Russia, Ukraine, and the Conflict in Donbas,” *Post-Soviet Affairs*, Vol. 34, No. 4, 2018.

²⁵ See Nikolai Silaev, “Prodolzhenie drugimi sredstvami: Uroki peregovorov po ukrain-skomu voprosu” [“Continuation by Other Means: Lessons from the Negotiations on the Ukrainian Issue”], *Rossiya v Globalnoi Politike [Russia in Global Affairs]*, Vol. 22, No. 6, November/December 2024; Vladimir Kalita, “Nevypolnenie Minskikh Soglashenii: Kto Vinovat I Chto Delat?” [“Non-Implementation of the Minsk Agreements: Who Is to Blame and What Is to be Done?”], *Nauchno-analiticheskii zhurnal Obozrevatel’ [The Observer]*, 2018; E. Tsedilina, “Minskij Gambit Prezidenta Zelenskogo” [“President Zelenskyy’s Minsk Gambit”], *Rossiya i novyye gosudarstva Yevrazii, [Russia and the New States of Eurasia]*, No. 111, 2019.

²⁶ Paul D’Anieri, “Commitment Problems and the Failure of the Minsk Process: The Second-Order Commitment Challenge,” *Post-Soviet Affairs*, Vol. 39, No. 4, 2023.

²⁷ D’Anieri, 2023; Petro Burkovsky, “Polityko-pravovyy status Mins’kykh domovlenostey: ryzyky ta mozhlyvosti dlya myrnoho protsesu” [“Political and Legal Status of the Minsk Agreements: Risks and Opportunities for the Peace Process”], *Stratehichni Priorityty [Strategic Priorities]*, Vol. 3, No. 40, 2016.

weakness,²⁸ Russia's imperial ambitions,²⁹ and Moscow's perception of North Atlantic Treaty Organization's (NATO's) encroachment.³⁰ In this report, we instead focus on the Minsk agreements themselves—specifically, their flaws—and the institutional design of the peace process.³¹ Our analysis identifies lessons learned from particular issues in the Minsk agreements that contributed to the failure of the peace process. In the next section, each lesson learned is followed by a recommendation for how the architects of a future ceasefire agreement in Ukraine could apply its insights to create a more robust and durable peace.

Lessons Learned

Textual Ambiguity Creates Space for Competing Interpretations and Opportunities to Exploit the Process

As written documents, the Minsk agreements are vague. The February 2015 Package of Measures (Minsk-2) reaffirmed the general principles for ending hostilities and pursuing a political settlement, but it omitted important details. One interviewee involved in the peace process described a belief at the time that the crisis could be resolved through sheer political will—

²⁸ Farid Guliyev and Andrea Gawrich, "OSCE Mediation Strategies in Eastern Ukraine and Nagorno-Karabakh: A Comparative Analysis," *European Security*, Vol. 30, No. 4, 2021.

²⁹ Maria Mälksoo, "The Postcolonial Moment in Russia's War Against Ukraine," *Journal of Genocide Research*, Vol. 24, No. 3–4, 2022.

³⁰ John Mearsheimer, "John Mearsheimer on Why the West Is Principally Responsible for the Ukrainian Crisis," *The Economist*, March 19, 2022.

³¹ For further reading on the Minsk agreements' design flaws, see Kristian Åtland, "Destined for Deadlock? Russia, Ukraine, and the Unfulfilled Minsk Agreements," *Post-Soviet Affairs*, Vol. 36, No. 2, 2020; Konstantin Zadyrak, "Mins'ki Ugody: Istoriya, Interesy, Perspektivy" ["The Minsk Agreements: History, Interests, Prospects"], *Spil'ne [The Commons]*, November 2, 2016; Cindy Wittke, "The Minsk Agreements—More Than 'Scraps of Paper'?" *East European Politics*, 2019, Vol. 25, No. 3, 2019; Powirska, 2022; Tim B. Peters and Anastasiia Shapkina, *The Grand Stalemate of the Minsk Agreements*, Konrad Adenauer Foundation, February 2019; Allan, 2020; and Judy Dempsey, "Judy Asks: Can the Minsk Agreement Succeed?" *Strategic Europe* blog, Carnegie Europe, February 22, 2017.

demonstrated by high-level negotiations within the Normandy Format and the TCG—rather than a properly delineated text.³² The result was an agreement that lacked the clarity associated with more successful ceasefires, leaving out basic parameters for implementation.³³

For example, Minsk-2 failed to specify the procedures and conditions for withdrawing heavy weapons. It called for establishing a security zone based on two de facto lines of contact as they existed when both Minsk-1 and Minsk-2 were signed, but it did not provide precise geographic coordinates for these lines.³⁴ This lack of precision led to competing interpretations of the situation on the ground, complicating efforts to objectively measure the withdrawal or identify noncompliance.

Additionally, Minsk-2 was unclear about how some of its stipulations related to one another. For example, it outlined a formal sequence for how implementation ought to proceed, and some steps were clearly laid out, such as Ukrainian control over its border coming after local elections took place. In other cases, however, there was ambiguity about whether and how certain steps were conditional on the completion of others. For example, the agreement specified that Ukraine should enact constitutional reforms by the end of 2015, but it left unclear whether Kyiv was required to fulfil this obligation if the ceasefire and military withdrawal, which were supposed to occur first, never happened. This ambiguity created room for differing interpretations while providing plausible deniability to parties trying to skirt their obligations.³⁵ Later efforts to clarify some of these stipulations failed to satisfactorily resolve this ambiguity.³⁶

Two other areas of ambiguity in Minsk-2 proved particularly detrimental to the ceasefire: the roles and responsibilities of the parties involved and

³² Official involved in the Minsk process, interview with the authors, June 11, 2024.

³³ Hilde Haug, “The Minsk Agreements and the OSCE Special Monitoring Mission: Providing Effective Monitoring for the Ceasefire Regime,” *Security and Human Rights*, Vol. 27, No. 3–4, 2016, p. 355.

³⁴ Kemp, 2025, p. 11.

³⁵ Mathieu Boulègue, “The Political and Military Implications of the Minsk 2 Agreements,” Fondation pour la Recherche Stratégique [Foundation for Strategic Research], May 19, 2016.

³⁶ Åtland, 2020, pp. 132–133.

the interrelationships of different organizations within the broader Minsk framework. These are discussed below.

Roles and Responsibilities

One important characteristic of effective ceasefire agreements is their explicit identification of the roles and responsibilities of all relevant actors.³⁷ Several stipulations in Minsk-2 lay out the actions to be done without identifying who will do them—or how they will be carried out. For example, while article 9 called for the “restoration of full control over the state border by the Ukrainian government throughout the conflict zone,”³⁸ it did not identify which forces must cede that control or the actual process for transferring it.

This ambiguity was exacerbated by one of the Minsk agreements’ most glaring deficiencies: They failed to identify Russia as a party to the conflict or assign it any obligations. From the beginning of the conflict, Moscow had denied any direct military involvement in Ukraine, insisting that it was a civil conflict.³⁹ Neither Minsk-1 nor Minsk-2 dispelled this fiction. Thus, the documents implicitly endorsed the Russian position that it was not a conflict party and allowed Moscow to play the role of disinterested mediator and avoid accountability for the actions of its proxies in the Donbas.⁴⁰ As a result, Russia was free from explicit responsibilities and given plausible deniability for any noncompliance.

Ambiguity Within the Conflict-Resolution Ecosystem

The peace process in Ukraine established a set of disparate organizations whose relationships between one another were poorly—if ever—defined (see Figure 3.1 and Table 3.1). For example, the Normandy Format ostensibly served as a semiformalized political steering mechanism, but its decisions had no formal authority over the TCG or its working groups. The TCG, in turn, received reports from the SMM, but it had no mechanism

³⁷ Potter, 2004, pp. 4–5.

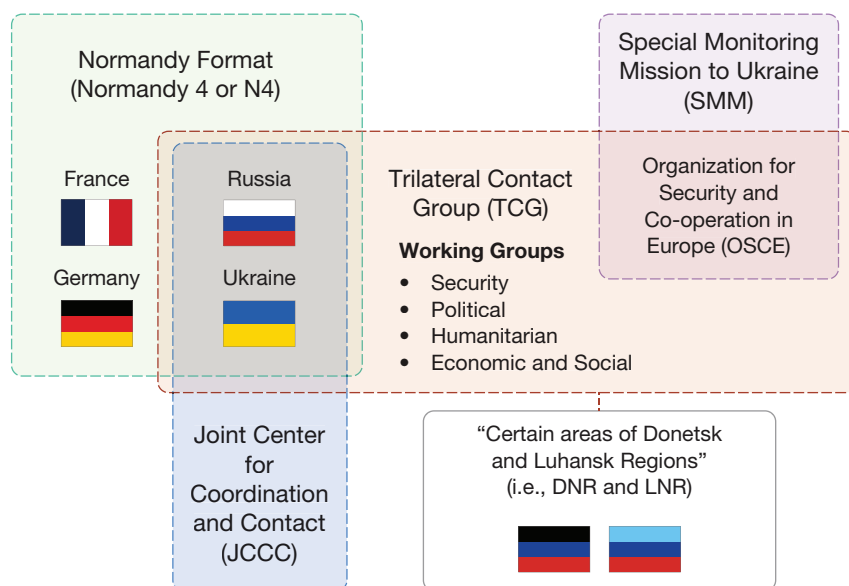
³⁸ Package of Measures, 2015.

³⁹ Pavlo Hai-Nyzhnyk, “Rosiy’s’ko-ukrayins’ka Viyna—Viyna Za Zhyttya (2014–2022 Rr.): Periodyzatsiya” [“Russian-Ukrainian War—War for Life (2014–2022): Periodization”], *Ukrainoznavstvo [Ukrainian Studies]*, Vol. 82, No. 1, 2022.

⁴⁰ Åtland, 2020, p. 134.

FIGURE 3.1

The Minsk Conflict-Resolution Ecosystem



SOURCE: Adapted from Tanner et al., 2021, p. 33.

for translating those findings into action. The JCCC lacked a clear mandate and mutually agreed-on terms of reference, and later efforts to clarify its responsibilities and coordinate its activities with the SMM proved moot when the Russian contingent withdrew in 2017.⁴¹ The SMM, meanwhile, predated the Minsk agreements entirely, meaning it was not designed to meet the peace process's needs as they developed over time. The OSCE's consensus decisionmaking process effectively precluded any changes to its mandate.

⁴¹ Nazariy Sitsinskiy, "Kompleksne bachennya napryamiv ta shlyakhiv zabezpechennya vykonannya polozhen' Mins'kykh domovlenostey u konteksti diyal'nosti Spetsial'noyi monitorynhovoyi misiyi OBSYE v Ukraini" ["A Comprehensive Understanding of the Directions and Ways to Ensure the Implementation of the Provisions of the Minsk Agreements in the Context of Activities of the Special Monitoring Mission of OSCE in Ukraine"], *Derzhavne Upravlinnya: Udoskonalennya ta Rozvytok* [Public Administration: Improvement and Development], No. 8, 2016; Tanner et al., 2021, p. 34.

TABLE 3.1
The Minsk Conflict-Resolution Ecosystem

Entity	Participants	Purpose
Normandy Format	• France • Germany • Russia • Ukraine	Provide high-level political steering for the peace process.
TCG	• Russia • Ukraine • OSCE • DNR and LNR^a	Conduct technical consultations with working groups focusing on security, political, humanitarian, and economic and social issues.
SMM	• OSCE Secretariat (management) • Monitors from many OSCE-participating states	Monitor and verify the implementation of the ceasefire regime.
JCCC	• Russia • Ukraine	Military-to-military support for the implementation of the Minsk agreements and the stabilization of the line of contact.

^a Representatives from the self-proclaimed DNR and LNR, identified in official OSCE and TCG documents as “certain areas of Donetsk and Luhansk Regions,” participated in the TCG proceedings, but they were not formal members.

Internal incoherence within these entities further hampered the peace process. For example, the TCG’s vague structure and mandate impeded its ability to operate. While Minsk-2 called for the TCG and its working groups to intensify their work in supporting implementation, it provided no clear mandate or guidance on how to do so. There were no written rules on these entities’ composition, functioning, or interaction. Without formal arrangements for its proceedings, TCG and working group meetings became mired in unproductive finger-pointing and disputes over inconsequential procedural matters. One interviewee described how meetings proceeded haphazardly, without clear agendas or minutes taken, and often devolved into petty disagreements, such as disputes over what had happened in the previous meeting.⁴² The result was an incoherent organizational ecosystem that

⁴² Official involved in the Minsk process, interview with the authors, June 11, 2024.

proved ineffective. Moreover, the convoluted layers of consultative bodies and their ambiguous authorities provided the conflict parties with opportunities to undermine or hold up the process.

Recommendation

A future agreement should assign explicit roles and responsibilities and include precise and comprehensive protocols and operating procedures. In other words, while the content of the stipulations is important, so too is the specificity of those stipulations.⁴³

The problem of the ambiguity surrounding Russia's role will not apply to any future ceasefire agreement, given Moscow's acknowledgement of its involvement in the war since 2022. Regardless, obligations that are narrowly and indisputably codified will make it more challenging for either Russia or Ukraine to shirk them while claiming good-faith adherence to the process.

The Absence of Accountability Mechanisms for Violations Undermines the Agreement

An agreement could lay out all roles, responsibilities, and procedures in great detail and specificity, leaving no room for dispute, but it will nonetheless likely fail if it does not hold parties accountable for following through on their commitments as written. As noted in Chapter 2, robust ceasefire agreements require mechanisms to observe and verify violations, attribute responsibility, and impose sufficient costs to deter future transgressions. While the Minsk agreements achieved this first requirement, they lacked the means for attributing violations and imposing costs for them, thus allowing both sides to break the ceasefire with impunity.

The SMM served a valuable role by monitoring conditions on the ground and providing near-real-time information on violations. While its monitors produced regular reports identifying the nature and frequency of violations—e.g., the number of artillery shells or bullets fired—they were

⁴³ Kemp, 2025. Kemp (2025, p. 6) recommends that, in addition to being written in “precise technical language,” a future ceasefire agreement would benefit from a glossary of agreed terms, which would define both overarching objectives and more-granular technical content.

not authorized to attribute responsibility.⁴⁴ While there are certainly technological challenges to attribution, which a future monitoring mission will need to overcome (as discussed in Chapter 4), the SMM simply lacked the authority to assign responsibility for what it observed.⁴⁵

Attribution is necessary but not sufficient for accountability, however. Even if the SMM reports had unambiguously attributed responsibility for each violation, the Minsk agreements failed to establish or authorize any mechanism for adjudicating and sanctioning noncompliance.⁴⁶ As a result, credible documentation of violations did not translate into meaningful political, economic, military, or other costs.

An additional limitation was that the Minsk agreements did not have the force of law. Neither former Ukrainian President Kuchma nor Russian Ambassador Zurabov had the legal authority to sign international treaties, and neither country's legislature could ratify the agreement to give it the force of law.⁴⁷ This approach had its benefits, as it allowed representatives from the LNR and DNR to participate in the process without recognizing their legitimacy. But as political acts, rather than legal ones, Minsk-1 and Minsk-2 had limited weight. Noncompliance incurred no formal legal consequences in either Ukraine or Russia.⁴⁸

⁴⁴ Tanner et al., 2021, p. 46.

⁴⁵ Verjee, 2022, p. 811.

⁴⁶ Wittke, 2019, p. 279.

⁴⁷ Powirska, 2022; Oleksandr Demyanchuk, and Vladyslav Urubkov, "Ukhvalennya politychnykh rishen'u trystoronnnykh kontaktynykh hrup: neoinstytutsiynny pidkhid" ["Adoption of Political Decisions in the Trilateral Contact Group: A Neo-Institutional Approach"], *Derzhava i pravo: zbirnyk naukovykh prats': yurydychni i politychni nauky* [State and Law: Collection of Scientific Works: Legal and Political Sciences], No. 88, 2015.

⁴⁸ Nazar Zabolotnyy, "Mins'k kryvykh dzerkal" ["Minsk of Crooked Mirrors"], Tsentr Spil'nykh Diy [Center for Joint Actions], August 28, 2020. While the UN Security Council endorsed Minsk-2 in February 2015, some Ukrainian legal experts have argued that this was insufficient to make the agreement binding under international law. For example, Volodymyr Vasylenko, who served as a judge for the International Criminal Tribunal for the former Yugoslavia, has noted that the UN Security Council Resolution 2202 fails to reference Chapter VII of the UN Charter in its preamble, which is customary for resolutions held to be legally binding on all UN members. See Vladimir Vasylenko, "Vykhod iz lovushki Minskikh dogovorennostey: kak vernut'sya k mezhdunarodnomu pravu," ["Getting Out of the Trap of the Minsk Agreements: How to Return to Interna-

A ceasefire does not need to be legally binding; indeed, many are not. Semiformalized and ad hoc frameworks are common international practices for conflict resolution, especially where a more formal document is infeasible.⁴⁹ Nonetheless, the status of the Minsk agreements as purely political arrangements arguably limited the available mechanisms for enforcement—and lessened the standing of the document for the parties.

