Aerospace & Defense
Journal of the Elrom Center for Air and Space Studies at Tel Aviv University
No. 2(2) | December 2025

Integrating Active, Passive, and Offensive Defense: A Comparative Study of Ukraine and Israel (2022-2025)

Sarah Fainberg, Yuval Peleg, and Tomer Fadlon[1]

Abstract

The wars in Ukraine and Israel have been shaped by persistent missile, rocket, and drone attacks on civilian and military targets, illustrating the return of total warfare. This article investigates why and how different states withstand aerial coercion and develops a three-tier analytical framework of active defense (interception), passive defense (early warning, shelters, functional continuity), and offensive defense (degrading enemy strike capacity at its source). We argue that the degree of integration across these layers shapes home-front endurance, and we demonstrate this through a comparison of Ukraine, marked by wartime adaptation under material scarcity, and Israel, where prewar institutionalization enabled rapid but at times uneven adaptation after October 7. Drawing on open-source data, policy and media materials, and interviews with officials, practitioners, and civil society actors in Ukraine and Israel, we show that variations in defense integration affect each case's defense trajectory and performance. The findings contribute to scholarly debates on coercion, resilience, and adaptation in air warfare and offer an empirical basis for shaping defense integration in other high-threat environments.

1 **Dr. Sarah Fainberg** is a Senior Researcher and Head of the Great Powers Research Program at Tel Aviv University's Elrom Center for Air and Space Studies.
Yuval Peleg is a Researcher at Tel Aviv University's Elrom Center for Air and Space Studies and a Ph.D. candidate in International Relations at the Hebrew University of Jerusalem.
Dr. Tomer Fadlon is Academic Director and Senior Researcher at Tel Aviv University's Elrom Center for Air and Space Studies and a lecturer at Tel Aviv University.

To cite this article: Fainberg, S., Peleg, Y., & Fadlon, T. (2025). Integrating active, passive and offensive defense: a comparative study of Ukraine and Israel. *Aerospace & Defense*, 2(2), 69-102. https://socsci4.tau.ac.il/mu2/elrommagazine-eng/

Keywords: Airpower, Active Defense, Offensive Defense, Passive Defense, Total Defense, Ukraine, Israel

Introduction

Over the past three-and-a-half years, both Ukraine and Israel have found themselves engaged in prolonged warfare characterized by persistent and intense aerial threats. The comprehensive nature of these threats has compelled both states to adopt whole-of-government and whole-of-society approaches, mobilizing military and civilian resources during wartime to confront the challenges posed by sustained aerial attacks. Whether these cases are context-specific or indicative of broader trends in contemporary warfare, a central question emerges: How do states shape their defense architectures to withstand continuous aerial threats and maintain functional continuity under wartime conditions?

This question resonates with ongoing scholarly and policy debates on the concept of total defense in the post-Cold War era. Existing literature on total defense has primarily emphasized comprehensive responses to hybrid threats, particularly cyber operations, information warfare, and limited land incursions. However, the Russo-Ukrainian war and Israel's multi-front war since October 7 underscore the centrality of the air domain across all phases of contemporary high-intensity conflict. This highlights a notable discrepancy between existing approaches to total defense and the operational realities of the two largest wars of the early twenty-first century. This article addresses this gap by analyzing how Ukraine and Israel developed comprehensive defensive responses to unprecedented aerial threats during wartime by integrating three levels of defense: *active*, *passive*, and *offensive*.

Empirically, the analysis draws on open-source datasets on aerial assault patterns, interception rates, and air-alert activity in Ukraine and Israel. Given the inherent uncertainty and contestation surrounding wartime figures, emphasis is placed on identifying trends and shifts rather than precise numerical counts. These data are supplemented by academic and policy research and media analyses. To deepen the evidence base and validate findings, a dozen semi-structured interviews were conducted between 2023 and 2025 with current and former defense officials, public emergency administrators, air-defense practitioners, and civil society actors in both countries (Appendix 1, p. 100). Most interviews were conducted under wartime conditions and are anonymized for security reasons. Interviews took place in Kyiv in August 2023, in Israel in 2025, and via video communication platforms in the summer of 2025 with respondents occupying mid- and senior-level positions in government and military institutions of both countries.

Our findings show that the evolving nature of aerial threats compels states to adopt multi-layered and adaptive defense architectures that integrate active, passive, and offensive components. The absence or weak integration of any single layer diminishes the resilience and effectiveness of the system as a whole. Both Ukraine and Israel built defense architectures combining active interception, passive protection, and offensive disruption of enemy fire, yet they represent distinct models of wartime adaptation. Ukraine illustrates a predominantly *in bello* model characterized by decentralized improvisation, civilian-military innovation networks, and rapid adaptation under severe material constraints. Israel reflects a primarily *ante bellum* model shaped by extensive prewar institutionalization, layered missile defense, and centralized command structures, yet one that also underwent accelerated adaptation following the systemic shock of October 7.

This article contributes to scholarly literature in three main ways. First, it examines how evolving airpower platforms and their operational use reshape the nature and perception of aerial threat and defense. Second, it analyzes how Ukraine and Israel mobilized, adapted, and integrated active, passive, and offensive defense layers under conditions of sustained aerial attacks. Third, it provides an empirically grounded basis for ongoing scholarly and policy debates on the relationship between total defense and integrated air and missile defense: an issue of increasing relevance not only for Central and Eastern Europe and the Middle East but also for Southeast Asia.

Conceptually, the three-tier framework (active, passive, and offensive defense) does more than describe known dimensions of air and civilian defense. It seeks to explain variation in home-front endurance under sustained air attacks by specifying how different degrees of integration among offensive, active, and passive defense shape three observable outcomes: (1) the effective volume and tempo of incoming strikes; (2) interception rate; and (3) state and societal functional continuity under fire. By comparing Ukraine's predominantly reactive construction of its defense architecture under fire and Israel's primarily proactive and prewar model, the study suggests an explanation of why some states can absorb massed missile and drone campaigns with limited systemic disruption while others face prolonged strain despite impressive tactical adaptation.

The article is structured as follows. The next section outlines the literature on total defense and presents the analytical framework. The subsequent section traces the structural and technological shifts in contemporary airpower and their systemic implications for the defender's state and society. The article then applies the three-layered framework to a comparative assessment of Ukraine's and Israel's defense organization and wartime adaptation before concluding with implications for home-front defense in contemporary conflicts.

Literature Review and Analytical Framework

Russia's annexation of Crimea in 2014 reactivated debates surrounding total defense across Europe and in other regions facing heightened security threats, including Taiwan. While the notion of total defense is today undergoing renewed conceptual elaboration, it draws on Cold War-era foundations, particularly among non-aligned states bordering the Soviet Union, where the principle of the Nation-in-Arms sought to ensure national survival through the continuous integration of military institutions, state administration, civilian industry, and the general population (Bērziņa, 2020; Shaishmelashvili, 2023).