Recommendation

A future ceasefire agreement can better hold the parties accountable if it establishes robust mechanisms that attach costs to noncompliance, sanctioning and ultimately deterring violations. While the legal status of any future agreement will inform the enforcement mechanisms available to its architects, even a political arrangement can still be effective if it provides for meaningful costs for violations.

There can be provisions to create accountability at the individual level, by holding individual soldiers responsible for violations that they commit, or the unit level, with commanders held responsible. Alternatively, the agreement could allow for compensatory military measures as a penalty, allowing the compliant side to undertake certain actions that it would otherwise be prohibited from taking.⁵⁰ At the state level, costs could be imposed through sanctions. The Joint Comprehensive Plan of Action (JCPOA), the “Iran nuclear deal,” provides an example with its “snapback” provisions that reimpose sanctions if Tehran does not comply with its commitments.⁵¹ While the details will inevitably be hashed out in negotiations, the archi-

tional Law”], *Evropeiskaya Pravda*, August 31, 2021. For example, UN Security Council Resolution 1929 (2010), which authorizes sanctions on Iran for its nuclear program in 2010, ends its preamble with “Acting under Article 41 of Chapter VII of the Charter of the United Nations” (p. 3).

⁴⁹ Åtland, 2020, p. 135.

⁵⁰ We are grateful to Alexander Hug for these suggestions.

⁵¹ Michelle Nichols, “Explainer: How UN Sanctions on Iran Could Be Restored,” *Reuters*, April 10, 2025.

pects of an agreement should ensure that effective accountability mechanisms are included.

A Ceasefire Agreement Will Not Produce an Enduring Cessation of Hostilities If the Underlying Drivers of the Conflict Are Left Unaddressed

Moscow understood the conflict in Ukraine in starkly geopolitical terms. Russia's primary concern in the Minsk negotiations was Ukraine's geopolitical alignment and its implications for the broader European security architecture.⁵² The Minsk agreements did not directly address—let alone resolve—these core security concerns motivating Russia's military intervention.⁵³

For example, the question of Ukraine's possible membership in NATO is completely absent from the Minsk agreements. But Minsk-2 compelled Kyiv to negotiate constitutional reform with the separatists that would have codified their autonomy. So, Moscow sought to insert provisions ensuring Ukraine's neutrality in the constitutional amendments proposed by the separatist negotiators.⁵⁴ Yet there was never an open discussion among officials, let alone explicit agreement in the documents themselves, on these matters.

Because these issues were not directly on the table, relatively banal disagreements became proxies for broader dynamics relating to geopolitical alignments and regional security. Perhaps most salient was the protracted dispute over local elections in the separatist republics—a prerequisite for devolving the additional power to these regions per Minsk-2—prior to reestablishing Ukrainian state control over its border with Russia. Rather than a routine matter of regional politics, the question of local elections

⁵² Nadezhda Arbatova, "Were the Minsk Agreements Doomed to Failure? An Alternative History," *Puti k miru i bezopasnosti* [Pathways to Peace and Security], Vol. 62, No. 1, 2022, p. 113.

⁵³ Silaev, 2024; Vasyl Filipchuk, Anatoliy Oktysiuk, and Yevgeniy Yaroshenko, *International Interim Administration as a Model for Conflict Resolution in Donbas*, International Centre for Policy Studies, 2017.

⁵⁴ "Popravki DNR i LNR v Konstitutsiyu Ukrainy" ["Amendments of the DPR and LPR to the Constitution of Ukraine"], Donetsk News Agency, March 13, 2015.

became existential to Ukrainian sovereignty. Holding elections before securing the border would allow Russia and its proxies to control the process and ensure an outcome favorable for them. Devolving political power under these conditions would effectively enshrine Russian influence within Ukraine. Under Moscow's influence, these regions could then undermine Kyiv's efforts to anchor itself in the Western security order.⁵⁵ As a result, despite repeated efforts by France, Germany, and the OSCE to proceed with these elections, and protracted arguments among all parties, the poll was never held—or rather, the separatists organized their own elections that neither Ukraine nor its Western partners recognized.

Recommendation

Addressing broader political and security disputes explicitly in a separate, parallel negotiation track could depoliticize a ceasefire, lowering the stakes over practical implementation steps. Larger disputes need not be fully resolved before a ceasefire is implemented. A process to address them could take months or years, while the pressures of war may demand quicker action to end hostilities. Nonetheless, a mandate and mechanism for addressing these issues can proceed in parallel to the task of implementing an agreed-on end to fighting.

A Rushed and Haphazard Negotiation Process Has Long-Term Consequences

The ceasefire negotiations in Minsk took place under imperfect conditions, which contributed to the flawed agreements they produced. First, these discussions were not led by technical experts trained in the granular details of conflict resolution. Instead, the leaders of the Normandy Format countries spearheaded the process. The decision to conduct negotiations at this level presumably reflected a belief that senior leadership could uniquely provide sufficient political weight to sort out the conflict and set the peace process on a viable path forward.⁵⁶

⁵⁵ Thomas Graham and Joseph Haberman, "The Price of Peace in the Donbas: Ukraine Can't Keep Both Territory and Sovereignty," *Foreign Affairs*, February 25, 2020.

⁵⁶ Official involved in the Minsk process, interview with the authors, June 11, 2024.

Unfortunately, this approach came at the expense of technical precision, contributing to the problems of textual ambiguity discussed above. By contrast, involving experts early in the process has been recognized as a best practice for ceasefire negotiations, because they are better able to identify critical but easily missed details that should be incorporated, as well as potential flaws in draft proposals that should be avoided.⁵⁷

Second, rather than a methodical, well-planned process, the Minsk-2 talks were haphazard and rushed. The agreement came together over the course of just one week, culminating in a single night of 16-hour marathon talks.⁵⁸ This quick turnaround effectively precluded thorough preparations, which could have equipped Ukraine and its partners with well-designed draft proposals and plans for adapting to various negotiation scenarios.

The haphazardness of the negotiation process was exacerbated by mounting military pressure on the battlefield. Before negotiators met in February 2015, Russian and Russian-backed rebel forces had begun a major escalation around Debaltseve, a key transit hub in the Donbas, which put Ukraine on the back foot. Its advantageous position—and the prospect of further gains—gave Russia leverage to frame the agreement’s terms, while Ukraine felt pressured to accept a flawed agreement to stop the Russian advance.⁵⁹

Recommendation

Stakeholders involved in a future ceasefire would benefit from beginning preparations and preliminary talks as soon as possible rather than waiting until conditions demand a quick solution. This way, they can enter formal negotiations ready with draft proposals and precise modalities for their implementation.

⁵⁷ Potter, 2004, p. 3.

⁵⁸ Serhiy Harmash, “Chotyry ‘Minska’: Mify I realnist’ Minskoho protsesu vid pershoi osoby” [“Four ‘Minsk’: Firsthand Account of the Myths and Reality of the Minsk Process”], *Mirror Weekly*, March 29, 2021.

⁵⁹ Andreas Umland and Hugo von Essen, *Russia’s Dictated Non-Peace for Ukraine in 2014–2022: Why the Minsk Agreements Were Doomed from the Start and What Lessons They Teach*, Stockholm Centre for Eastern European Studies at the Swedish Institute of International Affairs, June 1, 2022, p. 3.

Agreements Should Provide for an Adaptation or Renegotiation Process If Implementation Proves Unsuccessful Within a Specified Period

Although Minsk-2 dramatically reduced the intensity of the conflict, hostilities never completely ceased while disputes over noncompliance froze any progress on a political settlement. Despite clear evidence that the process was not progressing, the leaders of Russia, Ukraine, France, and Germany (and the United States) remained steadfast in their public commitment to the Minsk framework up until Russia's full-scale invasion of Ukraine in February 2022.

The leaders of France and Germany had staked substantial political capital in the process and, thus, had incentive to try to keep it going—or to go through the motions of doing so to avoid admitting failure.⁶⁰ The scheduling of local elections in the Donbas, for example, illustrated both the parties' waning faith in the Minsk process and their unwillingness to abandon it. Minsk-2 stipulated that elections in "certain areas of Donetsk and Luhansk Regions" (i.e., DNR and LNR) would take place under Ukrainian law by the end of 2015. As that year came to a close and it became obvious that conditions would not allow for these elections, the leaders of the Normandy Format publicly agreed to extend the deadline by one year.⁶¹ A year later, however, as that new deadline similarly passed without any signs of progress, the leaders neither officially acknowledged nor extended the lapsed deadline. At their next summit three years later, they nominally reaffirmed their commitment to elections under the Steinmeier Formula—which helped clarify sequencing issues—but their public statement lacked any dates or deadlines, suggesting their unwillingness to stake any further credibility on the actual implementation of the Minsk agreements.⁶²

For Paris and Berlin, this process had become a key test of their ability to address a major European security crisis without direct U.S. involvement. Russia, for its part, had little reason to renegotiate an agreement that,

⁶⁰ Official involved in the Minsk process, interview with the authors, June 11, 2024.

⁶¹ President of Russia, "Telephone Conversation with Angela Merkel, Francois Hollande and Petro Poroshenko," press release, December 30, 2015.

⁶² Official Website of the President of France, 2019.

if implemented according to Moscow's understanding of the terms, would have served its interests. It was clear that any renegotiation would have produced an outcome more favorable to Ukraine. Ukraine, dependent on the European Union for support, recognized that it had little choice but to nominally remain committed to the agreement, even as frustrations with the ceasefire grew—and implementation of the political elements had become a nonstarter in Kyiv. The codification of the document in UN Security Council Resolution 2202, rather than giving it additional authority, merely raised the perceived costs to all parties from a renegotiation. The process carried on for seven years without meaningful progress toward implementation until Russia's full-scale invasion of Ukraine rendered it irrelevant. Indeed, while nothing excuses Moscow's decision, it is certainly true that the failure of the Minsk agreements to produce a mutually acceptable outcome incentivized the Kremlin to act.

Recommendation

The architects of a future ceasefire should build in timelines for reassessment of the agreement and renegotiation mechanisms to modify its terms to avoid the same fate. While some ceasefire violations are inevitable, systematic nonimplementation should prompt an amendment or revision process. An agreement might specify a set of conditions that automatically trigger such a process or incorporate an automatic review after a certain period. The Nuclear Non-Proliferation Treaty provides one model: Article 8 of the treaty lays out a process for convening formal review conferences every five years to assess its implementation.⁶³

One potential concern with such a mechanism, however, is that it could incentivize one party to undermine the ceasefire regime in order to trigger a revision process in the future, when it might have more negotiating leverage. There may be no way to fully remove this risk—just as there is no way to guarantee that both parties will adhere to any ceasefire—but it should be weighed against the proven dangers of locking in parties to an unsatisfactory or ineffective agreement. The Minsk agreements demonstrated

⁶³ Treaty on the Non-Proliferation of Nuclear Weapons (NPT), United Nations Office for Disarmament Affairs, July 1, 1968.

that a broken process can lead to outcomes that are worse than a politically fraught renegotiation process.

Summary

Table 3.2 summarizes lessons learned from the Minsk agreements and related recommendations for future ceasefires.

Conclusion

The Minsk process failed to establish peace in Ukraine. It produced flawed ceasefire agreements, negotiated in haste and under duress, that left room for obstruction and failed to hold the parties accountable for noncompli-

TABLE 3.2
Lessons Learned from the Minsk Agreements and
Recommendations for a Future Ceasefire Agreement

Lesson Learned	Recommendation
Textual ambiguity creates space for competing interpretations and opportunities to exploit the process.	Be explicit in specifying roles and responsibilities, protocols, and operating procedures.
The absence of accountability mechanisms for violations undermines the agreement.	Establish robust accountability mechanisms to adjudicate incidents, sanction violations, and deter noncompliance.
A ceasefire agreement will not produce an enduring cessation of hostilities unless the underlying drivers of the conflict are addressed.	Establish a separate negotiation track for addressing overarching geopolitical questions, held in parallel with ceasefire discussions.
A rushed and haphazard negotiation process has long-term consequences.	Immediately begin preparations for eventual negotiations, including by holding preliminary talks and drafting proposals for ceasefire modalities.
Agreements should provide for an adaptation or renegotiation process if implementation proves unsuccessful within a specified period.	Establish a timeline for iteratively assessing the ceasefire, as well as conditions (such as serial noncompliance) that would automatically trigger a process to renegotiate or adapt parts of the agreement.

ance. Its failure to address underlying grievances and motivations for the conflict further undermined prospects for a durable peace once hostilities ceased. The diplomatic framework remained stagnant for years after its failures had become evident.

The architects of a future ceasefire agreement in the Russia-Ukraine war should learn from the failures of the Minsk process. They should precisely craft an incentive structure that increases the costs of violations and the benefits of compliance. Such a future agreement can increase costs by stipulating unambiguous rules backed by the credible threat of sanction for noncompliance. It can increase the benefits of compliance by addressing each side's overarching security concerns, which may expand beyond the scope of a cessation of hostilities. Ceasefires are inevitably complicated, and negotiators may want to begin preparations early to ensure that parties are not pressed to accept a haphazard or otherwise flawed agreement under duress. If the agreement ultimately fails to balance the costs and benefits of adherence for each party, it will fail. Rather than sticking to a failing process, parties should have access to mechanisms that allow them to reassess, amend, or overhaul the ceasefire regime. These principles can contribute to a more durable peace in Ukraine. Stakeholders should begin careful preparations immediately to put them into practice when the time comes to negotiate a ceasefire.

The Role of Remote-Sensing Technology

As noted in Chapter 2, effective third-party monitoring can play a crucial role in ensuring the success of a ceasefire agreement. In Ukraine, a future monitoring mission will be faced with unprecedented challenges to effectively carrying out its mandate. It would be tasked with upholding a ceasefire along an expansive conflict line, likely more than 3,000 km, crossing disparate environments, minefields, and varied terrain. Recent technological advancements in remote sensing present monitors with more-effective and cheaper means of detecting possible violations across a far larger area. Remote-sensing technology will therefore play a critical role in an eventual ceasefire in the Russia-Ukraine war.

We use the term *remote-sensing technology* to refer to sensing capabilities and the systems or platforms on which they are placed when those systems or platforms do not need to be continuously operated by humans in close proximity. The most commonplace contemporary examples of remote-sensing technologies are cameras mounted on satellites or those carried by drones. Remote-sensing technologies are regularly used for intelligence, surveillance, and reconnaissance (ISR) in warfighting and peacetime intelligence gathering. Increasingly, these technologies are used in ceasefire monitoring as well.

Indeed, the SMM pioneered the use of remote-sensing technology in ceasefire monitoring.¹ Over its seven years of existence, the SMM deployed more than 50 short- and mid-range UAVs, several long-range UAVs,

¹ Andreas Wittkowsky, “Human or Machine? Lessons from the Use of Technology in the Monitoring Mission to Ukraine,” International Peace Institute, April 12, 2021;

24 ground-based fixed cameras, and acoustic sensors and obtained satellite imagery to support the efforts of human monitors on the ground in Ukraine.² In recent years, the role of technology in ceasefire monitoring has garnered significant international attention while the use of remote sensing in ceasefire monitoring has increased.³

In this chapter, we examine the role of remote-sensing technologies in ceasefire monitoring and the ways in which these technologies could be used in the specific context of the Russia-Ukraine war. We begin with a brief overview of the ways in which remote-sensing technology has been used in past ceasefire-monitoring missions and an assessment of how it can contribute to ceasefire maintenance. The subsequent section makes the case for the importance of remote-sensing technology in any potential Russia-Ukraine ceasefire-monitoring mission. Next, we examine the environment and geography of the conflict line in Ukraine and the challenges for ceasefire monitoring posed by its unique characteristics. The final section provides a survey of remote-sensing technologies that could be used in a future Russia-Ukraine ceasefire-monitoring mission and how best to employ them. The chapter concludes with a discussion on critical considerations when deciding which remote-sensing technologies to deploy and geography-informed recommendations on how best to deploy specific remote-sensing technologies in a potential ceasefire-monitoring mission in Ukraine.