Although attention to total defense receded after the 1990s, Russia's aggressive posture since 2014 has reopened debates across Europe on how societies prepare for severe, multi-domain wartime disruption (Government of the Republic of Estonia, 2023; Government Offices of Sweden, 2024). Notably, these discussions have not evolved uniformly. States adopting total defense models vary significantly in how they conceptualize civilian participation, digital civil engagement, critical infrastructure continuity, reserve-force readiness, and the distribution of responsibilities across municipal, regional, and national levels (Bērziņš, 2023; Jordan, 2024; Ljungkvist, 2025). Even among the Nordic states most closely associated with the model, differences remain in institutional design, societal expectations, and civil-military synergies (Rakov & Fainberg, 2025). Fundamentally, states define total defense according to different strategic logics depending on their threat representation (Ångström & Ljungkvist, 2024).

The renewed relevance of total defense has been empirically tested in two contemporary conflicts that imposed unprecedented pressure on both state capacity and societal endurance: the full-scale Russo-Ukrainian war and Israel's multi-front war following the October 7 attacks. Despite markedly different geopolitical contexts and asymmetries of military power, both Ukraine and Israel experienced strategic shock that temporarily strained command institutions, emergency management systems, and civilian populations, leading scholars to describe them as cases illustrating the return of "total war"—i.e., comprehensive conflicts necessitating whole-of-society and whole-of-government responses (Karlin, 2024). Both governments mobilized not only the armed forces but also municipal authorities, volunteer organizations, private-sector actors, and civilian networks on a rapid and extensive scale (Rakov & Fainberg, 2025), thereby embodying the central logic of total defense: the integration of state and societal resources in response to an overwhelming threat.

Crucially, both wars reveal that the defense of the state and society has been centrally shaped by the need to withstand persistent, multidirectional, and high-intensity aerial attacks. Whereas earlier discussions of total defense focused heavily on hybrid interference, information operations, cyber disruption, and limited territorial incursions (Bērziņa, 2020, p. 5), the wars in Ukraine and Israel illustrate a shift in the center of gravity of coercion. Both conflicts have been defined primarily by sustained missile and drone campaigns targeting national infrastructure, military command nodes, and densely populated civilian areas.

This shift reflects broader structural transformations in airpower. While the integration of civilian technologies into military operations, the proliferation of dual-use objects, and the expansion of warfare into cyberspace and space have already eroded the boundary between the front line and the home front, the transformation of airpower constitutes an additional cumulative layer that exposes entire societies to continuous, large-scale aerial attack. Together, these dynamics reshape the spatial and temporal experience of warfare and place civilians at the center of the battlefield (Stewart, 2025).

Despite its centrality, the air dimension of warfare remains relatively under-conceptualized in total defense scholarship. Much of the post-2014 literature has concentrated on disinformation, cyber operations, and territorial defense forces, reflecting the security priorities of the Nordic-Baltic environment prior to 2022. By contrast, sustained aerial disruption and saturation attacks have only recently been incorporated into national resilience planning, as indicated for example in Sweden's Civil Defense Modernization Program (2026-2028).

The present study, therefore, seeks to advance understanding of the nexus between total defense and aerial threats by focusing specifically on the defense dynamics of Ukraine and Israel, with particular attention to the air domain. Analytically, the study identifies three key physical dimensions of defense critical to a state's ability to mitigate the impact of aerial attacks: active, passive, and offensive defense. This three-layered analytical framework is the basis of the present study.

Active defense refers to detecting, intercepting, or neutralizing incoming aerial threats through kinetic and electromagnetic means. In contemporary conflicts, the decisive variable of defense is the combination of platform sophistication and multi-layered integration: sensors, interceptors, and command-and-control fused into a coherent, multi-layered network across altitudes and domains.

Passive defense comprises non-kinetic mechanisms that preserve life and functional continuity: geo-targeted early warning, shelter policy, continuity of government and services, critical infrastructure protection, and grassroots civilian initiatives. In air campaigns marked by mass production and employment of projectiles, improved precision, extended ranges, and multi-directionality, passive defense re-emerges as constitutive of national resilience (Karlin, 2024).

Offensive defense (*in bello*) refers to calibrated air (and supporting ground) operations based on high-quality intelligence, drawing on early warning and real-time threat detection, aimed at reducing the adversary's capacity to generate and sustain aerial attacks. It targets launch systems, command-and-control nodes, production chains, and logistical networks during wartime. Conceptually, it complements active interception by degrading strike potential at its source, thereby restoring the defender's initiative and alleviating pressure on active and passive defense layers.

Taken together, these three layers of defense (active, passive, and offensive) are analytically distinct but operationally interdependent (Figure 1). Offensive defense reduces the frequency and volume of incoming salvos; active defense intercepts or neutralizes those that are launched; passive defense mitigates harm and preserves societal and governmental continuity. A failure or shortfall in any single dimension imposes a disproportionate burden on the others, creating observable patterns of overstretch (air defense saturation, shelter network discrepancies and insufficiency, exhaustion of offensive resources). By contrast, higher levels of integration and synergy across the three tiers reduce cumulative vulnerability and enhance home-front endurance, as measured by damage levels and functional continuity under fire.

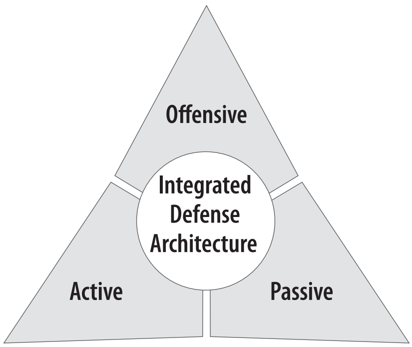

Figure 1: The Three Layers of Integrated Defense Architecture
Source: Elrom Center for Air & Space Studies, 2025.

While acknowledging that additional layers of wartime defense, such as urgent diplomatic mobilization to secure transfers of air-defense assets, play critical roles in shaping outcomes, this article focuses specifically on the capabilities and adaptive behavior of the defender state and society, rather than on arms acquisition or the development of wartime partnerships. Likewise, although network-centric warfare and cognitive warfare, including information operations and psychological warfare, are increasingly intertwined with aerial coercion campaigns (Healey, 2024; Khoroshko et al., 2024), these dimensions fall outside the scope of this study. Future research could reconnect these layers by examining how network-centric warfare alongside cyber and information operations amplifies the coercive effects of missile and drone campaigns.