These recommendations, it should be noted, are for a third-party monitoring mission, not for the conflict parties to implement themselves. Russia and Ukraine both deploy many of the remote-sensing technologies discussed in this chapter for warfighting ISR, and they will maintain many of these capabilities after any cessation of hostilities. Therefore, the role of

Kelsey D. Atherton, “The Past and Future of the Drones That Monitor Ceasefires in Ukraine,” Center for Public Integrity, April 6, 2022.

² Cono Giardullo, Walter Dorn, and Danielle Stodilka “Technological Innovation in the OSCE: The Special Monitoring Mission in Ukraine,” *OSCE Yearbook 2019, 2020*, pp. 122, 127–128.

³ Sticher and Verjee, 2023, p. 2; Expert Panel on Technology and Innovation in UN Peacekeeping, *Performance Peacekeeping: Final Report of the Expert Panel on Technology and Innovation in UN Peacekeeping*, United Nations, 2015; Sarah Grand-Clément, *Exploring the Use of Technology for Remote Ceasefire Monitoring and Verification*, United Nations Institute for Disarmament Research, 2022a.

remote-sensing technology for a third-party monitoring mission in this context is not to deliver information to the parties that they cannot otherwise obtain. Instead, it is to provide the referee with better binoculars. For a third-party monitoring mission to serve as a neutral arbiter in a no-trust environment, it must have its own sources of information, independent of the parties.

Past Uses of Remote-Sensing Technology in Ceasefire Monitoring and Peacekeeping

The changing nature of armed conflict in recent decades has presented new challenges for monitoring and peacekeeping missions. At the same time, technological advancement has produced new capabilities in sensing technology that have broad utility for monitoring. Historically, monitoring and peacekeeping missions have been slow to adopt new technology and only fielded sensing technology on a small scale. When missions have employed sensing technology, it has been effective in compensating for a lack of personnel, monitoring hazardous terrains, and covering large areas.

In the mid-1990s, the United Nations Peacekeeping Force in Cyprus (UNIFYCP) adopted stationary cameras to monitor points of known tension and document violations when faced with the necessity of performing its mission with a smaller force. In 2005, UNIFYCP personnel were cut by 30 percent, from 1,224 to 860.⁴ To compensate for these personnel losses, UNIFYCP placed cameras in Nicosia's city center where violations had been most frequent and set up an operations center that monitored the cameras and could dispatch response forces.⁵ While the closed-circuit television (CCTV) cameras at the time were not cutting-edge technology and initially only a limited number of them were deployed, including 100 to monitor the UNIFYCP premises and six to monitor the buffer zone in Nicosia's city center, their adoption was an important factor in UNIFYCP's ability to con-

⁴ A. Walter Dorn, "Electronic Eyes on the Green Line: Surveillance by the United Nations Peacekeeping Force in Cyprus," *Intelligence and National Security*, Vol. 29, No. 2, 2013.

⁵ Dorn, 2013, p. 6.

tinue its missions while cutting personnel and greatly reducing the cost of operations.⁶

In 2013, the United Nations Organization Stabilization Mission in the Democratic Republic of the Congo (MONUSCO) employed uncrewed aerial systems (UASs) in a UN peacekeeping operation for the first time.⁷ Although the mission deployed only a handful of UASs, the systems were effective at performing ISR and assisting search and rescue operations.⁸ UASs were particularly useful in the Democratic Republic of Congo because the country has an area close to 1 million km² but only 2,250 km of paved roads, making mobility on the ground difficult.⁹ The UAS provided to the mission greatly expanded the reach and persistence of peacekeepers and their ability to protect civilians.

In the most recent and relevant example, the SMM implemented many new technologies on a small scale, including small-, medium-, and long-range UASs; cameras; satellite imagery; and acoustic sensors. Former First-Deputy Chief of Mission Alexander Hug attributes the adoption of these technologies to several factors, including the need to reduce costs, minimize the risk to monitors, cover a vast area, and overcome a lack of mobility.¹⁰ Through the use of this technology, the SMM could cover 15,000 km² with only 600 deployed monitors.¹¹

⁶ Dorn, 2013, p. 23.

⁷ Lloyd Axworthy and A. Walter Dorn, "New Technology for Peace & Protection: Expanding the R2P Toolbox," *Daedalus*, Vol. 145, No. 4, Fall 2016.

⁸ "Peacekeeping's Eye in the Sky," *Africa Defense Forum*, Vol. 10, No. 4, 2017, p. 11; Christian Clausen, "The Evolution of the Combat RPA," U.S. Air Force, December 17, 2016.

⁹ "Peacekeeping's Eye in the Sky," 2017, p. 11.

¹⁰ Alexander Hug, *Ceasefire Monitoring and Verification and the Use of Technology: Insights from Ukraine 2014–2022*, ed. by Simon J. A. Mason, Center for Security Studies, Swiss Federal Institute of Technology, ETH Zurich, 2024, p. 22.

¹¹ Hug, 2024, p. 53.

How Remote-Sensing Technology Can Contribute to Ceasefire Maintenance

Remote-sensing technology can support a ceasefire in three ways. First, it can alter the incentives of conflict parties toward compliance by making ceasefire monitoring much more effective. Second, it can reduce the risk to monitoring personnel. Third, remote-sensing technologies can enable coverage of expansive areas with a limited number of personnel and ensure monitoring in denied or complex environments.

Increasing the Effectiveness of Monitoring

As noted in Chapter 2, effective monitoring can raise the expected costs of violations by increasing the likelihood that they will be detected and reducing the probability of sustaining any derived military benefits. Because violations are more likely to be punished if documented by monitors, effective monitoring also reduces the risk to conflict parties that comply rather than violate a ceasefire arrangement. Remote-sensing technology can support the effectiveness of ceasefire monitoring in three ways: increasing the probability that violations will be detected, decreasing the uncertainty around individual violations, and enabling rapid response by the monitoring mission, the guarantors of the ceasefire agreement, and the broader international community.

The most direct way that remote-sensing technology can support a ceasefire is that better, persistent, and more-ubiquitous sensors increase the probability that violations will be detected, as sensors provide a given number of personnel with much greater coverage than could otherwise be achieved. This increased probability of detection, in turn, reduces the expected value that a conflict party might see in purposefully violating an agreement by increasing the probability that violations will be punished. In general, effective sensing that enables effective monitoring can serve as a deterrent by raising the perceived likelihood of incurring costs for violations.

If remote sensing is demonstrably effective, this can also increase the confidence a conflict party has in a monitoring mission's ability to assess the other party's compliance or noncompliance. Because uncertainty about the other party's intentions is a possible reason for a conflict party to violate

a ceasefire agreement, confidence in a monitoring mission's ability to accurately assess compliance and noncompliance may reduce the likelihood that hostilities restart.¹²

Remote-sensing technology can also decrease the uncertainty around individual violations. According to Valerie Sticher and Aly Verjee, remote-sensing technology can increase the likelihood that those committing violations will be held accountable by making clear the nature of violations to such stakeholders as other states or international organizations that want the ceasefire to succeed. Such stakeholders are often reluctant to impose costs on conflict parties, because they might face consequences for doing so, and having clear evidence provided by remote-sensing technology via an independent third-party monitor can compel stakeholders to act.¹³ This greater likelihood of accountability decreases the expected value that a conflict party may see in intentionally violating an agreement, thus increasing the incentives to comply.

Remote sensing can also improve the stability of a ceasefire by clarifying the intentionality of violations to conflict parties, thereby preventing escalation spirals stemming from unintentional or accidental violations.¹⁴ Although both conflict parties may see more benefits from a ceasefire than from war, they will be skeptical or fearful of the other party's intentions and, thus, inclined to interpret *any* violation as intentional and, thus, a precursor to potential renewed hostilities.¹⁵ A conflict party with ambiguous information about the intentionality of a violation may feel the need to respond in kind and violate the ceasefire. A monitoring mission equipped with remote-sensing technology that is better able to characterize the nature of a violation—for instance, violations that are unintentional or are committed by rogue actors—can thus support a ceasefire by reducing occurrences of unnecessary tit-for-tat escalations.¹⁶

¹² Fortna, 2003b, p. 342.

¹³ Sticher and Verjee, 2023.

¹⁴ Sticher and Verjee, 2023.

¹⁵ Fortna, 2003b, p. 340.

¹⁶ Fortna, 2003b, p. 341.

Lastly, remote-sensing technology can decrease the likelihood of violations by giving monitors the ISR capabilities to respond to violations in real time, enabling rapid action. This can help deter and prevent small, repeated violations that may provide a cumulative military advantage to the side violating the agreement.

Reducing the Risk to Monitors

While keeping monitors safe is an important priority in itself, casualties among monitors can have broader consequences for a ceasefire. Specifically, casualties can threaten the political will necessary to sustain a monitoring mission because countries committing personnel to such missions are often sensitive to casualties.¹⁷ This may lead to contributor states withdrawing their personnel, undermining stability further, and potentially contributing to the breakdown of a ceasefire.

Additionally, for monitoring missions operating in dangerous environments, there is a trade-off between the danger to personnel and effectiveness.¹⁸ Operations in areas close to the line of contact may expose monitors to higher risks from accidents (including from residual hazards of war, such as unexploded ordnance) or direct confrontations with the belligerents, but monitoring those areas is crucial to ensure that violations are observed, documented, or prevented. Casualties that occur during such operations may lead to missions adjusting their procedures to protect their personnel at the cost of effectiveness. For example, after an incident in 2017 when a medic was killed by a landmine, the SMM restricted its patrols to paved roads to reduce the risk to its personnel.¹⁹

Remote-sensing technology also provides personnel on the ground with real-time information for situational awareness. The 2021 *Strategy for the*

¹⁷ Molly M. Melin and Jacob D. Kathman, “Sticking It Out: Instability, Regime Type, and Personnel Withdrawals from UN Peacekeeping Operations,” *Conflict Management and Peace Science*, Vol. 40, No. 4, 2023.

¹⁸ Andreas Umland, *Achievements and Limitations of the OSCE’s Special Monitoring Mission to Ukraine*, Stockholm Centre for Eastern European Studies at the Swedish Institute of International Affairs, 2021.

¹⁹ Sticher and Verjee, 2023.

Digital Transformation of UN Peacekeeping emphasizes that monitoring convoys to provide movement protection requires technology to update personnel on any developments in the threat environment while on patrol and in near real time.²⁰ Some researchers have noted that remote-sensing technologies, such as UAS-enabled surveillance and satellite imagery, provide more accurate, real-time information on ground conditions for monitoring personnel operating in or near conflict areas.²¹ Access to real-time information regarding the threat environment not only helps protect monitoring personnel on the ground by ensuring their safe movement but also potentially enables time-sensitive and informed decisionmaking around contentious issues, including how to handle active violations.²²

Remote-sensing technology allows monitors to collect information while limiting their exposure to hazards. Given that ceasefire-monitoring casualties can undermine mission success and effectiveness, remote sensing could thus increase the likelihood of mission success.

Expanding Reach While Reducing In-Field Personnel Requirements

Traditional ceasefire-monitoring missions consisting of ground-based patrol units are limited in the kind of information they can collect, the geographic scope they can cover, and the conditions in which they can realistically monitor. Remote-sensing technology can contribute to ceasefire maintenance by enabling monitoring at a far greater scale and in denied and complex environments where monitoring would have otherwise been impossible. Such pervasive and persistent monitoring dissuades potential violations because they are much more likely to be detected.

²⁰ Department of Peace Operations, Department of Operational Support, and Department of Management, Strategy, Policy and Compliance, *Strategy for the Digital Transformation of UN Peacekeeping*, United Nations, September 2021, p. 20.

²¹ Buchanan, Clayton, and Ramsbotham, 2021, p. 21.

²² UN, “Ceasefire Monitoring ‘Can No Longer Be Just About Being Present,’ Senior Official Tells Security Council, Noting New Capabilities for Real-Time Observation,” coverage of the 9892nd meeting (AM) of the UN Security Council, SC/16039, April 7, 2025; Buchanan, Clayton, and Ramsbotham, 2021, p. 21.

Remote-sensing technologies, such as UASs and satellites, have enabled monitoring missions to cover larger swaths of territory with fewer personnel. For example, in the Democratic Republic of the Congo, MONUSCO's 17,000 peacekeepers were charged with monitoring a country the size of Western Europe with a population of 67 million. This daunting mismatch between personnel numbers and the geographic scope of the mission inspired the first use of UASs for ceasefire monitoring in 2013.²³ In Mali, the United Nations Multidimensional Integrated Stabilization Mission in Mali (MINUSMA) similarly used air-based remote-sensing technology to enable its relatively small number of personnel to cover its geographic mandate.²⁴ In Cyprus, UNIFYCP set up six fixed CCTV cameras at hotspots after the mission was forced to reduce its size by almost 30 percent, enabling effective monitoring at a lower cost and with fewer required personnel.²⁵ Air-based remote-sensing technologies, especially, allow monitoring at a geographic scale and persistence far greater than ground monitoring and crewed air monitoring alone could, enabling monitors to collect previously unimaginable scales of information.²⁶

Additionally, remote-sensing technologies allow monitoring missions to operate safely around the clock. Researchers have noted that the SMM deployed such technologies to overcome the limitations of nighttime monitoring with ground patrols and to accommodate requests for 24-hour monitoring.²⁷ Conflict parties often use the cover of darkness to carry out ceasefire violations.²⁸ In Ukraine alone, half of all ceasefire violations

²³ Royal United Services Institute, "Drones in the Service of Peace: Unmanned Aircraft in UN Deployments," commentary, February 18, 2013.

²⁴ Seán Smith, *Protecting Civilians in Mali: Why Air Assets Matter for MINUSMA*, Center for Civilians in Conflict, 2020, p. 8.

²⁵ Walter Dorn and Cono Giardullo, "Technology Investments Paying Off in Peace Operations," Security and Human Rights Monitor, June 8, 2020.

²⁶ Sticher and Verjee, 2023, p. 3.

²⁷ Giardullo, Dorn, and Stodilka, 2020, p. 136.

²⁸ Sticher and Verjee, 2023, p. 6. For more examples, see Bashir Ali Abbas, "The Hot Line of Control: Why Pakistan Keeps Violating Ceasefire with India," *Indian Express*, May 3, 2025; Alexandra Kuenning, "EUMA Increases Nighttime Patrols as Azerbaijani Accusations of Ceasefire Violations Mount," OC Media, April 10, 2025; A. Walter

observed by the SMM occurred at night.²⁹ UASs and fixed cameras have become a primary enabler for monitoring missions to effectively implement their mandates.³⁰

Remote-sensing technology also allows for monitoring in complex conditions and denied environments where monitoring would otherwise be dangerous or impossible. In Mali, MINUSMA found that UASs enabled monitoring despite rainy seasons that cause extensive annual flooding and poor road infrastructure.³¹ In Ukraine, where ground conditions include snow and ice in the winter and mud in the fall and spring, air-based remote sensing could play a critical role in maintaining a monitoring presence. Remote-sensing technology further allows for monitoring in hazardous conditions, such as potential and known mined areas and sites of chemical, biological, radiological, and nuclear (CBRN) exposure. Indeed, the SMM used a UAS fleet to monitor areas inaccessible to monitoring personnel because of mines. Remote-sensing technology, specifically high-resolution cameras and infrared detectors mounted on UASs, has even been used to detect buried mines.³²

Remote-sensing technology's ability to expand the reach of monitors and monitoring missions overall not only reduces the number of personnel needed to directly perform monitoring on the ground but also frees up monitoring personnel for tasks that only human monitors can perform. As Sarah Grand-Clément notes, remote-sensing technology has allowed monitors to focus on dialogue activities that only humans can undertake,

Dorn, "Blue Sensors: Technology and Cooperative Monitoring in UN Peacekeeping," Cooperative Monitoring Center Occasional Paper 36, Sandia National Laboratories, SAND 2004-1380, April 2004, pp. 25–27; OSCE Special Monitoring Mission to Ukraine, "OSCE SMM Spotted Convoys of Trucks Entering and Exiting Ukraine in Donetsk Region," video, August 10, 2018.

²⁹ SMM, "2019: Trends and Observations," infographic, January 27, 2020a; SMM, "Trends and Observations: JAN–MAR 2020," infographic, April 15, 2020b.

³⁰ UN, 2025.

³¹ Smith, 2020, p. 8.

³² Hug, 2024, pp. 127, 134; T. Hutsul, M. Khobzei, V. Tkach, O. Krulikovskiy, O. Moisiuk, V. Ivashko, and A. Samila, "Review of Approaches to the Use of Unmanned Aerial Vehicles, Remote-Sensing and Geographic Information Systems in Humanitarian Demining: Ukrainian Case," *Heliyon*, Vol. 10, No. 7, 2024.

which plays an important role in fostering trust and building confidence in a ceasefire agreement.³³

The Case for Remote Sensing in a Possible Russia-Ukraine Ceasefire

The circumstances of the Russia-Ukraine war pose immense challenges for ceasefire monitoring. Specifically, the dangers to human monitors and the geographic scope of the conflict are both unprecedented.