In addition, our framework also engages with scholarly debates on aerial coercion. Pape's (1996) typology of coercive air strategies and Horowitz and Reiter's (2001) quantitative study both demonstrate that the effectiveness of air campaigns is conditional rather than automatic, depending not only on strike characteristics but also on the vulnerability and resilience of the defender's military capacity.

Recent airpower scholarship further substantiates this dynamic. Saunders and Souva (2020) demonstrate that airpower correlates with strategic and operational success predominantly when the defender lacks the capability to contest the air domain. Their findings indicate that the coercive effect of air strikes is conditional rather than intrinsic, emerging only when defensive counter-air capacity is weak or absent. Similarly, Kreuzer (2024), and Vogt and Haider (2024), argue that contested skies, dense and adaptive air-defense networks, and extensive drone employment increasingly characterize contemporary air warfare. These structural conditions elevate the importance of robust, multi-layered defensive architectures.

Taken together, this body of literature indicates that modern coercive airpower does not succeed by virtue of strike capacity alone. Instead, its effectiveness is mediated by the defender's ability to integrate and synchronize multiple defensive layers in real time, transforming air defense into a core determinant of wartime endurance.

This article contributes to these debates by examining how Ukraine and Israel integrate active, passive, and offensive defense as mutually reinforcing components of national resilience under sustained aerial attacks. By empirically tracing how these layers interact under stress, we demonstrate how home-front endurance emerges not from any single system but from the synergy between interception, protection, and offensive disruption: a triad that reduces cumulative vulnerability and enables states to function under continuous aerial threats.

Shifts In Air Threats and Their Impact on the Home Front

This section examines the nature of contemporary air threats as illustrated by the wars in Ukraine and in Israel and highlights their systemic impact on the defender (state and society). We highlight five main characteristics of contemporary air threats: accessibility/affordability, mass employment-quantity, precision, range, and versatility (Figure 2).

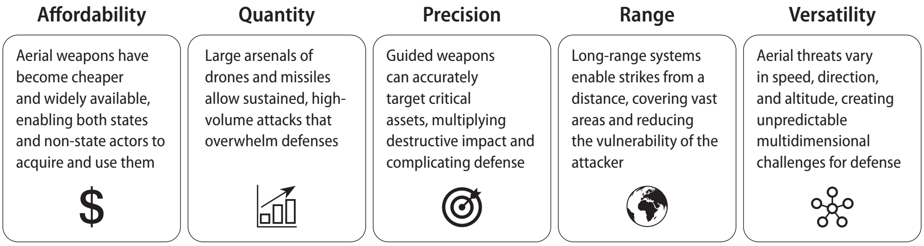

Figure 2: Main Characteristics of Air Threats in the 21st Century
Source: Elrom Center for Air & Space Studies, 2025.

Affordability: What had once been the preserve of advanced militaries is now widely accessible: even poorly resourced actors can acquire drones, loitering munitions, and improvised airborne weapons to sustain disruption and impose psychological pressure on adversaries' home fronts (Hammes, 2016, p. 35; Cronin, 2019, p. 52; Yan, 2025). Miniaturization, commercial components, and dual-use innovation have lowered production thresholds, creating a global market for low-cost and destructive aerial weapons (ADF, 2025). Many of these systems require minimal technological and operational knowledge to use and maintain, leading to their diffusion across actors and war theaters.

Illustrative is the extensive use of relatively inexpensive long-range OWA drones, loitering munitions, and First-Person View (FPV) drones, as well as cheaper short- and medium-range surface-to-surface missiles (SSMs) and cruise missiles (Hammes, 2016; Molloy, 2024; Kunertova, 2025). Russia's One Way Attack (OWA) drone campaign since mid-2022, along with Iran's and its proxies' widespread use of similar systems in the Middle East shows how low-cost standoff drones can overwhelm advanced air defenses and impose strategic costs on defenders (Hollenbeck et al., 2025; Plichta, 2025). Drones are far less expensive than other types of munitions such as surface-to-surface missiles, making them operationally cost-effective, as a single drone can inflict critical damage on an opponent's infrastructure or strategic assets (Hollenbeck et al., 2025). At the time of writing, the Iranian Shahed 136/131, a common type used both by Russia and in the Middle East, is estimated to cost around 25,000-35,000 USD per unit. The cost-effective transformation of rockets into precision-guided missiles, illustrated by Hezbollah's 'Precision Project,' also shows how low-cost innovation can help non-state actors acquire consequential systems.[2]

Quantity: The principle of mass has long been central to warfare; technological change enables greater destructive power to be achieved through fewer resources (Alman & Venable, 2020; Podestà, 2024). At the same time, it reduces production and maintenance costs, enabling state and non-state actors to acquire, sustain, and employ air capabilities on a massive scale.

Iran and its proxies have exploited this “massification” of aerial weapons, while Russia, after early air force failures in Ukraine, turned to mass missile and drone strikes (Shiferman, 2023). Both have built arsenals that can be produced rapidly and launched in sustained waves, whether as concentrated salvos or as cumulative barrages over time (Elran et al., 2024). These arsenals serve not only to overwhelm air defense and inflict destruction but also to prolong wars.

Since October 7, 2023, Iran and its proxies have fired more than 37,000 projectiles towards Israel (Fabian, 2024) with around 10,000 projectiles launched during the first month, one-third of them in the initial hours of the October 7 attack (Zitun, 2023). Hezbollah, for its part, planned to unleash thousands of rockets and drones, supplemented by smaller numbers of SSMs and cruise missiles, in a single salvo (Zitun et al., 2024).[3]

By 2025, Russia’s capacity had expanded to the point where hundreds of projectiles could be launched weekly (Harding, 2025; Jensen & Atalan, 2025; Sabbagh, 2025). Between 2024 and 2025, Russia’s monthly use of kamikaze drones surged from roughly 1,900 to 5,300, driven primarily by expanding domestic production capacity. In the same period, long-range ballistic missile launches increased fourfold, collectively enabling Russia to push closer to saturation of Ukraine’s air-defense system (Atalan et al., 2025; Adams, 2025; Hollenbeck et al., 2025; Jensen et al., 2025; Kullab & Novikov, 2025).

Precision: The precision revolution initiated by the development of precision-guided munitions (PGMs) in the late 1970s and operationalized by the US military during the first Gulf War in 1991 significantly improved weapons’ effectiveness by enabling targeted strikes on command centers, sensors, logistics

2 Throughout the 2010s and 2020s, Hezbollah converted unguided long-range rockets into precision-guided missiles, thereby enhancing its technological capability to hit targets within Israel. According to different estimations, this resulted in a cost a fraction of what an SSM would cost, estimated at $5,000-$10,000 per missile (BICOM, 2019).