Dangers to Human Monitors

The dangers to human monitors for any ceasefire in Ukraine stem from two sources: the capabilities of the belligerents and the potential hazards to monitors. The Russian and Ukrainian militaries have been fighting a relatively high-intensity war for more than three years. The two sides are armed with cutting-edge military technology, ranging from first-person-view drones to long-range precision-guided strike systems, as well as large quantities of more-traditional weapons, such as tanks and artillery. Russia has employed a range of missiles in Ukraine, including cruise and ballistic missiles, as well as glide bombs. Both sides have modern fighter jets. And both have extensive ISR capabilities. As of this writing, there are hundreds of thousands of soldiers on both sides of the conflict line. This collective destructive capability represents an unprecedented threat to potential monitors in Ukraine.

As noted earlier, the SMM suffered casualties from landmines. Since the 2022 full-scale Russian invasion of Ukraine, the number of potential hazards for monitors has grown dramatically as both sides have extensively used artillery and have relied on minefields for protection. Both sides' extensive use of landmines has made Ukraine the most mined country in the world.³⁴

³³ Sarah Grand-Clément, "What Role Technology Can Play in Ceasefire Monitoring and Verification," *Futuring Peace* blog, July 11, 2022b.

³⁴ United Nations Development Programme, "In Ukraine, Tackling Mine Action from All Sides to Make Land Safe Again," October 14, 2024.

The United Nations Development Programme estimates that 23 percent of Ukraine's land may be contaminated with landmines and unexploded ordinance.³⁵ Both sides have employed cluster munitions, which produce a disproportionate amount of unexploded ordinance. Additionally, the munitions that Russia uses are particularly likely to be “duds”—an advantage for the Ukrainian armed forces that are currently fighting but a challenge for any future monitoring mission as the resulting amount of unexploded ordinance increases proportionally. This likelihood is especially true for Russian cluster munitions, which have a dud rate of 40 percent or greater.³⁶ As the war continues, the quantity of these hazards will continue to increase.

Estimates of how long it will take to decontaminate Ukraine range from decades to centuries. In 2023, the think tank GLOBSEC estimated that it would take more than 700 years to decontaminate the country given the current availability of certified demining personnel.³⁷ In a more optimistic estimate, then-Ukrainian Economy Minister Yulia Svyrydenko set a goal of returning 80 percent of contaminated land back to economic use within ten years.³⁸ Regardless, these hazards will pose a risk to monitoring personnel until that process has been completed and particularly in the first years of a future mission—and that initial period is the most critical for ensuring the viability of a ceasefire.

Geographic Scope for Monitoring

The scale of any post-war monitoring operation in Ukraine could be immense, given the country's size and the length of the conflict line. As of

³⁵ United Nations Development Programme, “”2024.

³⁶ David E. Sanger and Eric Schmitt, “Biden Weighs Giving Ukraine Weapons Banned by Many U.S. Allies,” *New York Times*, July 6, 2023.

³⁷ Iuliia Osmolovska, *Walking on Fire: Demining in Ukraine*, GLOBSEC, 2023, p. 5.

³⁸ Vera Bergengruen, “Ukraine Is Using AI to Help Clear Millions of Russian Landmines,” *TIME*, November 2, 2023. The Ukrainian government has certified new personnel, received international funding for demining, developed and produced its own demining equipment, and deployed new technology leveraging satellite imagery and artificial intelligence (AI)-enabled image processing to clear land faster (Iuliia Osmolovska and Nataliia Bilyk, *Cleaning the Augean Stables: Humanitarian Demining in Ukraine*, GLOBSEC, January 2024).

this writing, we calculate the conflict line to be approximately 3,300 km or 2,000 miles.³⁹ This distance includes the *line of contact*, or the locus of most of the fighting, which extends from the Russia-Ukraine border in the north near the administrative boundary between the Luhansk and Kharkiv regions to the Black Sea in the south. That line measures 1,100 km or 680 miles.⁴⁰ The portion of Ukraine's internationally recognized border with Russia and Belarus that extends west from the northernmost point of the line of contact to the Poland-Ukraine border—2,100 km or 1,300 miles—has also seen repeated attacks by both sides since the first days of the war. It therefore is also a line that effectively separates the two militaries. Those two measurements together form what we refer to as the *conflict line*. While the precise location of the conflict line at the end of the war is unknown, it is unlikely to contract significantly. The sheer length of the line will impose expansive demands on a potential monitoring mission.

By comparison, the Korean Armistice line is about 250 km, while the buffer zone in Cyprus, also called the Green Line, which divides Greek and Turkish Cypriot communities, is 180 km long.⁴¹ When UNFICYP first deployed in 1964, it consisted of 12,000 peacekeepers. This represents approximately 67 peacekeepers per kilometer.⁴² To illustratively extrapolate

³⁹ This length is based on official border distances and estimates of the line of contact. However, a lower-resolution measurement that simplifies the border may be more representative of the distance that a monitoring mission would need to patrol. A measurement with a 5-km resolution, for example, shortens our measurement of the line of contact to approximately 2,500 km. This would reduce the subsequent estimates of required personnel by a proportional amount, or about 25 percent.

⁴⁰ Nicole Wolkov, Angelica Evans, Grace Mappes, Olivia Gibson, and Frederick W. Kagan, Nate Trotter, and William Runkel, "Russian Offensive Campaign Assessment," Institute for the Study of War, March 16, 2025.

⁴¹ Alan James, "The UN Force in Cyprus," *International Affairs*, Vol. 65, No. 3, Summer 1989.

⁴² Importantly, peacekeeping operations often entail large deployments over an extended period, and UN peacekeeping missions can last for decades. Depending on the mandate of the monitoring or peacekeeping mission, this may mean a massive commitment in resources and personnel. UNFICYP continues to this day, with more than 150,000 peacekeepers sent to Cyprus over the past 60 years. For more information, see Public Information Office of the United Nations Peacekeeping Force in Cyprus, *Blue Beret 2024: UNFICYP Special Edition*, ed. by Thaiza Castilho, 2024, p. 7.

the potential requirements for Ukraine's 3,300-km conflict line, that ratio of monitors per kilometer would equal 220,000 monitors—double the number of UN peacekeepers active today across the globe. The requirements for a monitoring operation in Ukraine would be even higher if it matched the relative number of personnel active in the United Nations Interim Force in Lebanon (UNIFIL). UNIFIL patrols the Blue Line, which separates Israel and Lebanon and is roughly 120 km long. Following the 2006 War, the UN set the number of personnel deployed as part of UNIFIL to 15,000.⁴³ This represented about 125 peacekeepers per kilometer. Over a 3,300-km boundary in Ukraine, this ratio would scale to 412,500 monitors. Lebanon has a much higher population density than Ukraine—450 people per square kilometer in 2006—but Cyprus's population density in 1964 was comparable to Ukraine's in 2025. At that time, Cyprus had a population density of about 64 people per square kilometer. Depending on how many Ukrainian refugees return in the event of a ceasefire, Ukraine may have a population density between 50 and 60 people per square kilometer.

Using a similar methodology, the European Council on Foreign Relations published research in 2016 that used the figures from the United Nations Transitional Authority in Eastern Slavonia, Baranja and Western Sirmium to estimate that 50,000 peacekeepers may have been required to secure the comparatively small area of the front dividing the Ukrainian military and Russian-backed separatist forces in the Donbas in the pre-2022 phase of the conflict. At that time, the line of contact was less than 500 km long. Using the same methodology, roughly 330,000 peacekeepers would be required for a future monitoring mission in Ukraine.⁴⁴

These comparisons and quantitative extrapolations are not meant to suggest precise requirements for a future ceasefire-monitoring mission in Ukraine. Indeed, they could drastically overestimate the number of required ceasefire monitors. But they underscore a basic reality: Covering the length of the conflict line using only human monitors would require an unprecedentedly large number of monitoring personnel. The interna-

⁴³ Jim Zanotti, *United Nations Interim Force in Lebanon (UNIFIL)*, Congressional Research Service, IF11915, December 27, 2022.

⁴⁴ Christopher Miller, "Guns of August: Fears of Full-Scale War Return as Casualties Mount in Ukraine," Radio Free Europe/Radio Liberty, August 9, 2016.

tional community is unlikely to be able or willing to provide hundreds of thousands of trained personnel for such a mission. Remote-sensing technology thus will have a clear role in reducing personnel requirements for a future Russia-Ukraine ceasefire-monitoring mission. Easing these requirements can make a mission more likely to be supported by key third-party stakeholders.

The Geography of the Current Conflict Line

Before assessing the particular technologies that could be used in a Russia-Ukraine ceasefire-monitoring mission, it is crucial to understand the geography of the expansive conflict line. While the precise location of the line of contact at the time of a future ceasefire is uncertain, as of 2025, the front crosses through four distinct environments: (1) the section of Ukraine's northern border that lies within the geographical region known as Polesia, a large floodplain area that crisscrosses international borders; (2) Ukraine's flat steppe, which extends through the Donbas; (3) the coastal waters along the Black Sea, possibly including the Sea of Azov; and (4) the areas along the Dnipro River, as well as other rivers, lakes, or narrow straits. Each of these environments poses specific challenges to remote-sensing technology and ceasefire-monitoring operations (see Figures 4.1–4.4).

On land, ceasefire monitoring would most likely entail monitoring a cessation of hostilities, disengagement, and potentially a DMZ between Ukrainian and Russian forces. In this context, a mission will need to monitor a specified area extending along the line of contact, ensuring that neither side violates a ceasefire agreement nor garners a military advantage.⁴⁵

In the maritime domain, while bodies of water can form natural boundaries between opposing sides, ceasefire violations often occur across waterways. For example, following the 1967 Six-Day War, Israeli and Egyptian forces were separated by the Suez Canal and the Gulf of Suez, while Israeli and Jordanian forces were largely separated by the Jordan River. Nonetheless, there were numerous raids and strikes across these bodies of water

⁴⁵ Dennis Jett, "Why Peacekeeping Fails," *Foreign Service Journal*, Vol. 96, No. 4, May 2019.

from 1967 to 1970, as well as attacks on shipping, to the point that this conflict was referred to as the War of Attrition. While no party permanently seized territory on the opposite side of the bodies of water that separated them, both parties attacked civilian and military ships, killed personnel on the other side's shores, destroyed installations, and captured equipment and personnel.⁴⁶

Any of these activities could occur during a Russia-Ukraine ceasefire, as could the illicit smuggling of weapons to proxy forces on the other side or the emplacement of clandestine observation equipment or mines to provide future advantages. One side might also try to permanently encroach on a coastline or riverbank. Moreover, either side may try to prevent the other side from using waterspace for civilian purposes, such as shipping, fishing, or industrial uses, or from patrolling within its own waterspace if permitted under the terms of a ceasefire. Ways of achieving waterspace denial could include laying naval mines or physical obstructions; damaging key infrastructure, such as ports or dams; using swarms of vessels to block the passage of those from the other side; or actively targeting vessels.

As we discuss below, there are differences between these physical environments in terms of which types of monitoring capabilities are likely to be effective. To frame our discussion in terms of these physical environments, Figure 4.1 shows Ukraine, its neighbors, the conflict line, and these distinct environments.

Monitoring Ukraine's Northern Borders

Most of Ukraine's northern borders with Belarus and Russia lie within Polesia—a relatively flat, marshy area that spans southern Belarus, northern Ukraine, eastern Poland, and a small section of Russia. This area, shown in greater detail in Figure 4.2, contains geographic features that hinder mobility and observation. The northern part of Polesia on the Ukraine-Belarus border is flat but swampy. One-third of this area is covered with bogs and marshes, with the area near the border significantly swampier than the areas to the south where most of the population is located.⁴⁷ This area also

⁴⁶ Chaim Herzog, *The Arab-Israeli Wars: War and Peace in the Middle East*, Knopf Doubleday Publishing Group, 2005.

⁴⁷ Internet Encyclopedia of Ukraine, "Polisia," webpage, undated.

FIGURE 4.1

The Conflict Line and Surrounding Areas



SOURCES: Features data from Institute for the Study of War, "Interactive Map: Russia's Invasion of Ukraine, Assessed Control of Terrain in Ukraine as of May 14, 2025," webpage, May 15, 2025; and Wild Polesia, homepage, undated; overlaid on d-maps, "Ukraine," webpage, undated.

features a high density of river networks that regularly flood and form part of the Dniipro Basin.⁴⁸ Polesia is also one of the most densely forested areas in Ukraine.⁴⁹

⁴⁸ Anna Kuzemko, "Dry Grasslands on Sandy Soils in the Forest and Forest-Steppe Zones of the Plains Region of Ukraine: Present State of Syntaxonomy," *Tuexenia*, Vol. 29, 2009, p. 371.

⁴⁹ State Forest Resources Agency of Ukraine, "General Characteristic [sic] of Ukrainian forests," webpage, undated.

FIGURE 4.2

The Conflict Line in Polesia

SOURCES: Features data from Institute for the Study of War, 2025; and ArcGIS, "Chernobyl Exclusion Zone," web map, October 30, 2014; overlaid on d-maps, undated.

While, on average, 27 percent of the area is covered by forests, in parts, coverage exceeds 40 percent, with much of that forest lying directly on the Ukraine-Belarus border. Although features such as forests hinder observation from above, their most powerful effect is to impede ground sensors (as well as personnel). Forests obstruct vision, while bogs, rivers, and marshes hinder movements to emplace and maintain sensors. According to the UN peacekeeping taxonomy, these features would be regarded as obstacles that result in "restricted" movement—movement that is only possible at reduced speeds and within a confined channel.⁵⁰ Such features, in turn, make the use of air assets more valuable. For example, the United Nations Observer Group in Central America, which operated in densely forested and hilly ter-

⁵⁰ UN, *Military Peacekeeping-Intelligence Handbook (MPKI HB)*, 2019, p. 78.

rain, consistently used helicopters for monitoring.⁵¹ In Ukraine, the lack of foliage in late fall and winter will also make sensing from above considerably easier.

Importantly, this region also contains the Chernobyl Exclusion Zone, which may need to be monitored, as it is located on one of Russia's primary axes of attack in its 2022 invasion of Ukraine. Much of this area is a low-level radiological hazard. The biggest obstacles posed by its presence is its large size and the inability to construct permanent living quarters there because of radiological concerns. The International Atomic Energy Agency, which in the decades since the Chernobyl disaster has continued to monitor radiation levels at this site, provide technical assistance, and support the rehabilitation of contaminated areas, has adapted its operations in response to this problem by rotating personnel every two weeks.⁵² Remote-sensing technology may be beneficial in this context by alleviating the need to maintain a permanent personnel presence.

Monitoring the Steppe

The conflict line (at the time of this writing) east and south of Polesia falls within Ukraine's forest-steppe zone, or within the Pontic-Caspian Steppe, shown in Figure 4.3. This area is mostly flat or gently sloped. Well over half of the area in this region is cultivated land, which has been cleared for agriculture.⁵³ This has created large expanses of open terrain separated by tree lines and dotted with dense forests, towns, and cities.⁵⁴ The line of contact also occasionally runs adjacent to rivers and lakes that drain into the Dniro River as part of the Dniro Basin. Compared with other environments, this

⁵¹ United Nations Peacekeeping, "Central America—ONUCA: Background," undated.

⁵² International Atomic Energy Agency, *Nuclear Safety, Security, and Safeguards in Ukraine: Third Summary Report by the Director General, February 2022–February 2023*, 2023; Joanne Liou, "IAEA, EBRD Commit to Further Support Decommissioning, Safety Projects at Chornobyl," International Atomic Energy Agency, April 27, 2021.

⁵³ Sławomir Matuszak, *The Breadbasket of the World? Agricultural Development in Ukraine*, trans. by Paweł Biernacki, Center for Eastern Studies, December 2021.

⁵⁴ Jan Kallberg, "Ukraine's War of the Treelines," Center for European Policy Analysis, October 2, 2023.

FIGURE 4.3
The Conflict Line in the Steppe



SOURCES: Features data from Institute for the Study of War, 2025; overlaid on d-maps, undated.

geographical area is more conducive to monitoring operations and sensing. This flat and cleared terrain provides ground sensors with greater lines of sight, and the open terrain and lack of tree cover also expand the ability to sense by air.⁵⁵

⁵⁵ In general, peacekeeping operations in rural areas are considered less stressful than those in urban areas, regardless of access to advanced technology. Peacekeeping oper-

The towns and cities along the line of contact will present a greater challenge for monitoring. Urban and suburban areas have seen intense fighting during the war. This pattern will likely continue. The built environment gives defenders cover, and these areas are natural logistics hubs of great value to both conflict parties.⁵⁶

Buildings obstruct sensors' lines of sight and expose them to more clutter and noise from human activity and electronics, which degrades their monitoring performance. The built environment can also create *multipath errors*, where radio frequency or acoustic signals take multiple paths to reach the same location. While this can decrease the transmission loss of signals, it can also create uncertainty in time for the receiver, which might manifest as positional errors for such systems as the Global Positioning System (GPS) or acoustic sensors. Additionally, urban areas pose a particular challenge to UASs not found in other cluttered environments, such as forests. Although small UASs can perform surveillance effectively in urban areas, operating UASs in towns and cities creates privacy, safety, and airspace management issues that are absent in other environments.⁵⁷

Monitoring Along Ukraine's Coastline

We do not know what parts of Ukraine's coastline will be under Ukrainian control when the fighting stops. Regardless, both sides will have several vital goals related to the coastlines that will shape what needs to be monitored; many of these needs will relate to documenting the types of cross-waterway violations that occurred in the Arab-Israeli War of Attrition, as described above. The first goal is to be able to ship goods via sea without hindrance. While Ukraine can divert some goods via land, and Russia can divert goods to the Baltic Sea or other ports, these routes are much less efficient and more

ations in rural areas are also associated with smaller peacekeeper deployments. See David Michael Green, Chad Kahl, and Paul F. Diehl, "Predicting the Size of UN Peacekeeping Operations," *Armed Forces & Society*, Vol. 24, No. 4, Summer 1998.

⁵⁶ Michael G. Anderson, "DECIDED among the Cities: The Past, Present, and Future of War in Urban Environments," *Military Review*, Vol. 103, No. 3, May–June 2023.

⁵⁷ Andrija Vidović, Igor Štimac, Tomislav Mihetec, and Silvio Patrlj, "Application of Drones in Urban Areas," ed. by Novák Andrej, *Transportation Research Procedia*, Vol. 81, December 2024.

constrained for handling grain or other bulk items than those on the Black Sea. One indication of the difficulty of movement via alternative routes is the extent to which overall Ukrainian grain exports have been reduced during periods when maritime routes were targeted during the war but sprung back when maritime routes reopened.⁵⁸ Such shipments are vital both for Russia's and Ukraine's economies, especially Ukraine's, and for global food supplies. In 2021, just before the war, Russia was the world's largest exporter of wheat, shipping 14 percent of global exports, and Ukraine was the fifth-largest, with 10 percent.⁵⁹ A second goal entails securing both nations' ability to fish in the Black Sea. Before the war, Ukrainian fishing vessels caught about 16,300 metric tons of fish annually, although they had been catching about five times that amount before Russia seized Crimea in 2014.⁶⁰ For both shipping and fishing, these nations need to be able to safely move ships in and out of their coastal waters and ports without hindrance. Monitors may also need to minimize any interference with commercial shipping or fishing in open waters. The third and final consideration is protecting coastal areas and infrastructure from intrusions into forbidden waterspace, attacks in any domain, or infiltrations that extend ashore. The violator's goal may be to conduct espionage, smuggle people or goods (e.g., saboteurs, weapons), demonstrate their intrusion capability to achieve psychological and political effects, or capture or destroy people, ships (including in port), or infrastructure.

Ukraine's internationally recognized coastline, shown in Figure 4.4, extends from the Ukraine-Romania border in the west through Odesa and other ports, along the entire coast of diamond-shaped Crimea, and most of the northern coast of the Sea of Azov. Ukraine's territory also includes small islands in the Black Sea, most notably Snake Island, which sits at the westernmost extent of its territorial waters. Russia captured Snake Island in the early days of the full-scale invasion, but Ukrainian forces retook con-

⁵⁸ Iuliia Tetteh, Joana Colussi, and Nick Paulson, "Exploring New Export Routes for Ukrainian Grain," *farmdoc daily*, Vol. 13, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, November 2023.

⁵⁹ Food and Agriculture Organization of the United Nations, "Crops and Livestock Products," database, undated.

⁶⁰ Aleksandra Petersen, "Ukraine: War Forces Fishing Cooperative to Relocate from Seas to Estuaries," *Eurofish*, October 31, 2024.

FIGURE 4.4**Ukraine's Coastline**

SOURCES: Features data from Institute for the Study of War, 2025; and “How Much Grain Is Ukraine Exporting . . .,” 2024; overlaid on d-maps, undated.

trol in late June 2022. By international law, the Sea of Azov is considered to be shared territory between the two countries. At the time of this writing, Russia occupies most of Ukraine's internationally recognized coastline, including an area west of a short stretch of its coast and west of the Dniro River. At times during the early stages of the war, Russia targeted commercial ships handling Ukrainian grain and other products, greatly harming Ukraine's economy and constraining world food supplies. After five months, Moscow and Kyiv agreed to the Black Sea Grain Initiative, which

established a corridor for grain exports.⁶¹ That deal collapsed in July 2023.⁶² Subsequently, Ukraine has been able to restore exports by using a corridor within its territorial waters and those of its western neighbors.⁶³ Ukraine has used missiles and uncrewed surface vehicles (USVs) to target Russian warships, damaging or sinking much of Russia's Black Sea Fleet and driving the remainder to the easternmost reaches of the Black Sea, rendering these vessels largely operationally ineffective. Both sides have periodically conducted strikes against the other's civilian shipping vessels during the intervening period.

The length of coastline that could require monitoring may be much smaller than the standard geographic length of that coastline. For example, the CIA's *World Factbook* indicates that Ukraine's coastline—including all of its recognized territory—is 2,782 km (1,729 miles) long.⁶⁴ However, as with any coastline, it is a fractal shape, with numerous indentations and protrusions.⁶⁵ As Figure 4.4 shows, even a measurement of the coastline that conforms closely to its edge is just more than half of that at 1,554 km. Ukraine currently controls about one-fifth of that length (300 km), stretching from the Ukraine-Romania border to the mouth of the Dniro River. At its eastern edge, the Ukrainian coastline includes the northern shore of the Dnirovska Gulf, a body of water roughly 50 km wide, facing a Russian-controlled peninsula whose distance from Ukrainian-controlled shores varies between 3 and 10 km. If Russia continues to occupy most of Ukraine's coastline, including a stretch west of Crimea, Crimea itself, and the northern shore of the Sea of Azov, the length of the coastline to secure might be only about 300 km. Such a measurement could correspond to the length over which some types of monitoring equipment (such as buoys, which we

⁶¹ UN Trade and Development, "The Black Sea Initiative," webpage, undated.

⁶² "How Much Grain Is Ukraine Exporting and How Is It Leaving the Country?" BBC, April 2, 2024.

⁶³ Prior to the war, Ukraine exported about 55 million metric tons of grain and oilseeds annually via the Black Sea (Constant Méheut, "Ukraine's Seaborne Grain Exports Bounce Back to Near Prewar Levels," *New York Times*, May 12, 2024).

⁶⁴ Central Intelligence Agency, "The World Factbook: Ukraine," webpage, April 17, 2025.

⁶⁵ Benoit Mandelbrot, "How Long Is the Coast of Britain? Statistical Self-Similarity and Fractional Dimension," *Science*, Vol. 156, No. 3775, May 5, 1967.

discuss later) might be emplaced. Alternatively, an array of tethered aerostats along the shoreline that could surveil at long ranges might need to cover only about 1,000 km of effective coastline.

The extent of the area that needs to be monitored may depend heavily on the specific provisions of a ceasefire agreement. For example, one side's warships may be precluded from approaching within a given distance of the other side's coastline, above and beyond rules that already apply under international law. That law is specified under the United Nations Convention on the Law of the Sea (UNCLOS), which Russia and Ukraine have ratified. According to UNCLOS, states' territorial waters extend 12 nautical miles (nm) (or 22.2 km) from their shores. States have full legal authority over all activities within those waters, although they are required to permit the transit of ships that are exercising the "right of innocent passage" through straits. Within the "contiguous zone" between 12 and 24 nm from shore, a state can exert limited authorities to protect its territorial waters from such threats as pollution or attempted infiltration.⁶⁶ All states have an exclusive economic zone (EEZ) that extends 200 nm (370.4 km) from their shores, within which only they can fish, extract minerals, or conduct any other economic activity. However, other nations' vessels can transit the EEZ without hindrance. The entirety of the Black Sea lies within the EEZs of specific nations. When two nations have overlapping areas within a given distance of their shores, the midline between the two coastlines marks the boundary between territorial seas, contiguous zones, or EEZs.⁶⁷ Overall, depending on the provisions of the agreement, monitors may be required to observe activity extending up to 370 km offshore or perhaps to as little as 22 km offshore, resulting in vast differences in requirements.

⁶⁶ See Part II, Territorial Sea and Contiguous Zone, of United Nations Convention on the Law of the Sea, December 10, 1982.

⁶⁷ National Oceanic and Atmospheric Administration, "Maritime Zones and Boundaries," webpage, December 13, 2024; Aaron L. Shalowitz, *Shore and Sea Boundaries, with Special Reference to the Interpretation and Use of Coast and Geodetic Survey Data*, U.S. Department of Commerce, U.S. Government Printing Office, 1962.

Monitoring Along the Dnipro River

At the time of writing, the line of contact from Zaporizhzhia city to the Black Sea lies on the Dnipro River. The river served several key economic purposes for Ukraine before the war. Riverine transit was important for bringing export goods south for further transit through the Black Sea. The Kakhovka Dam and associated hydroelectric power plant was a major source of electricity. The Kakhovka Reservoir played an important role in providing water for agricultural purposes in the area surrounding the river, and its waters were used for industrial purposes as well. Since Ukraine retook control over Kherson city on the west bank of the river in November 2022, the Dnipro has served as a natural barrier between the sides. With the destruction of most of the bridges, crossing the river is not a plausible prospect for either side.

Importantly, this area has been greatly affected by the destruction of the Kakhovka Dam. In addition to generating hydroelectric power, the dam created a reservoir and a deepwater route. Normal operation of the Kakhovka Dam requires that the water level does not fall below 14 m, which allows ships to safely transit.⁶⁸ The destruction of the Kakhovka Dam and the draining of the dam's reservoir exposed a large section of riverbed. Yevhen Ihnatenko, the former head of Ukraine's shipping administration, stated that the destruction of the Kakhovka Dam has left this stretch of river unnavigable.⁶⁹ This reduces the possible set of maritime platforms that can be used for monitoring; if mobile platforms, such as crewed boats and USVs are to be used at all, they will need a very shallow draft to navigate safely. Without the regulation of the dam, this section of the Dnipro River has returned to its historical course. In spring 2024, snowmelt caused the river to flood and much of the area exposed by the drainage of the reservoir was again covered with water.⁷⁰ A monitoring mission looking to employ static

⁶⁸ United Nations Environment Programme, *Rapid Environmental Assessment of Kakhovka Dam Breach, Ukraine*, 2023, p. 4.

⁶⁹ "Dnipro River Below Zaporizhzhia Will Not Be Navigable for a While—Shipping Administration," *Ukrainska Pravda*, June 8, 2023.

⁷⁰ Nadiya Palyvoda, "Water Returns to Kakhovka Reservoir: How It Will Affect Combat Operations," *Mind*, March 14, 2024.

ground sensors will need to be cognizant of the varying breadth of the river and its floodplain.

There are several ways in which monitoring ceasefire violations along inland bodies of water and narrow straits differs from similar operations in coastal environments or more open waters, which we discuss below. These differences reflect each side's various needs to use the waterspace and to ensure protection from infiltrations or attacks across it. The underlying nature of the threats is much the same as discussed above: Either side may attempt to prevent the other side from using its waterspace or may attempt to intrude into the other's waterspace or adjacent land for nefarious purposes (e.g., espionage, smuggling, intimidation, attacks).

Remote-Sensing Technology for Ceasefire Monitoring

This section provides an overview of remote-sensing technologies that could be used in a future ceasefire-monitoring mission in Ukraine. To frame our discussion, we analyze sensing technologies along the lines of the three primary domains of ceasefire monitoring: air, land, and maritime. For each sensing technology, we discuss its function, utility to a ceasefire-monitoring mission, and suitability in a Ukraine-specific context. The discussion of each technology concludes with recommendations on its potential role in a future ceasefire-monitoring mission in Ukraine.

As noted earlier, we use the term *remote-sensing technology* to refer to both the sensing capabilities (e.g., acoustic sensors, radars) and the systems or platforms on which they are placed or in which they are embedded (e.g., UASs, buoys). Certain sensing capabilities can be placed on a variety of platforms, but some capabilities are inseparable from a specific system or platform (e.g., cameras on satellites). We provide a list of the sensing capabilities discussed in this section in Table 4.1.

TABLE 4.1**Summary of Discussed Sensing Capabilities**

Capability	Description
Acoustic sensors	Detect and help locate the source of sounds, such as those of artillery fire
Cameras	Includes stationary cameras, such as CCTV, as well as mobile cameras, which can be placed on aerial platforms to monitor specific areas or hotspots
CBRN sensors	Detect the presence and level of toxic gases, aerosolized biological agents, radiation, and nuclear materials
Counter-battery radars	Locate artillery, mortars, and rocket launchers by tracking incoming projectiles and determining their origin
Infrared imaging sensors	Detect and measure changes in light that are not visible to the human eye; create thermal images of objects in low-light conditions
Infrasound sensors	Detect acoustic waves from 20 Hz and below, thus capturing sounds beyond the range detectable by acoustic sensors (e.g., could be used to detect explosions)
Motion sensors	Can be integrated into cameras to detect movement and set up to provide an alert on suspicious movement(s)
Radars	Use radio waves to detect stationary and moving objects, such as military equipment or weapons, and can show the velocity of an object
Satellite-based cameras	Can demonstrate the evolution of a site over time by taking pictures from space (e.g., to monitor the moving of military equipment or changes to infrastructure)

Air-Based Sensing Technologies

Uncrewed Aerial Systems

UASs—often referred to as *drones*—are small aircraft operated without a pilot on board and controlled remotely by a pilot from a ground station. A system consists of a UAV, controls, and any additional sensing equipment or software needed for the UAV to carry out its specified mission. UASs are classified based on their range, endurance, takeoff requirements, and weight-bearing capacity as follows: short-range or mini (3–5 km), medium-range (15–50 km),

and long-range (100–200 km).⁷¹ The sensing capabilities commonly embedded on UASs for monitoring missions are cameras (including infrared and thermal), radars, and acoustic sensors.⁷²

UASs can aid ceasefire-monitoring missions in two primary ways. First, UASs greatly extend observation capabilities without creating a large personnel burden. UASs are typically operated by small teams. For example, the Ukrainian military operates each of its short-range UASs with a team of two, consisting of only a UAV pilot and a technician.⁷³ The contractors operating UASs for the SMM used a team of three, consisting of a pilot, sensor operator, and engineer.⁷⁴ Given the enormous area that a monitoring mission may be required to cover, UASs offer monitors a distinct advantage. Second, as with all remote sensors, UASs reduce safety risks to monitors. The scale of hazards in Ukraine make UASs a valuable tool for monitors to employ.

Best-use cases for UASs vary based on UAS classification. Short- and medium-range UASs equipped with high-resolution cameras are the most versatile sensing technology for ceasefire monitoring because they are the cheapest and most readily available UAS class and easiest to operate for non-specialist ground-based controllers.⁷⁵ Geographically, short- and medium-range UASs could also play a critical role in monitoring the highly mined areas near the conflict line in Ukraine's open and flat steppe and in the inland maritime environments. Short- and medium-range UASs could provide situational awareness and real-time imagery, assess critical infrastruc-

⁷¹ Classifications of UASs vary from country to country. However, these ranges and corresponding classifications have been most commonly referenced in the literature on the UASs deployed in the SMM. For more, see Sticher and Verjee, 2023, p. 13; and Giardullo, Dorn, and Stodilka, 2020, p. 23.

⁷² Grand-Clément, 2022a, p. 44.

⁷³ The Ukrainian military typically operates its drones in groups, with multiple reconnaissance and strike drones working together to observe and destroy personnel, vehicles, and defensive positions. Monitors seeking to observe violations will probably not need to replicate this arrangement. For more information, see David Hambling, "Teams of IDF Drones Work Together in Gaza Combat," *Forbes*, October 10, 2024b.

⁷⁴ Hug, 2024, p. 69.