3 While failing to do so for different reasons, mostly because of Israeli action, Hezbollah was still able to launch extensive salvos of tens of rockets and other projectiles throughout the entire conflict, in some cases even reaching a few hundred in a single salvo (McKernan, 2024).

hubs, and air defenses (Singer, 2016; Hubbard et al., 2019).[4] New precision strike technologies can be used deliberately for precise and persistent attacks on civilians and civilian infrastructure, a technological development that serves a new "autocratic way of war" used for "civilian victimization" (Bales & Mutschler 2025; Euronews, 2025; Santora, 2025).

The combination of precision and mass, or "precise mass in action" (Plichta, 2025, p. 42), enables states to conduct numerous low-cost, high-precision strikes. Once the exclusive preserve of advanced militaries, these are now accessible to a wide spectrum of actors, from global powers to non-state groups and terrorist organizations. Precision warfare thus magnifies destructive potential: fewer weapons can achieve disproportionate effects while reducing risk to the attacker, whereas mass, low-cost weapons with increased precision broaden the threat landscape (Slusher, 2025).

In Israel's case, militant groups and Iran managed to incorporate precision technologies and weapons (in full capacity since October 7), allowing both massed salvos and highly targeted strikes with growing accuracy (Klein, 2008; Michael, 2022; Antebi & Yanko-Avikasis, 2023; Antebi & Adar, 2024; Zitun, 2024; Jensen et al., 2025). Russia similarly relied heavily on precision weaponry. In the opening phase of its invasion of Ukraine, Moscow sought to establish air superiority and degrade strategic targets through precision strikes, rapidly depleting much of its stock of cruise missiles and precision bombs. It has since ramped up production and procured additional systems from Iran and North Korea, employing them against both military and civilian targets (Hecht & Shabtai, 2023; Hinz, 2025; McCurry, 2025).[5]

Crucially, PGMs are often employed alongside unguided weapons in mixed salvos. Mass barrages of rockets or missiles are launched simultaneously with smaller numbers of guided projectiles, aiming to overwhelm air defense systems, saturate radars and early warning networks, and ensure at least partial penetration of defenses (Goldberg, 2024; Zitun, 2024; Jensen et al., 2025).

Range: Technological advancements have increased the operational range of many air weapons, enabling the attacker to cover vast areas within the defender's territory while maintaining the survivability of air platforms and operators. In Ukraine, Russia launches projectiles of varying ranges, many from within its own territory. For example, long-range cruise missiles like the Kh-101, Kh-47,

4 One often considers navigation and guidance systems such as GPS or other GNSS systems, such as Russia's GLONASS. However, when considering precision weapons, we also refer to optical, infrared, and TV-guided technologies that enable strikes against mobile or concealed targets (Mahnken, 2011; Lifshitz & Meents, 2020; Maurer, 2023; Hoehn & Courtney, 2024).

5 Some examples include the family of Shahed drones used extensively all over Ukraine and short-range missiles such as the Iranian Fatah-360s and North Korean Hwasong-11A/B, which are used for both short-range and front-line attacks.

and Kalibr (1,500–2,500 km) and Shahed 136/131 drones (1,300–1,500 km) can hit targets across Ukraine (Dmytriieva, 2024). Shorter-range systems such as Hwasong-11A/B, Fatah-360, Iskander, and Tochka (120–700 km) strike both frontline and deep-strike targets, including civilian sites (Atalan & Jensen, 2025; Daly, 2025; Hinz, 2025). Israel faces similar threats on a smaller scale, from Yemen, Lebanon, Syria, Iraq, and Iran, with some Iranian and Houthi systems reaching ranges of 1,300–1,750 km that can strike Israel from well beyond its neighborhood.

Versatility: Contemporary aerial threats are increasingly defined by their shifting and at times unpredictable trajectories, velocities, and altitudes (Schütz et al., 2019). Unlike ground operations constrained by borders and terrain, aerial systems exploit the openness of airspace, maneuvering unpredictably and complicating detection, interception, and early warning (Schütz et al., 2019). Drones and missiles are launched from land, sea, and air platforms across multiple regions and countries, arriving at different times and intensities (Kubovich, 2024).

Some threats are extremely fast: Russian weapons such as the Kinzhal air-launched ballistic missile reportedly reach Mach 12, or nearly 14,700 km/h, while the Iskander SSM variant reaches Mach 6.3, about 7,560 km/h. Others are comparatively slow, such as propeller-driven Shahed 136/131 drones, which cruise at around 200 km/h (Epstein, 2025; Kramarenko & Vialko, 2024; Norsk Luftvern, 2025). Altitude adds another layer of complexity. Some drones fly at very low altitudes to evade radar, while others operate at medium altitudes. Ballistic and certain cruise missiles ascend to high altitudes before descending on their targets. This range of flight profiles demands multilayered defenses capable of addressing threats across the spectrum.

A small radar cross-section (RCS) deepens this challenge. Many of these systems exploit gaps in radar coverage and defensive envelopes, reducing warning time and complicating interception even when defenders field a robust air defense architecture (Foreign Policy Council "Ukrainian Prism," 2025; Kalisky, 2025; Kubovich, 2024).

The evolution of airpower described above has redefined both the nature and the perception of threat for both the state and society. Based on comparative insights from Ukraine and Israel supported by expert consultations with Ukrainian and Israeli officials and practitioners (Appendix 1, p. 100), this transformation manifests along several interrelated shifts in threat exposure and perception.

First, the shift from episodic bombardments to constant salvos (enabled by the availability, affordability, and massification of projectiles) has created a perception of permanent danger, transforming the air threat into a continuous condition. This has fostered a "routine emergency" mindset, in which daily civilian life coexists with the pervasive anticipation of attack. Citizens become accustomed to prolonged stays in shelters, maintaining functionality amid recurring alerts and bombardments. The routinization of alerts and sirens has paradoxically both enhanced and weakened resilience: normalization of danger enables continuous functioning under fire, yet it breeds complacency and delayed responses, occasionally resulting in preventable casualties (personal communication, senior-level Israeli official, October 2025).

Similarly, the increased range and versatility of projectiles have erased the notion of "safe zones." Entire national territories, including peripheral or border areas previously considered as exceptional danger zones, now fall within the range of enemy fire. In addition, the precision strikes interwoven with indiscriminate barrages magnify fear and disruption, spreading terror among civilian populations. The precise, mass targeting of critical national infrastructure and urban nodes has heightened the psychological impact of every strike. Public pressure mounts on governments to ensure high interception rates. In response, civilians organize spontaneously to maintain continuous functionality under fire, securing essential supplies during prolonged periods of disruption or blackout, and engaging in grassroots solidarity and reconstruction efforts.

Increased projectile speed shortens early warning and reaction time, compelling defenders to automate key functions of active and passive defense. Digitalized early-warning systems, rapid command decision loops, and the public's ability to discern between different levels of threat (depending on the projectiles used or their origin) can create a sense of "control" and generate a modicum of wartime routine.

At the same time, uneven exposure to threat and differential access to shelters have revealed and reinforced socio-spatial inequalities. Peripheral communities, often with weaker infrastructure, are at times less covered by air defense systems. These disparities, documented by Ukrainian and Israeli civil-defense officials, generate internal population displacement (whether forced or spontaneous), reverberating across entire areas, particularly border regions, which become economically disaffected and impose a burden on the host communities.

Three-Tiered Defense: Comparing Ukraine and Israel

This section analyzes how Ukraine and Israel have adapted to the evolving aerial threats through active, offensive, and passive defense, which, together, illustrate distinct yet comparable models of state and societal adaptation.

Active Defense

Ukraine

At the start of Russia's full-scale invasion in February 2022, Ukraine's aging but layered Soviet-era air defense network proved qualitatively strong yet quantitatively inadequate for the scale of attack. Its mix of short-, medium-, and long-range systems, aided by early-warning radars and U.S. intelligence-guided dispersal, initially denied Russia quick air superiority (Kofman, 2025; Simmill, 2025). However, the system's static design, logistical fragility, and reliance on Soviet interceptors made it unsustainable against a prolonged, multi-domain assault (Bronk et al., 2022).

Ukraine's air defense evolution unfolded through three main phases, each reflecting distinct adaptations to Russia's shifting aerial campaign and Ukraine's technological and organizational learning curve (Appendix 2, pp.101-102). The first phase (Failed Opening Strike, February 2022) saw Russia attempt to replicate a Crimea-style blitz through concentrated strikes on radar sites, command nodes, and airbases, seeking rapid air superiority. Ukraine's Soviet-legacy Ground-Based Air Defense (GBAD) system (built around S-300, Buk-M1, Osa-AKM, and MANPADS) denied that objective, creating a contested airspace that limited Russian fixed-wing and rotary operations (Kofman, 2025; Shiferman, 2023, p. 52). Yet the system's rigidity, radar dependence, and limited interceptor stocks rendered it unfit for sustained, multi-domain warfare. As Russia introduced Iranian Shahed-131/136 drones from mid-2022, targeting Ukraine's energy grid and cities, the defenders decentralized GBAD deployments, enhanced mobility, and relied increasingly on civilian innovation to maintain operational continuity amid attrition.

The second phase (Russia's transition to "bombing to win" logics, summer to fall 2022) marked the progressive integration of Western technologies and the adaptation of Ukraine's air defense to massed drone and missile warfare. The arrival of Patriot, NASAMS, IRIS-T, and mobile systems such as Gepard improved defense of Kyiv and other critical sites but remained insufficient for nationwide coverage. These high-end capabilities were gradually layered with surviving Soviet assets to form a hybrid structure, while Ukraine's defense industry and volunteer foundations began upgrading older systems.

The third phase (Attritional Punishment, 2023 through August 2025) reflects consolidation and learning under sustained pressure: with monthly attacks exceeding 2,000 projectiles since 2025, Ukraine further institutionalized its hybrid model combining Western high-end interceptors, refurbished legacy systems, and localized production. Appendix 2 summarizes these phases in greater technical detail; hereafter, we focus on the mechanisms of adaptation rather than on an exhaustive system description.

As Russian strikes intensified, Western assistance proved insufficient to ensure comprehensive national coverage, underscoring a persistent asymmetry between Ukraine's defensive needs and its partners' industrial and political capacity to sustain replenishment. In response, Ukraine implemented three imperatives: decentralization, low-cost response, and synergetic government-civilian effort.

Consider first decentralization: beginning in late 2022, Ukraine shifted from fixed high-value air defense batteries to mobile formations capable of rapid repositioning. These mobile air defenses were deployed to intercept drones at low cost, conserve high-value interceptors, and ensure air defense sustainability through dispersion. Operating primarily in high-risk northern and northeastern regions, these units relied on continuous mobility to evade Russian targeting.

Second, Ukraine resorted, when possible, to low-cost, quick, available, and rapidly diffusible solutions to be able to scale its defenses and keep up with the tempo of Russian attacks. This necessitated the development of early detection mechanisms differentiating between cruise and ballistic missiles and UAVs (Simmill, 2025). This reliance on low-cost solutions was enabled by the development of grassroots innovation and production. Ukraine's defense and security innovation ecosystem has become a cornerstone of its adaptive air-defense strategy, fusing government, industry, academic, and civilian innovation to compensate for Ukraine's limited traditional air-defense capacity. Beginning in 2023, this ecosystem accelerated the development of drones as air defense instruments, notably interceptor drones designed to neutralize enemy ISR UAVs and rocket-drones such as Palianytsia and Peklo, which combine missile-like range and speed with drone agility (Miroshnichenko, 2025). Civilian innovation, supported by crowdfunding and open-source collaboration, played an essential role in bridging capability gaps and fostering continuous adaptation (Matlack, et al.,2025).

Beyond drone platforms, Ukrainian engineers have advanced electronic warfare (EW) and counter-EW technologies, including FPV drones capable of changing frequencies mid-flight and employing machine vision for autonomous target acquisition (Miroshnichenko, 2025). Parallel efforts in swarm automation sought to create coordinated defensive formations capable of intercepting enemy drones or missiles. Institutional initiatives such as the Unmanned Systems Force within the Armed Forces and the Brave1 platform formalized this synergy, providing grants and testing infrastructure as well as doctrinal integration for unmanned systems (Matlack et al., 2025). Academic actors, notably the Institute of Artificial Intelligence Problems (IAIP), have contributed algorithms for predicting missile trajectories and optimizing radar and sensor fusion (Miroshnichenko, 2025). Collectively, this state-civilian synergetic transformation has embedded innovation into Ukraine's air defense fabric, positioning Ukraine as a global testbed for distributed air-defense architectures (Matlack et al., 2025; Miroshnichenko, 2025).

Israel

In contrast to Ukraine's adaptive wartime evolution, Israel's experience reflects a long-standing, institutionalized model of prewar preparedness. Rooted in its early statehood, Israel's air defense doctrine aimed to offset limited strategic depth through deterrence and early warning, protecting population centers and infrastructure from regional air threats (Brun, 2022). Over time, the threat of ballistic missiles, long-range rockets, and UAVs reshaped this threat environment. Operationally, as a response to the rise of different aerial threats from the 1980s, Israel developed a multilayered air defense architecture capable of engaging diverse aerial threats at different altitudes and ranges.