⁷⁵ Hug, 2024, p. 74.

ture, and monitor the withdrawal of troops and weapons from designated areas.⁷⁶ Notably, because short- and medium-range UASs can fly low and slow, they may be valuable for approaching areas where a violation is occurring or is imminent. Equipped with noise emitters, UASs could transmit messages or irritating sounds to warn or deter potential violators. A key limitation of these small UASs is that they typically have limited endurance, on the order of a few hours or less, so large numbers of them will be needed to maintain continuous coverage over wide areas.

By comparison, long-range UASs have a greater range, can fly for longer periods (most for more than 24 hours), and at a higher altitude. Long-range UASs can also fly at night—a critical capability, as about half of all ceasefire violations observed by the SMM occurred during the night.⁷⁷ Equipped with cameras and infrared sensors, long-range UASs could be best employed to monitor along long stretches of coastline and persistently monitor sites of frequent ceasefire violations both day and night. While long-range UASs are less expensive to purchase, operate, and maintain than pilot-controlled aircraft (and ground-based UAS pilots typically require less training than aircraft-based pilots), long-range UASs are considerably more expensive and complicated to operate than short- and medium-range UASs. The SMM lacked the capacity to operate long-range UASs on its own and used a service contractor to set up and run its long-range UAS mission. This contract represented 17 percent of the SMM's overall budget in 2016.⁷⁸ While long-range UAS technology has advanced rapidly in recent years, offering somewhat lower cost and more easily operated models, a future monitoring mission should focus on employing long-range UASs in a way that is financially and technically sustainable to the overall monitoring mission.

While UASs would provide great benefits for a future ceasefire-monitoring mission in Ukraine, there are several drawbacks. Specifically, UASs are vulnerable to electronic warfare, small-arms fire, and short-range surface-to-air missiles, and a monitoring mission planning to employ UASs needs to be prepared to deal with some attrition of its equipment. Addition-

⁷⁶ Hug, 2024, p. 75.

⁷⁷ SMM, 2020a; SMM, 2020b.

⁷⁸ Giardullo, Dorn, and Stodilka, 2020, p. 121.

ally, for soldiers on the ground, it is difficult to identify a UAS overhead detected visually or by radar as belonging to a monitoring mission rather than the opposing conflict party.⁷⁹ This challenge is significant, because UASs have made the battlefield extremely lethal and become a central part of Ukraine's and Russia's targeting architectures. Both sides have used UASs, equipped with munitions, as one-way aerial bombs, slamming them into a variety of targets, including individual vehicles, energy infrastructure, and personnel.⁸⁰ In this context, electronic warfare represents an essential layer of protection for Ukrainian and Russian forces. Like mines and trench lines, it forms an important part of a defensive position, and the experience of the two militaries will lead them to treat a drone flying overhead as a serious threat. Thus, at the outset of a ceasefire and before trust in a ceasefire agreement is established, it will be challenging to compel the parties to remove their electronic warfare equipment from the front.

There are several options for reducing the impact of electronic warfare on UAS monitoring operations. First, any agreement should explicitly forbid such interference and treat jamming (as well as kinetic attacks on UASs) as a ceasefire violation. (See the next section for further discussion of jamming.) Second, monitors can establish a mechanism for deconflicting flights of larger and more capable UASs with both conflict parties to protect expensive and high-value assets. Deconfliction makes flights known to both conflict parties and, therefore, can help establish that any interference is intentional. This can increase the likelihood that jamming by either conflict party will be clearly identified as a violation, possibly deterring such behavior. Third, flights should be made often and, if possible, continuously. Not only will that minimize the impact of jamming on the overall sensing landscape, but also it will increase the probability that a violation is uniformly detected over the entire conflict line.

⁷⁹ Siobhán O'Grady and Kostiantyn Khudov, "Drones Are Crowding Ukraine's Skies, Largely Paralyzing Battlefield," *Washington Post*, April 14, 2024.

⁸⁰ Frederick W. Kagan, Kimberly Kagan, Mason Clark, Karolina Hird, Nataliya Bugayova, Kateryna Stepanenko, Riley Bailey, and George Barros, *Ukraine and the Problem of Restoring Maneuver in Contemporary War*, Institute for the Study of War, August 2024, p. 12.

Recent technological advances in autonomy allow drones to operate even if electronic warfare measures separate a drone from its operator or its external position, navigation, and timing source. Monitors should explore the possibility of employing UASs equipped with terrain-matching algorithms, as this technology is demonstrably effective, has seen recent advances, and is becoming more accessible. For example, some Ukrainian military UASs are equipped with software called Eagle Eyes that uses AI to compare live video with pre-existing maps, allowing UASs to navigate without GPS and through Russian jamming.⁸¹ The use of video data for terrain matching is especially useful in Ukraine's steppe where traditional terrain-matching algorithms would fail to accurately assess the steppe's relatively uniform, flat terrain.⁸² Furthermore, most early terrain-matching algorithms were developed for cruise missiles flying close to the speed of sound, far faster than UASs.⁸³ They would be ineffective for small, slow-flying drones that may want to loiter in a particular area.

Besides autonomy, vulnerability to electronic warfare can be minimized by connecting the UAS to a ground station with a physical cable. For example, Russian forces have adapted to electronic warfare by tethering drones to control stations with 10-km-long fiber optic cables, ensuring an uninterrupted connection.⁸⁴ This alternative solution has the benefit of maintaining communication with a UAS rather than relying on autonomy, allowing continuous high-quality video transmission back to an operator, thereby providing real-time ISR. However, this configuration has a negative impact on UAS range and mobility. The range of these drones is directly limited by the length of cable, a disadvantage for a monitoring mission that may need to cover thousands of miles of front. While these tethered drones cannot be

⁸¹ "Many Ukrainian Drones Have Been Disabled by Russian Jamming," *The Economist*, May 29, 2024.

⁸² Q. Q. Zhang, L. Zhao, J. H. Zhou, B. H. Wang, and Y. P. Zhang, "A Real-Time Airborne Terrain Aided Inertial Navigation System and Its Performance Analysis," *Advances in Space Research*, Vol. 60, No. 12, December 2017.

⁸³ Zhang et al., 2017; Kenneth P. Werrell, *The Evolution of the Cruise Missile*, Air University Press, September 1985, pp. 110–111.

⁸⁴ David Hambling, "Russian Fiber Optic Drone Beats Any Jammer (UPDATE: Ukraine Version)," *Forbes*, March 8, 2024a.

considered an ideal solution, they may provide monitors a niche ISR capability in areas where jamming remains especially prevalent.

Monitors can also dissuade jamming by deploying some UASs with jamming-resistant equipment and passive phased-array radars to detect and document jamming sources.⁸⁵ If this strategy is successful in suppressing jamming, it would protect, in turn, the rest of the monitors' drone fleet, which may not be outfitted with the same capabilities because of cost constraints.

Recommendations

- Deploy short- and medium-range UASs equipped with cameras to monitor hazardous and targeted areas, particularly for situational awareness and collecting real-time imagery.
- Deploy long-range UASs equipped with electro-optical/infrared (EO/IR) sensors for monitoring missions that would be otherwise impossible—most critically, those conducted at night, along lengthy coasts, and for persistent monitoring of the conflict line.
- Prepare to counter interference with UAS operations.

Aerostats

An *aerostat* is an aircraft that generates lift using a lighter-than-air gas (typically helium or hydrogen, though the former is preferred, as hydrogen is highly flammable) and relies on buoyancy to stay aloft. There are two primary forms of aerostats: (1) balloons, which lack propulsion capabilities and must be tethered to the ground, and (2) airships, more commonly known as blimps, which are powered, free-flying aerostats with steering capability. Given their relative stability, aerostats make an ideal platform for several sensing capabilities, including air-based radars, EO/IR cameras, cameras, and other sensors. And whereas UASs are capable of kinetic attacks, teth-

⁸⁵ Jamming sources can be located by using angle-of-arrival techniques on array elements or time-difference-of-arrival techniques across multiple synchronized antennas. For more, see Stuart William Harmer and Gianluca De Novi, "Distributed Antenna in Drone Swarms: A Feasibility Study," *Drones*, Vol. 7, No. 2, 2023; and Joon Wayn Cheong, Andrew G. Dempster, Joe Fleming, Ming Zhu, and Graeme Hooper, "Detecting and Geolocating Jammers and Spoofers Using Integrated AOA and TDOA Measurements," *Inside GNSS*, September 21, 2019.

ered blimps are clearly not shooting platforms and, thus, are likely to be seen as more benign by the civilian population and are less prone to being treated as threats by the conflict parties.

The greatest benefit of aerostats for a future monitoring mission is their persistence: Unlike UASs, they can remain aloft indefinitely, although they typically need to be lowered during rough winds or other stormy conditions. They also generally require limited maintenance. Aerostats can derive their power from a grid or from an onboard generator and be lowered intermittently for maintenance and refueling, if needed. A prime example of the use of tethered aerostats for monitoring sensitive areas is the U.S. Customs and Border Protection's Tethered Aerostat Radar System, which is deployed to detect and characterize air, maritime, and land activity along U.S. borders. These aerostats can achieve elevations of several thousands of feet and largely focus on low-flying aerial threats.⁸⁶ Military forces from the United States and Israel have also used tethered aerostats to maintain awareness and detect prospective threats.⁸⁷ Over the past decade, the use of aerostats in monitoring and peacekeeping missions has been pioneered by MINUSMA and the United Nations Multidimensional Integrated Stabilization Mission in the Central African Republic (MINUSCA), both of which use tethered aerostats equipped with high-resolution cameras, thermal cameras, counter-battery radars, and other sensors.⁸⁸

In a future ceasefire-monitoring mission in Ukraine, tethered aerostats equipped with cameras, air-based radars, counter-battery radars, or EO/IR

⁸⁶ U.S. Customs and Border Protection, "AMO to Deploy Aerostat over Cudjoe Key, Florida," press release, September 17, 2024.

⁸⁷ Thomas Harding and Nada Homsy, "Hezbollah 'Blinds' Israeli Defences with Drone Strike on Sky Dew Airship," *National News*, May 17, 2024; Defense Industry Daily, "JLENS: Co-Ordinating Cruise Missile Defense—and More," undated.

⁸⁸ United Nations Secretary-General, *Report of the Secretary-General on the Situation in Mali*, UN Security Council, S/2016/281, March 28, 2016, p. 13; United Nations General Assembly, "Financing of the United Nations Multidimensional Integrated Stabilization Mission in the Central African Republic," A/RES/79/302, July 2025, p. 59; Sebastian Rietjens and A. Walter Dorn, "The Evolution of Peacekeeping Intelligence: The UN's Laboratory in Mali," in Floribert Baudet, Eleni Braat, Jeoffrey van Woensel, and Aad Wever, eds., *Perspectives on Military Intelligence from the First World War to Mali*, T. M. C. Asser Press, 2017, pp. 209–210; Tamir Eshel, "Unmanned Peacekeepers over Africa," *Defense Update*, September 5, 2016.

cameras could contribute to the monitoring of land, near-shore, offshore, and heavily forested areas to detect potential ceasefire violations and troop movement. Aerostats tethered near the Black Sea coast could be studded with sensors that generate radar data and imagery while being provided with continuous power and communications via cables, offering an alternative to long-range UAS observation. The persistent nature of surveillance provided by tethered aerostats could also play a critical role in monitoring sites of frequent ceasefire violations and withdrawal or disengagement areas, where effective monitoring could build greater confidence in the ceasefire process. The heavily forested region of Polesia, where the primary concern is massive troop movements coming over the border, is also conducive to monitoring by tethered balloons.

Radars mounted on aerostats that can provide low-altitude surveillance would be particularly important given the extensive use of UASs and artillery by both sides in the war. Drones are small, can fly low over the horizon, can be launched by a single individual, and are deployed in massive numbers. To detect and document UAS violations, monitors can deploy high-frequency radars on aerostats.

Aerostat-mounted counter-battery radars could also prove useful in Ukraine. These radars function similarly to acoustic sensors, detecting and locating the source of artillery fire. However, counter-battery radars have longer ranges and can track many projectiles at the same time, whereas acoustic sensors are overwhelmed by a large volume of fire. Counter-battery radars can support a ceasefire by giving conflict parties more certainty that a monitoring mission will be able to detect and attribute violations, reducing the expected value a potential offender might see in committing a violation. In their traditional use on mobile, crewed, ground-based platforms, these radars pose risks for the monitors operating them: Detectable radar emissions have the potential of drawing fire from a conflict party that has misidentified a monitor's sensor as the other side's equipment. This risk deterred the SMM from deploying them.⁸⁹ When mounted on aerostats, counter-battery radars are far less likely to be misidentified as belonging to

⁸⁹ Hug, 2024, p. 92.

a conflict party and pose no risk to monitors even if they came under fire, because the aerostats are uncrewed.

Aerostats and UASs can complement each other: An anomaly detected by the aerostat's sensors can then be more closely scrutinized by those aircraft. A UAS that has been cued by an aerostat to approach a potential violator can make clear to them that their movements are being monitored. Even if the potential violator cannot be contacted via radio, an aircraft's visual and auditory signatures can still have the desired effect. Given that this activity is meant to be overt, those signatures can be enhanced. For example, an aircraft can tow a pennant or generate unnecessary noise to draw attention to itself. Even a small aircraft can loudly project warning messages. At the outset of the COVID-19 pandemic, Estonian authorities used UASs to fly over popular gathering areas, loudly telling the crowds to avoid behaviors that could spread the virus.⁹⁰

The primary risk associated with tethered aerostats is that they can break free, dragging their cables through ground environments.⁹¹ Given their comparatively fragile nature and static positioning, aerostats are vulnerable to direct fire, attacks to their ground-based tethers, and inclement weather.⁹² Aerostats have a high up-front cost stemming from their more survivable components—including a mooring platform and heavy-duty winch used to power the payload and download data via fiber optics—and require personnel to continuously monitor the data that they gather.⁹³ However, tethered balloons that are struck down (by direct fire, ground attack, or weather) could be relaunched in as little as one day, while the sensing-capability payload and other system components of aerostats are more durable than the balloons; they will likely survive even if the balloon is destroyed.⁹⁴

⁹⁰ "Tallinn Uses Drones to Inform People About Coronavirus Restrictions," ERR News, April 14, 2020.

⁹¹ Jen Judson, "After Blimp Broke Free and Crashed, JLENS Program Hangs by a Thread," *DefenseNews*, October 30, 2015.

⁹² Rietjens and Dorn, 2017, pp. 209–210; Karina Tsui, "Strong Winds Send US Customs Blimp Nearly 600 Miles Across Texas," CNN, March 6, 2025.

⁹³ Matteo Luccio, "Tethered Aerostats Provide Another Option in the Sky," *xyHt*, October 29, 2014.

⁹⁴ Dorn, 2013, p. 21.

Recommendations

- Deploy tethered aerostats (i.e., balloons) with a variety of sensors for land, near-shore, and offshore (where relevant) monitoring, specifically at sites of frequent ceasefire violations and withdrawal or disengagement areas where monitoring could build greater confidence in the ceasefire process, such as along the heavily forested border regions of Polesia.
- Use short- and medium-range UASs to complement aerostats and act on data received from persistent tethered balloons.

Satellites

Satellites can be equipped with a variety of sensing capabilities to detect visible light, infrared light, microwave radiation, and more. Taken together, the data from their remote sensors produce high-resolution images of Earth's surface.

In a future monitoring mission, satellite observation could complement other monitoring methods, building on the rapid growth of the commercial satellite industry and the decreasing cost of overhead imagery. Increasingly dense constellations of satellites can enable commercial providers to be responsive to requests for imagery of specific areas within minutes or hours rather than having to wait appreciable periods before any satellite reaches the right location. The primary value of satellite imagery would be to further document compliance or noncompliance to support evidence detected by other sources. Satellite imagery would also be beneficial for monitoring regions where large-scale troop movement has been more prevalent than small-scale combat, especially on Ukraine's northern borders with Belarus. Satellite imagery has successfully tracked large-scale troop movement in this region in the past.⁹⁵

Using commercially available satellite imagery on a case-by-case basis would not require a monitoring mission to maintain its own satellites or

⁹⁵ Christoph Koettl, "New Satellite Images Show More Russian Forces Massing on Three Sides of Ukraine," *New York Times*, February 10, 2022.

the staff to manage them. A monitoring mission could instead dedicate resources to trained imagery analysts to evaluate imagery.⁹⁶

However, there are significant reasons why a future monitoring mission should not rely on satellite imagery too heavily. While satellites can image large areas both day and night (with synthetic aperture radar), the images they produce are aperiodic snapshots not delivered in real time. That satellites can image over such a large area is very beneficial when considering the geographic scope that a monitoring mission may need to observe in Ukraine. However, given its aperiodic nature, satellite imagery will never be as timely as images captured by other platforms, such as drones or aerostats. Additionally, as satellites have predictable schedules and trajectories, conflict parties could strategically alter their movements to avoid being captured violating the terms of a ceasefire during the flyover—although this has become more difficult to do in recent years as the number of satellites and satellite constellations have grown.⁹⁷

Recommendations

- Use satellite imagery to track changes over time in areas of potential conflict and withdrawal or disengagement areas where satellite imagery can verify compliance with the ceasefire terms.
- Leverage existing open-source satellite imagery.