Despite decades of development, Israel's air defense faced unprecedented challenges after October 7, 2023, requiring full mobilization of national and international resources. For the first time, its entire multilayered system was tested simultaneously against diverse, overlapping threats.

First, Israel implemented its policy of selective interception to reconcile the dilemma between the high cost of interceptors and the potentially catastrophic consequences of a successful strike (Chang & Granados, 2025). This approach helped preserve interceptor stocks and optimized resource allocation, which proved critical during protracted conflict, such as the 2023-2025 war.

Israel also leveraged the operational complementarity of its multilayered system. The Iron Dome, initially conceived for short-range rockets and UAVs launched from Gaza, Lebanon, and Syria, demonstrated flexibility by intercepting residual fragments of longer-range ballistic missiles fired from Iran and Yemen. When advanced enemy missiles fragmented into submunitions mid-flight, thereby challenging the Arrow system's design parameters, Iron Dome compensated by neutralizing residual threats (Gilead, 2025).

Third, Israel bolstered its active defense through external assistance. Despite its strong indigenous innovation ecosystem, Israel's air defense remains structurally dependent on U.S. financial and technological support.[6] During the 2023-2025 war, this strategic dependence deepened. U.S. deployments of THAAD

---

6 Since 2009, Washington has allocated approximately $3.4 billion to Israel's missile defense programs (Bureau of Political-Military Affairs, 2025), with roughly one-third dedicated to Iron Dome. Israel's multilayered system, comprising Iron Dome, David's Sling, and Arrow 2/3, was co-developed through U.S.-Israeli partnerships: Rafael and Raytheon for David's

interceptors and coordination with allied forces provided critical reinforcement to Israel's defensive posture. The major Iranian missile and UAV assault of April 14, 2024, further underscored the regional dimension of Israel's defense network, with varying degrees of operational assistance from the US, UK, France, Jordan, Saudi Arabia, and the United Arab Emirates (UK Parliament, House of Commons Library, 2024).

Last, the IAF adapted to the evolving challenge of drone warfare defined by low-altitude, small radar signatures, and variable speeds (Fisher, 2024). It employed a spectrum of interception methods: air-to-air missiles launched from fighter aircraft and the use of guided anti-tank missiles and firing cannon rounds from helicopters, naval interceptors, and Iron Dome batteries (The Jerusalem Post, 2025). The prohibitive cost of repeated kinetic interceptions prompted an increasing reliance on EW systems. These proved particularly effective during the Twelve-Day War of 2025, when Iranian long-range UAVs presented extended flight durations that enabled detection and neutralization at distance. Beyond their economic advantage, EW measures provided a psychological benefit: by neutralizing threats before they entered Israeli airspace, they prevented the recurrence of nationwide sirens. Continuous tactical adaptation throughout the conflict improved interception rates and expanded the operational repertoire of Israel's defensive network.

Offensive Defense

Both Ukraine and Israel have resorted to offensive capabilities in wartime as a form of tactical prevention, seeking to degrade the adversary's strike potential and/or to impose logistical, economic, or reputational costs that would postpone or disrupt its ability to conduct sustained and effective attacks.

Ukraine

In Ukraine's case, this evolution marked a deliberate shift from reactive air defense to a proactive, offensive defense posture, designed to reduce Russia's capacity and willingness to wage aerial aggression by striking at the sources of its military and economic power (personal communication, senior Ukrainian military official, August 2023; Simmill, 2025). Ukraine's transition to offensive defense was made possible by two developments: the US (provisionally) authorizing Kyiv in November 2024 to strike with the Army Tactical Missile System (ATACMS) deep inside Russian territory, and the capacity to conduct

Sling, and Israel Aerospace Industries with American funding and technology for the Arrow series (IAI, n.d.).

massive FPV and OWA drone strikes due to the rapid expansion of its military-civilian defense production base.

By mid-2023, Kyiv had launched a sustained long-range drone campaign against enemy oil refineries, fuel depots, and energy infrastructure, expanding both the scale and geographical depth of its operations. A culminating moment in this campaign was Operation Spider Web, launched in June 2025 with over 100 FPV drones reportedly smuggled into Russia and launched in a coordinated strike on multiple strategic airbases. Ukrainian sources claimed that tens of strategic bombers were hit, with many destroyed. These bombers were imperative in Russia's plans of war against NATO, but for Ukraine, more important was the fact that these bombers were used to launch long-range cruise missiles against Ukraine. By attacking them, Ukraine was able, for the first time, to bring about a specific direct attack that would reduce Russian strike capability against it (Collett-White et al., 2025; Reuters, 2025).

The campaign has had some success in protecting the home front, and it successfully exposed Russia's vulnerability to "precise mass in action": the cumulative impact of numerous low-cost, high-precision strikes (Plichta, 2025, p. 42). Long-range drone strikes have constrained Russia's ability to launch and sustain air and missile operations (Reuters, 2025). The Spider Web operation destroyed key bombers (Tu-95, Tu-22, Tu-160, and Su-57), reducing the Russian air threat and forcing Moscow to divert air-defense assets to domestic protection, limiting its offensive flexibility (Collett-White et al., 2025). These strikes also had a psychological impact, bringing the war to Russian territory and demonstrating Ukraine's capacity to impose costs within Russia's home front (Plichta, 2025). However, Ukraine's offensive capabilities remain limited, relying mainly on drones with modest operational effect (landmark operations like Spider Web remain exceptions), with their ultimate effects primarily economic rather than military. [7]

Israel

The proximity of hostile neighboring countries and the lack of strategic depth in Israel shaped its defense doctrine. A central pillar in Israel's defense is its offensive capabilities, encapsulated in the national security concept of offensive defense. The core principle also entails striking threats at their source through preemptive and preventive attacks, both before and during conflict, to diminish enemy launch capacity, reduce projectile volumes, and minimize damage to military and civilian targets. For instance, over several days in August and

7 Ukrainian deep strikes disrupted an estimated 17 percent of Russia's refining capacity, equivalent to 1.1 million barrels per day (Sauer, 2025).

September 2024, the IAF preemptively destroyed thousands of rockets, UAVs, and launchers, effectively dismantling Hezbollah's planned missile offensive (FDD, 2024). In June 2025, Israel's preventive opening strikes on Iranian air defense assets, leadership nodes, weapons depots, and mobile launchers provided a decisive early advantage: the Iranian plan to fire 1,000 ballistic missiles on the first day was reduced to roughly 100 missiles, launched nearly twenty-four hours later, a delay that provided the Israeli home front with critical preparation time and substantially weakened Iran's initial offensive momentum.

Another aspect is direct strikes and fly-by operations that exploit aerial superiority to loiter over hostile territory, detect and neutralize launch sites before they fire, and deny the enemy's launch capability. Though geographically constrained in Gaza, Lebanon, and Iran, these missions relied on real-time intelligence fusion and not only eliminated imminent threats but also generated new targeting data that enhanced situational awareness and the overall targeting architecture (Zitun, 2025).

Passive Defense

Ukraine and Israel have developed parallel yet distinct passive defense models, each reflecting their institutional capacities, technological ecosystems, and levels of synergy among governmental, military, and civilian efforts.

Ukraine

In late February 2022, Ukraine relied on a Soviet-era early-warning network issuing undifferentiated alerts. In response, the newly established and technologically savvy Ministry of Digital Transformation took a leadership role, launching in partnership with private firms an Air Alarm application to deliver geolocated, device-based alerts. By 2023–2025, with satellite communications sustaining essential services during power cuts, the early warning network evolved into a layered, AI-assisted system capable of maintaining functionality during cyberattacks or blackouts (Arkin, 2025). The introduction of district-level alerts in Kyiv in 2025, provided by Israel, further improved functional continuity under fire.

This rapid government-initiated digitalization was accompanied by a broader grassroots mobilization for passive defense: volunteer-run Telegram channels and community-based observers extended coverage to remote regions, forming a hybrid civilian-state warning ecosystem (personal communication, O. Rubina, August 2025). At the local level, civilian authorities and volunteers repaired shelters, restored utilities, and coordinated relief for internally displaced persons (Simmill, 2025). Among the most emblematic initiatives is Dobrobat, a nationwide volunteer network that rebuilds damaged civilian infrastructure in heavily bombarded regions, enabling the rapid restoration of functional continuity (personal communication, D. Ivanov & M. Brizhko, August 2023).

Sheltering policy also improved *in bello*. Initially dependent on Cold War-era bunkers and Soviet underground metro networks, Ukraine's protection capacity was uneven (ABC News, 2022). From mid-2022 onward, the government elevated shelter construction to a national priority, with President Zelensky repeatedly pressing regional officials on shelter readiness (personal communication, senior Ukrainian official, July 2025). The Iron Shelter Project, launched in 2023 by the Ministry of Strategic Industries, institutionalized this effort through public-private partnerships, prioritizing schools and kindergartens, and mapping real-time shelter availability (Rubryka, 2023).

Israel

By contrast, Israel's approach to passive defense is built on systematic, institutionalized foresight rather than on ad hoc improvisation during wartime. As early as the 1948 War of Independence, Israel had to endure repeated airstrikes by the Egyptian Air Force on Tel Aviv (Nicolle & Gabr, 2024). This experience accelerated the institutionalization of civilian protection, culminating in the 1951 Civil Defense Law, which mandated the construction of shelters. The long-range missile threat demonstrated during the First Gulf War, when 39 ballistic missiles were launched from Iraq, created new challenges for Israel's home front. In response, Israel established the Home Front Command[8] and introduced new regulations requiring that every new apartment include a safe room (Brun, 2022; Israeli Ministry of Defense, 1951). Throughout the 1990s, passive defense was further shaped by intensifying short-range rocket fire from southern Lebanon, followed by similar threats from Gaza. These developments, combined with Israel's lack of strategic depth, reinforced the need for codified civilian protection measures. Given the lack of strategic depth, the use of advanced technologies appeared to be the best way to respond to increasing threats.

Beyond shelters, Israel strengthened its early warning mechanisms. Its digital infrastructure was developed to integrate real-time radar data with public alert mechanisms, transmitting geo-targeted warnings through smartphone applications, SMS, and radio broadcasts. The national *Tzeva Adom* system translates radar detections into locality-specific countdowns calibrated to missile flight times (Ringel, 2024). This precision proved lifesaving in a geographically small country where projectile flight durations can be measured in seconds for border

8 The Home Front Command's mission is to safeguard civilian lives by preparing the civilian environment ahead of conflicts and supporting it during emergencies.

communities. During the 2025 war with Iran, longer ranges initially provided up to thirty-minute warning windows; as hostilities intensified, these narrowed to approximately ten minutes, still sufficient for most civilians to reach safety.

Throughout the war, the Home Front Command sought to maintain societal functionality through graded situational guidelines disseminated via the National Emergency Portal (National Emergency Portal, n.d.). Despite its technological sophistication, Israel's passive defense remains marked by structural disparities and institutional fragmentation. A report by the State Comptroller (2021) indicates that approximately 2.6 million citizens, primarily residents of older housing and peripheral regions, still lack access to adequate shelters. Furthermore, persistent shortages of trained personnel, delays in providing assistance to displaced populations, and fragmented psychological support undermined comprehensive resilience. The Socio-Economic Cabinet, formally responsible for civilian continuity, frequently failed to convene or issue binding directives. As a 2024 audit concluded, "passive defense remains Israel's weakest layer," emphasizing that effective resilience depends as much on institutional communication and coordination as on technological sophistication and sufficient shelter coverage (Ran & Yagana, 2025).

Discussion and Conclusion

Causally, the argument advanced here is that integration across the three tiers functions as a coercion-dampening mechanism. Offensive defense reduces the attacker's capacity to generate and sustain intensive and high-tempo campaigns by degrading launch platforms, command-and-control centers, and production chains. Active defense further reduces the volume of incoming air threats by intercepting a share of projectiles and distributing damage spatially (if any). Passive defense determines how much of the residual harm translates into systemic disruption, displacement, and loss of functionality. Where these tiers are weakly connected, because offensive defense capabilities are limited, interception capability is insufficient, and passive protection is uneven, the same level of aerial attack produces higher levels of cumulative stress on the defender's system. Where integration is tighter, coercive pressure is partly or largely absorbed, preserving the defender system's functionality.

The comparative analysis of Ukraine and Israel under sustained and multidirectional aerial campaigns shows that both states rely on the three-tier defense architecture composed of active, passive, and offensive defense. Their shared reliance on this structure reflects the common character of the threat: high-tempo missile and UAV campaigns combining mass, precision, affordability, and extended range, many of which have been enabled by the deepening Russia-Iran strategic partnership (Fainberg & Matania, 2025). Yet their respective trajectories reveal two distinct models of adaptation to protracted air warfare: a predominantly *in bello* learning model in Ukraine and a primarily *ante bellum* preparedness model in Israel. Both cases reaffirm the relevance of total defense to contemporary high-intensity war, demonstrating that defense of the home front requires the integration of state and societal resources across these three layers.