Land-Based Sensing Technologies

Uncrewed Ground Vehicles

Uncrewed ground vehicles (UGVs) are the ground-based counterparts to UASs. Like UASs, UGVs are remotely controlled from the ground without a human operator onboard. The UGV industry has boomed over the past decade, and both sides have deployed UGVs on the battlefield in the Russia-Ukraine war.⁹⁸ An array of cameras and sensors could be mounted

⁹⁶ Notably, the use of imagery from commercial satellites would also make those data verifiable by third parties, which could increase trust in the activities captured by those satellites (Grand-Clément, 2022a, p. 42).

⁹⁷ Grand-Clément, 2022a, pp. 43–44.

⁹⁸ Aaron Mehta, “Industry, Nations Hope to Cash In on Unmanned Ground Vehicle Growth,” *DefenseNews*, October 9, 2018; David Hambling, “How Ukraine Is Replacing

on basic UGVs, and specialized UGVs for demining could complement monitoring efforts.

UGVs have distinct disadvantages when compared with the other ground sensors described below. UGV sensors would generally be at a lower altitude than tower-based and roof-based ones, limiting their fields of view. The movement of the vehicle would generally degrade sensor accuracy and sensitivity relative to fixed sensors, even if they were mounted to reduce shaking; this might limit them to being used only when the vehicle is stationary. UGV sensors would also likely require more maintenance than fixed sensors, because they would be repeatedly subject to motion—the vehicles themselves would also need to be purchased, fueled, and maintained—and, unlike fixed sensors, UGV sensors would require a vehicle driver in addition to imagery analysts.

However, there are limited cases in which UGVs mounted with certain sensors could benefit a future ceasefire-monitoring mission in Ukraine. Some areas—such as a local elevation—could accommodate the intermittent presence of a UGV or even a parked crewed vehicle, but not a fixed sensor. Furthermore, UGVs mounted with CBRN-sensing capabilities could more closely inspect ground conditions in the Chernobyl Exclusion Zone, which poses a hazard to human monitors, or on the site of alleged chemical weapons use.⁹⁹ The ability to monitor conditions in the exclusion zone from the ground and the state of radiation pollution in the zone would be especially important given periodic strikes on the Chernobyl radiation shield.¹⁰⁰ Additionally, humanitarian demining and decontamination will be a large part of post-war stabilization in Ukraine, and such efforts will be inextric-

Human Soldiers with a Robot Army,” *Forbes*, April 18, 2025.

⁹⁹ Patrick Hinton, *Uncrewed Ground Systems: Organisational and Tactical Realities for Integration*, Royal United Services Institute, 2023, p. 15; Zachary Kallenborn and Marcel Plichta, “Release the Robot Hounds: Providing Unmanned Ground Vehicles to Ukraine,” Center for Strategic and International Studies, April 3, 2023.

¹⁰⁰ Pavel Polityuk and Alessandra Prentice, “Ukraine State Nuclear Company Unable to Monitor Radiation Levels Around Chernobyl,” ed. by Timothy Heritage, Reuters, March 21, 2022; Ian Aikman, “Chernobyl Radiation Shield Hit by Russian Drone, Ukraine Says,” BBC, February 14, 2025.

cably linked with ceasefire monitoring.¹⁰¹ If deemed necessary, specialized UGVs for demining could facilitate access for monitoring teams in designated areas.

Recommendation

- UGVs should be deployed only in cases where close-up, persistent ground monitoring is necessary, such as in the Chernobyl Exclusion Zone, where camera and CBRN-sensing capabilities would reduce hazards to human monitors.

Fixed Ground Sensors

Two types of fixed ground sensors are most commonly used in ceasefire-monitoring missions: fixed cameras and acoustic sensors. *Fixed or stationary cameras*, such as CCTV cameras, are surveillance cameras that provide coverage of a specified area for 24 hours seven days a week by transmitting signals to a dedicated monitor. CCTV cameras are used widely around the world for surveillance in retail stores, parking lots, and the like. *Acoustic sensors* measure the small difference in time that it takes a sound wave to arrive at different elements in a microphone array. This array can either be contained within a single sensor or, as is the case with acoustic sensors designed to locate gunshots in cities, spread over a large area. Both fixed cameras and acoustic sensors are typically mounted to the outside of buildings and other stable structures.

The greatest advantage of both fixed cameras and acoustic sensors is their ability to establish persistent and permanent monitoring capabilities where the permanent physical presence of human monitors would be either infeasible or unsafe. The SMM relied heavily on fixed cameras, especially across hotspots that were known in advance to require constant surveillance. For these locations, fixed cameras' complete lack of mobility and limited observation area were not disadvantages. Compared with UASs, fixed cameras require comparatively less maintenance and specialized training, cost less, and can provide persistent coverage. Like UASs, these sensors can be operated remotely, reducing human exposure to hazards, and can monitor areas day and night. By April 2021, fixed cameras operated by

¹⁰¹ Kemp, 2025, p. 24.

the SMM had recorded 279,000 ceasefire violations—around 20 percent of the total number of ceasefire violations observed up to that date.¹⁰² Acoustic sensors—either a single fixed sensor or a network of fixed sensors—can help detect and locate the source of small artillery fire down to the specific acoustic signature of the fired weapon. As with fixed cameras, the SMM used acoustic systems to help monitors determine the source of fire of a given ceasefire violation. Acoustic sensors also supplement data obtained from other sensing technologies, which are typically visual (e.g., images from UASs, satellites, or fixed cameras).

A future monitoring mission in Ukraine could establish a permanent monitoring presence in high-traffic or critical areas using fixed cameras and acoustic sensors. In his report on ceasefire monitoring and the use of technology, Hug recommends the use of fixed cameras in five general locations: (1) hotspots, where ceasefire violations are likely to take place; (2) disengagement areas, where conflict sides have agreed to retreat from the line of contact; (3) storage areas known to contain weapons; (4) civilian checkpoints; and (5) essential civilian infrastructure.¹⁰³ Similarly, a monitoring mission could install acoustic sensors close to the conflict line where there could be potentially regular battle noise and at forward patrol bases.¹⁰⁴

While fixed cameras and acoustic sensors offer the benefits of persistent presence, they have several drawbacks. Critically, their fixed nature means that both sensing capabilities could be targeted by conflict parties to disable them.¹⁰⁵ Each has its own endemic drawbacks as well. Fixed cameras have a limited field of vision, require a power source to function, and can be hampered by poor weather—all significant obstacles given the length and diverse environments encompassing the conflict line in Ukraine. While acoustic sensors are cheaper than other audio sensors and have the benefit of being able to detect small-arms fire, they lack range and accuracy. Additionally, acoustic sensors can be overwhelmed by a large volume of fire. The

¹⁰² OSCE, “Technical Monitoring on the Contact Line: Making It Work for People,” April 16, 2021; SMM, “2021: Trends and Observations,” infographic, February 4, 2022a.

¹⁰³ Hug, 2024, pp. 79–83.

¹⁰⁴ Hug, 2024, p. 92.

¹⁰⁵ Grand-Clément, 2022a, p. 41.

SMM found that even though their acoustic sensors could locate the source of single shots from small arms and artillery fire, “their applicability for the monitoring of intensive, overlapping and multi-weapon-layered battles was questionable.”¹⁰⁶

Recommendations

- Deploy fixed cameras at sites where violations are likely to occur, withdrawal or disengagement areas, weapon storage areas, civilian checkpoints, and critical infrastructure.
- Supplement visual sensors and cameras with acoustic sensors, especially along the conflict line and at forward patrol bases.

Maritime-Based Sensing Technologies

Buoys

A *buoy* is a floating device that is typically moored or anchored to the seabed using concrete blocks or various kinds of anchors. While buoys have traditionally been used to mark maritime routes, monitor weather, and serve as mooring points for vessels, their low cost and persistent positioning make them an ideal platform for sensing capabilities in the maritime domain. In particular, buoys could host EO/IR cameras and other radars to aid in ceasefire monitoring.

If Russia and Ukraine end up sharing the use of a river or strait along the conflict line for transit or fishing, monitors may be called on to help demarcate specific waters and deter potential violations. To that end, monitors could potentially emplace fixed buoys in shallow, coastal environments. Such buoys can be linked to shore stations via cables that provide them with power and communication capabilities while anchoring them to the seabed. The buoys can also host EO/IR cameras or other sensors that enable personnel ashore to monitor for possible intrusions. Depending on the sophistication of the algorithms that process the incoming data, these systems may be used to cue humans about approaching vessels, enabling a limited number of personnel to monitor sensors atop a large number of buoys. Regardless,

¹⁰⁶ Hug, 2024, p. 92.

buoy-based sensors can provide continuous data that can then be reported to relevant stakeholders.

In addition to hosting sensing capabilities, buoys could also benefit a monitoring mission by serving as traditional maritime markers. Buoys could be designed to be highly visible, with bright colors and flashing lights, and can even warn potential intruders by periodically repeating audio messages via a loudspeaker. Such demarcation and warning can help reduce the number of accidental incursions and, thus, help establish when violations are intentional, because vessels cannot claim ignorance about the location of forbidden areas. For example, Estonia uses standard buoys to mark maritime routes on the Narva River—which acts as an international border between Estonia and Russia—to avoid navigational errors that could lead fishermen and other hobbyists to accidentally cross into Russian waters.¹⁰⁷

A future ceasefire-monitoring mission in Ukraine could deploy buoys with cameras and other sensors to establish a persistent presence along key waterways near and on the conflict line. In particular, the Dnipro River has been a site of repeated fighting during the war and serves as the conflict line from Zaporizhzhia city south to the Black Sea, making it an area of potential ceasefire violations in the future that could benefit from the persistent monitoring presence of sensing-enabled buoys.¹⁰⁸ Such sensing-enabled buoys could also benefit monitoring efforts in the Dniprovskia Gulf, a roughly 17-km-wide body of water where the Dnipro River meets the Black Sea. While long coastal regions on the Black Sea may be better monitored by cameras embedded on tethered aerostats, sensing-enabled buoys can provide demarcation in relevant areas there as well.

One key consideration is that buoys and their sensors will need to be periodically maintained to combat corrosion, encrustation by animal life, weather, and other degradation. While one side may tamper with or directly target buoys and their cables and sensors (e.g., by dragging an anchor across a cable or shooting sensors with rifle fire), the buoys would be able to detect those violations. Putting them within close enough proximity to one

¹⁰⁷ Estonian Police and Border Guard Board, “Border Guard of the Russian Federation Removed Light Buoys from Narva River,” press release, May 23, 2024.

¹⁰⁸ Khrystyna Zhevlakova, “On a Forgotten Part of Ukraine’s Front Line, Russian Forces Mass for Assault on Dnipro Islands,” *Kyiv Independent*, December 5, 2024.

another would enable each buoy to detect tampering or attacks directed at others, and simultaneous damage to multiple buoys would be a clear signal to immediately focus other observation assets on that area.

Recommendations

- Deploy buoys enabled with EO/IR cameras and radars in maritime environments in the Dnipro River and in the Black Sea to establish a persistent monitoring presence.
- Make the buoys brightly colored, clearly identifiable, and equipped with flashing lights and loudspeakers to warn both accidental and purposeful violators.

Uncrewed Surface Vessels

USVs are the surface-level maritime counterparts to UASs and UGVs. *USVs* are waterborne vessels capable of operating on the surface of water without human operators onboard. Although USV technology first emerged during World War I, it has developed rapidly in recent years, culminating in its emergence as a formidable capability, as shown in the Russia-Ukraine war.¹⁰⁹ While USVs have been used primarily in a wartime context, they could also act as platforms for sensing technologies for ceasefire monitoring at sea.

There are several advantages associated with using USVs for monitoring, alongside other types of systems. Like UASs, USVs could approach off-shore actors for closer observation or to deter violations through their presence. While they lack the speed and altitude of aircraft, they can monitor without interruption for days or longer, as opposed to hours with aircraft. Their surveillance may not be as persistent as buoys', but they can relocate either when cued or as part of ongoing patrols. Because they are mobile—like patrolling police cars—they also have an element of unpredictability that buoys lack, which can contribute to deterrence. The existence of a fleet of monitoring vessels that can appear unexpectedly may inhibit attempts to violate the ceasefire.

¹⁰⁹ Scott Savitz, "The Age of Uncrewed Surface Vessels," commentary, RAND Corporation, November 15, 2022.

In a Ukraine-specific context, USVs enabled with cameras and radars could roam parts of the Black Sea coastline either on a continual (rotating) or intermittent basis. However, vessels may be most useful at appreciable distances offshore, where they would need to be large enough to operate in open waters. Specifically, they may be the primary monitoring platform in areas whose expanse, depths, and rough seas may preclude a buoy network; that are too far from land for cost-effective ground-based UASs to have appreciable on-station time; and that cannot be monitored from land-based tethered aerostats. In offshore environments, the presence of USVs can help deter one side's ships or aircraft from harassing the other side's cargo and fishing ships or from conducting other proscribed activities. Even if USVs are unable to deter violations through their presence alone, they can document that behavior for accountability purposes. Compared with UAVs, however, USVs are much more expensive.

Recommendation

- Deploy USVs enabled with sensors on the Dnipro River or in the Black Sea where expanse, depth, or rough seas preclude the use of sensing-enabled buoys.

Uncrewed Underwater Vehicles

Uncrewed underwater vehicles (UUVs)—the underwater counterpart to UASs, UGVs, and USVs—are robots capable of performing underwater tasks that were previously accomplished only by submarine crews or divers. UUVs come in two forms: remotely operated underwater vehicles (ROUVs) and autonomous underwater vehicles (AUVs). The most common sensing capabilities embedded on UUVs for ISR purposes are cameras and passive sonar systems.

The primary strengths of UUVs compared with USVs are their stealth and the ability to vary their height in the water column. However, stealth is largely a disadvantage in a monitoring context in which the primary focus is on being visible to deter and reassure both sides. There is the potential need to inspect damaged infrastructure or hunt for naval mines during a ceasefire period, and both of these missions could benefit from the ability of undersea craft to descend below the surface. The craft in question could include small, short-range, free-floating AUVs and/or ROUVs. Given the heavy mining of the Black Sea, especially in Ukrainian ports, these capa-

bilities may be relevant to ceasefire-monitoring activities in the maritime domain.¹¹⁰

However, UUVs come with a host of drawbacks. They are much more expensive than their comparably sized surface counterparts, require many more skills to operate and maintain, and have more limited endurance. They inherently have very limited communication capabilities when submerged, unless they are tethered to a shore or vessel via a cable that provides power and communication capabilities. AUVs need to be highly autonomous, but such capabilities are currently very expensive and available to only select military forces.¹¹¹

Either a commercial company or a military service could assist in inspections of undersea infrastructure. In the event of a mine detonation or a credible naval mine threat, a military's mine countermeasure forces would be needed to conduct *mine-hunting* (searching for mines and neutralizing them) or *minesweeping* (detonating the mines without damaging ships). These activities require very specific equipment, advanced training, and decades of experience that would be unavailable to ceasefire monitors. For all these reasons, monitors should not attempt to employ UUVs.

Recommendation

- Monitoring mission resources and expertise should not be used on UUV capabilities. If significant undersea mine-hunting or mine-sweeping is needed, a commercial company or national military service should be brought in to assist.

¹¹⁰ Benjamin Jensen and Mark Montgomery, "How to Secure the Black Sea During a Russia-Ukrainian Ceasefire," Center for Strategic and International Studies, March 31, 2025.

¹¹¹ Robert W. Button, John Kamp, Thomas B. Curtin, and James Dryden, *A Survey of Missions for Unmanned Undersea Vehicles*, RAND Corporation, MG-808-NAVY, 2009; Kiran Suman-Chauhan, Nicolas Jouan, and James Black, "Navies Look to Uncrewed Systems to Counter Threats Beneath the Waves," commentary, RAND Corporation, May 21, 2024.

Summary

An effective monitoring mission would leverage a combination of remote-sensing platforms to achieve a persistent and pervasive presence capable of responding to emergent monitoring needs. A combined and integrated suite of remote-sensing platforms would also serve to limit the drawbacks of certain platforms and prevent an overreliance on any one platform. Table 4.2 provides a summary of the relative advantages and disadvantages of the remote-sensing platforms discussed in this chapter. This information supports the subsequent conclusions on how to employ these systems effectively in the different geographic areas along the conflict line.

TABLE 4.2

Remote-Sensing Technologies: Advantages, Disadvantages, and Recommendations

Platform	Advantages	Disadvantages	Recommendations
UASs	• Lower cost and less runway-restricted than crewed aircraft • Quick movement over land and sea	• Vulnerable to electronic warfare • Easily mistaken as threats • High cost of some UAS classes	• Deploy short- and medium-range UASs equipped with cameras to monitor hazardous and targeted areas, particularly for situational awareness and collecting real-time imagery. • Deploy long-range UASs equipped with cameras and infrared sensors for monitoring missions that would be otherwise impossible, most critically at night, along lengthy coastlines, and for persistent monitoring of the conflict line. • Prepare to counter interference with UAS operations.

Table 4.2—Continued

Platform	Advantages	Disadvantages	Recommendations
Aerostats	• Altitude • Persistence • Ability to host large payloads and multiple sensors with high-power demands • Hard-wired communication capabilities	• Potential to break free of tethers and cause damage • Susceptible to bad weather and direct ground attack	• Deploy tethered aerostats for land, near-shore, and offshore (where relevant) monitoring, specifically at sites of frequent ceasefire violations and withdrawal or disengagement areas where monitoring could build greater confidence in the ceasefire process. • Use short- and medium-range UASs to complement aerostats and act on data received from persistent tethered balloons.
Satellites	• Detailed overhead coverage	• Ability to observe only small areas • Limited vantage points • Data latency of minutes to hours • Persistence limited by constellation density	• Use satellite imagery to track changes over time in areas of potential conflict and withdrawal or disengagement areas, where satellite imagery can verify compliance with the ceasefire terms. • Leverage open-source satellite imagery.
UGVs	• Up-close, persistent coverage of ground conditions • Capable of demining	• Largely duplicative capabilities (very similar to UASs) • Not versatile	• UGVs should only be deployed in cases where close-up, persistent ground monitoring is necessary, such as in the Chernobyl Exclusion Zone, where camera and CBRN-sensing capabilities would reduce hazards to human monitors.

Table 4.2—Continued

Platform	Advantages	Disadvantages	Recommendations
Fixed ground sensors	• Low cost • Persistent presence	• Altitude limited by terrain, building heights, and/or accessibility	• Deploy fixed cameras at sites where violations are likely to occur, withdrawal or disengagement areas, weapon storage areas, civilian checkpoints, and critical infrastructure. • Supplement visual sensors and cameras with acoustic sensors, especially along the conflict line and at forward patrol bases.
Buoys	• Low cost • Persistent presence • Hard-wired communication capabilities	• Lack of altitude • Need for continual maintenance in maritime environment • Static	• Deploy buoys enabled with EO/IR cameras and radars in maritime environments in the Dnipro River and the Black Sea to establish a persistent monitoring presence. • Make the buoys brightly colored and clearly identifiable and equipped with flashing lights and loudspeakers to warn both accidental and purposeful violators.
USVs	• Ability to monitor maritime environments without onboard operators	• Expensive	• Deploy USVs enabled with sensors on the Dnipro River or in the Black Sea, where expanse, depth, or rough seas preclude the use of sensing-enabled buoys, and in areas that are too far from the shore for UASs or tethered aerostats.

Table 4.2—Continued

Platform	Advantages	Disadvantages	Recommendations
UUVs	• Ability to monitor objects, including infrastructure, at various heights within the water column	• Expensive • Technologically immature • Stealth (a negative trait for overt patrolling)	• Monitoring mission resources and expertise should not be used on UUV capabilities. If significant undersea mine-hunting or minesweeping is needed, a commercial company or national military service should be brought in to assist.

Critical Considerations When Employing Remote-Sensing Technology

Synergies Among Systems and Data Fusion

The technologies listed in Table 4.2 have different relative strengths and weaknesses; they can and should be used in concert with one another. Some are better for certain parts of the physical environment or for observing from specific vantage points. Some systems may usefully cue others: For example, fixed buoy-based or aerostat-based sensors may reveal activity that cues monitoring personnel to approach in a crewed vehicle, both to gain further information and to deter or halt a ceasefire violation. In some cases, systems of the same type may cue one another: For example, a UAS that discerns an anomaly may cue another UAS to approach for confirmation.

A key challenge in this context is being able to integrate and analyze reams of data emerging from multiple sources.¹¹² If dozens of cameras, radars, and other sensors are continually providing data from various locations, there needs to be some type of fusion center where algorithms identify anomalies, cue humans to look at them, and provide actionable information. Commercial systems, with some tailoring to reflect the monitors’

¹¹² Isaac R. Porche III, Bradley Wilson, Erin-Elizabeth Johnson, Shane Tierney, and Evan Saltzman, *Data Flood: Helping the Navy Address the Rising Tide of Sensor Information*, RAND Corporation, RR-315-NAVY, 2014.

specific needs, will be required to combine and analyze data streams. The SMM, for example, deployed an Enterprise Geographic Information System for processing, evaluating, and sharing such data.¹¹³

AI can limit the number of watch standers necessary to interpret incoming data streams—with a key caveat. AI is prone to *false positives* (recognizing an anomaly where none exists) and *false negatives* (not recognizing relevant anomalies), both of which can be exacerbated by deception. An abundance of false positives can lead to the system being ignored or having its threshold for reporting elevated to the point that false negatives are frequent. Any AI system should be tested, alongside other aspects of the fusion center, potentially by having monitors replicate apparent ceasefire violations and seeing how accurately those are detected and characterized.

Recommendation

- Build out an integrated data integration platform for the information generated by remote sensing, leveraging the latest advances in AI.

Interference with Sensors

Antonia Potter argues that one of the best practices for ceasefire monitoring and verification includes conflict parties forming agreed and defensible classification of types of violations.¹¹⁴ While inadvertent and targeted attacks on human monitors occur in ceasefire-monitoring and peacekeeping missions, monitoring mandates do not typically codify violence against a monitor as a ceasefire violation, relying on informal norms to deter such behavior.¹¹⁵ However, as Sarah Grand-Clément notes, the same normative and moral considerations may not exist surrounding ceasefire-monitoring technology (software or hardware), which could make sensing technology more likely to be targeted.¹¹⁶

¹¹³ Hug, 2014, p. 102.

¹¹⁴ Potter, 2004, p. 8.

¹¹⁵ Verjee, 2022, p. 809; Aly Verjee, *Ceasefire Monitoring in South Sudan 2014–2019: “A Very Ugly Mission,”* United States Institute of Peace, Peaceworks No. 150, August 2019, pp. 9–10; Grand-Clément, 2022a, p. 28.

¹¹⁶ Grand-Clément, 2022a, p. 28.

Neither the SMM's mandate nor the Minsk agreements covered the rules of engagement regarding sensing technology. Jamming of the SMM's UAVs happened frequently, and those engaging in this activity were not held accountable for it. Any future ceasefire agreement in Ukraine should treat interference with a monitoring mission's sensing technology as a violation—including the use of electronic warfare against sensing technology used by monitors.

Recommendation

- A future ceasefire agreement should codify sanctions for interference with the monitors' sensing technology.¹¹⁷ Interference with sensing technology should be dealt with swiftly and publicly to deter future violations by imposing costs on the conflict party at fault.

Accountability and Sensing Technology Data

Sensing technologies can be used to increase the scope, effectiveness, and safety of a future ceasefire-monitoring mission in Ukraine. But without accountability mechanisms, the practical impact of more effective monitoring is limited.¹¹⁸ As noted in Chapter 3, the SMM's human monitors and sensing technologies provided a wealth of information on violations, producing regular reports identifying the nature and frequency of violations. But without a mechanism for adjudicating and sanctioning noncompliance, there was minimal accountability for violations.¹¹⁹ As Hug notes, no amount of technology can offset the absence of an accountability mechanism.¹²⁰ Documenting and reporting ceasefire violations via sensing technologies is only one part of an effective ceasefire-monitoring mission—negotiators, conflict parties, and monitors must also map out and agree on how those data will be used to attach costs to noncompliance.¹²¹

¹¹⁷ Verjee, 2025, p. 7.

¹¹⁸ Buchanan, Clayton, and Ramsbotham, 2021, p. 13.

¹¹⁹ Wittke, 2019, p. 279.

¹²⁰ Hug, 2024, p. 2.

¹²¹ Aly Verjee, "Routine but Consequential: How Ceasefire Monitors' Reporting Constructs Opportunities for (Non)Compliance by Conflict Opponents," *International*

Recommendations

- Include accountability mechanisms in any ceasefire agreement. Even the best monitoring with remote sensors cannot compensate for the lack of such mechanisms.
- Accountability could entail reporting to an international body with the power to act (e.g., the UN Security Council). For example, UNIFIL in Lebanon reported violations that it observed directly to the Council.
- As noted in Chapter 3, beyond political measures, accountability mechanisms can be at the individual level (i.e., punishing a particular soldier who engaged in a violation), the military unit level (doing the same for a commander), or the state level (e.g., by imposing sanctions or permitting the compliant side to take otherwise prohibited steps). The “snapback” provisions in the JCPOA provide an example of pre-agreed accountability mechanisms for violating an international accord.

Conclusion

A future ceasefire-monitoring mission in Ukraine will take on the unprecedented task of monitoring a conflict line that is approximately 3,300 km long; spans an array of environments across air, land, and maritime domains; and traverses the dangerous ground of recent battlefields. Given the scale and hazard of such a mission, sensing technology will have to play a major role in monitoring a ceasefire in Ukraine. As discussed, Ukraine’s diverse geography requires tailored applications of sensing technology to best support ceasefire monitoring along the entire conflict line. We propose several ways to leverage sensing technology, informed by the sensor recommendations in this chapter, while taking into account the geographic peculiarities along the line of contact:

- *On Ukraine’s northern borders in the densely forested region of Polesia, tethered aerostats equipped with cameras and EO/IR cameras and satellite imagery can enable overhead monitoring in an environment that*

is not feasible with ground-based monitoring. Given that the primary threat on the Ukraine-Belarus border has been the amassing of troops and large-scale invasion, aerial monitoring could capture troop movements on either side of the conflict line and alert the monitoring mission of a potential impending ceasefire violation. Short- and medium-range UASs and CBRN-enabled UGVs can surveil the Chernobyl Exclusion Zone to reduce human monitors' exposure to CBRN hazards while preventing and deterring violations in the zone.

- *Along Ukraine's eastern border with Russia running through the flat steppe region and the line of contact*, camera-enabled long-range UASs can provide constant daytime and nighttime coverage of the areas where direct fighting has been most intense, while short- and medium-range UASs can be deployed to deter and document violations in hotspots and surveil heavily mined areas. Given the flat and open nature of the steppe, radars and counter-battery radars mounted on aerostats can be used to track and locate the source of violations.
- *In urban and suburban environments that have seen heavy fighting*, fixed cameras, acoustic sensors, and aerostats can provide persistent monitoring. Given potential civilian sensitivities to drones, selectively placed tethered aerostats may be better suited for aerial monitoring over urban and suburban areas.
- *Along the stretch of the conflict line that runs along the Dnipro River*, long-range UASs can provide constant aerial surveillance, while tethered aerostats can provide persistent coverage of the small islands located in the Dnipro River delta. Buoy-based cameras and radar can demarcate maritime boundaries while capturing and deterring maritime ceasefire violations. Camera and sensor-enabled USVs can patrol for potential violations.
- *To monitor Ukraine's coast along the Black Sea*, balloons embedded with cameras and radar can be tethered to the coastline for aerial monitoring while camera-enabled buoys can mark and monitor maritime boundaries close to shore. Camera and sensor-enabled USVs can patrol the Black Sea for potential violations and signal long-range UASs to perform aerial surveillance if needed.

While sensing technology could greatly extend the capacity and resources of a monitoring mission while reducing the risk to monitors, there are other key technology-related considerations. Any ceasefire agreement should treat interference with the monitoring mission's sensing technology as a ceasefire violation—including, and especially, the use of electronic warfare. The conflict parties, negotiators, and monitoring mission should also agree on how data from sensing technology will be integrated. Mechanisms to hold the conflict parties accountable for ceasefire violations will be needed too. While sensing technology is not a substitute for human monitoring, it can serve as a force multiplier—extending coverage, enabling faster response, and providing objective evidence that supports and enhances the credibility and effectiveness of a monitoring mission.

Conclusion

In this report, we discuss the implications for a potential future ceasefire in the Russia-Ukraine war derived from three lines of effort: a review of a robust body of academic literature and policy documents to distill ceasefire best practices, a study of the Minsk agreements, and an examination of remote-sensing technology. The recommendations presented in each chapter are meant to be relevant even if there are changes on the battlefield before hostilities cease. They can be adapted to the specific facts on the ground when the war comes to an end.

In this concluding chapter, we bring together the three sets of recommendations from the preceding chapters to provide some top-level guidance for future ceasefire negotiations based on our empirical research.

Top-Line Recommendations

For policymakers and stakeholders involved in considering the details of a future ceasefire agreement in Ukraine, we offer the following seven top-line recommendations:

- Negotiate overarching geopolitical questions in parallel with, but on a separate track from, ceasefire discussions.
- Start working on the ceasefire design long before negotiations begin.
- Design a formal ceasefire agreement that clearly specifies assigned roles and responsibilities, protocols, and operating procedures.
- Ensure that the agreement includes the following key components:
 - DMZs along the frontline

- CBMs, particularly mutual military inspection, on-site verification visits, and aerial surveillance
 - dispute-resolution mechanisms that involve the conflict parties in joint commissions
 - an extensive third-party monitoring mechanism
 - robust accountability mechanisms to identify, punish, and deter noncompliance.
- Include a robust remote-sensing infrastructure, featuring UAVs, aero-stats, fixed ground sensors, satellites, buoys, and USVs.
 - Ensure that the agreement treats interference with remote sensors as a violation.
 - Include mechanisms that allow for political-level oversight of implementation and possibly specified conditions that would trigger renegotiation.

Abbreviations

AI	artificial intelligence
AUV	autonomous underwater vehicle
CBM	confidence-building measure
CBRN	chemical, biological, radiological, and nuclear
CCTV	closed-circuit television
DMZ	demilitarized zone
DNR	Donetsk People's Republic
EO/IR	electro-optical/infrared
GPS	Global Positioning System
ISR	intelligence, surveillance, and reconnaissance
JCCC	Joint Center for Control and Coordination
JCPOA	Joint Comprehensive Plan of Action
LNR	Luhansk People's Republic
MINUSMA	United Nations Multidimensional Integrated Stabilization Mission in Mali
MONUSCO	United Nations Organization Stabilization Mission in the Democratic Republic of the Congo
NATO	North Atlantic Treaty Organization
OSCE	Organization for Security and Co-operation in Europe
ROUV	remotely operated underwater vehicle
SMM	OSCE Special Monitoring Mission to Ukraine
TCG	Trilateral Contact Group
UAS	uncrewed aerial system
UAV	uncrewed aerial vehicle
UGV	uncrewed ground vehicle
UN	United Nations
UNFICYP	United Nations Peacekeeping Forces in Cyprus
UNIFIL	United Nations Interim Force in Lebanon
USV	uncrewed surface vehicle
UUV	uncrewed underwater vehicle

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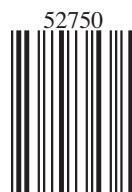


The Russia-Ukraine war is the largest military conflict in Europe since World War II. A *ceasefire*—an accord between the belligerents to cease active hostilities and avoid their resumption—will be a key component of any negotiated end to the war. Under any circumstances, designing, agreeing on, and implementing a ceasefire are extremely challenging tasks. The specific circumstances of the Russia-Ukraine war make doing so even more difficult. The conflict line is roughly 3,300 km long, spans land and sea, abuts multiple international borders, and crisscrosses heavily mined areas. The extremely high level of mistrust between the belligerents makes any agreements between them politically fraught. A ceasefire will create military vulnerabilities that both sides will worry could be exploited by the other side for tactical gain. And Russia and Ukraine have had recent experience, with the 2014–2021 Minsk agreements, of a ceasefire that never achieved a sustainable end to the fighting.

This report presents actionable insights for a durable cessation of hostilities derived from three sources: a comprehensive analysis of best practices in establishing and maintaining past ceasefires, particularly after interstate wars; a review of lessons learned from the pre-2022 ceasefire efforts in Ukraine; and an assessment of emerging remote-sensing technologies and how they can enhance ceasefire monitoring. Drawing on this original research, the authors provide recommendations for policymakers and stakeholders working toward a durable peace in Ukraine.

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