Ukraine: Vibrant yet Insufficient in Bello Adaptation

Ukraine's experience demonstrates the challenges and possibilities of constructing a national defense architecture in wartime without preexisting doctrinal or infrastructural foundations. When Russia launched its full-scale invasion in February 2022, Ukraine lacked a conceptual framework for home-front defense, adequate defensive infrastructure, and mechanisms to coordinate military and civilian layers of protection. This absence of prewar preparation at the conceptual, operational, and integrative levels initially limited Ukraine's capacity to protect civilian populations, critical infrastructure, and military installations (Rakov & Fainberg, 2023).

Over the course of the war, however, Ukraine embarked on a continuous process of learning and tit-for-tat adaptation. With limited external assistance and under sustained pressure, it developed new active defense platforms, improvised mobile interception units, and expanded its early-warning systems through rapid digitalization. Simultaneously, it expanded and mapped shelters, especially in major urban centers. These transformations were made possible by a whole-of-society mobilization that fused governmental coordination, civilian innovation, and grassroots entrepreneurship. The emergence of a wartime defense innovation ecosystem, spanning state agencies, start-ups, academic institutions, and grassroots organizations, allowed Ukraine to field cost-effective, decentralized, and scalable defenses.

Technologically, Ukraine's defense has become increasingly adaptive and economically efficient: high-value interceptors were reserved for complex missile salvos, while low-cost drones, mobile machine-gun units, and EW backpacks absorbed the majority of daily UAV attacks. Politically and socially, this distributed model of defense was enabled by Ukraine's highly developed technological culture and has strengthened national resilience and reduced dependence on external supplies. Yet, despite these remarkable wartime innovations, Ukraine's offensive-defense capabilities have remained limited. Deep-strike operations, such as the June 2025 Spider Web campaign, inflicted meaningful but temporary disruptions on Russian logistics and strike platforms. Ukraine has thus achieved a significant increase in defensive effectiveness but, at the time of writing, continues to operate below the tempo and scale of Russia's escalating airstrikes, constrained by the asymmetry in industrial capacity, range, and stockpiles.

Israel: Ante Bellum Conceptual and Operational Preparedness

Israel represents the inverse case: a state that entered conflict with an institutionalized, technologically sophisticated, and operationally tested defense architecture. Decades of doctrinal development, combined with sustained investment in layered interception systems, provided Israel with a strong capacity to protect its home front, military assets, and critical infrastructure. Conceptually, Israeli defense has long rested on mutually reinforcing pillars in which offensive defense aims to disrupt adversarial fire capabilities before launch, both *ante bellum* and *in bello*, thereby reducing pressure on active and passive defense layers.

Operationally, Israel possesses an advanced and institutionalized infrastructure of active defense assets (sensors, radars, command-and-control, and real-time prioritization mechanisms that integrate ground- and air-based interception systems), as well as a well-developed passive defense system (geo-targeted early warning, a nationwide shelter regime, and codified civilian wartime discipline).

This offensive tier is inseparable from Israel's defense architecture. Systematic efforts to degrade adversary strike capacity through early, preventive, and real-time detection-and-targeting operations are intended to reduce both the scale and simultaneity of incoming salvos. During the 2023-2025 war, preemptive Israeli strikes in Lebanon and preventive and real-time targeting campaigns in Lebanon and Iran against missile stockpiles, launch platforms, and command nodes delayed and diminished subsequent waves of attack. These operations illustrate the decisive value of offensive-defense integration for home-front protection. Active defense then intercepted what remained, while passive defense (anchored in shelters, early-warning systems, and the Home Front Command) absorbed residual impacts.

However, Israel's experience also revealed the limits of this doctrine, particularly the impossibility of preventing all attacks given the scale and technological evolution of missile and UAV threats. Despite high preparedness, the 2023-2025 war exposed persistent inequalities in shelter distribution, coordination gaps among civil-defense agencies, and the practical impossibility of achieving fully hermetic protection under conditions of saturation and multi-domain strike. Nonetheless, Israel's ability to enter the conflict with a high level of conceptual and operational readiness proved decisive in mitigating systemic disruption and enabling rapid adaptation under fire.

Beyond Differences, Converging Trajectories

The juxtaposition of the Ukrainian and Israeli cases underscores the centrality of integration and timing in determining defensive effectiveness. It also shows that integration operates within clear scope conditions: in extended theaters with limited assistance guarantees and industrial constraints, such as Ukraine, reactive wartime innovation can partially compensate for prewar under-preparation but cannot fully offset an adversary's strike capacity. In small, densely populated states with a robust technological base and strong military-defense industry, such as Israel, prewar integration of offensive, active, and passive tiers yields significant advantages but still cannot deliver hermetic protection. In both contexts, the three-tier framework helps explain why comparable patterns of aerial coercion can produce different patterns of damage and population displacement and functional continuity under fire.

Ukraine's *in bello* adaptation shows that a state can learn and innovate under extreme conditions, but at the cost of sustained civilian exposure and infrastructural attrition. Israel's *ante bellum* model demonstrates that prewar integration of offensive, active, and passive tiers yields a structural advantage, allowing the defender to begin from the highest defense level possible. Both cases reveal that a deficit in one tier imposes disproportionate strain on the others: limited offensive-defense capacity, as in Ukraine, increases pressure on interception and civil resilience, while shortcomings in passive defense, as in Israel, erode the benefits of advanced interception and preventive strikes.

The findings of this comparative study therefore indicate that adequate defense against sustained aerial coercion is best achieved through an integrative approach that combines offensive, active, and passive measures within a coherent and mutually reinforcing system. The three tiers function as interdependent layers of a unified defensive architecture: offensive defense seeks to suppress the adversary's strike capacity; active defense filters and neutralizes the projectiles that evade suppression; and passive defense mitigates harm, sustains continuity, and underpins societal endurance. Integration across these tiers reduces cumulative risk, enhances protection, and strengthens functional continuity and endurance on the home front.

Adjusting Total Defense to Shifts in Airpower

Ångström and Ljungkvist (2024) argue that total defense is not a fixed model but is shaped by how states interpret the character of the threats they face. The findings of the present study suggest that the prevailing scholarly emphasis on hybrid warfare, societal resilience to disinformation, territorial defense structures, and reserve mobilization reflects a specific strategic context, namely the Baltic and Nordic experience before 2022 with sub-threshold coercion and information warfare. While foundational to the development of the contemporary total defense paradigm, these emphases no longer sufficiently capture the primary pressures exerted in high-intensity interstate conflict.

The wars in Ukraine and Israel indicate that sustained aerial coercion has emerged as a central mechanism through which national endurance is contested. Drone and missile campaigns do not merely supplement hybrid or cyber operations; they impose continuous, cumulative strain on state institutions, civil protection systems, and socio-political cohesion. In both cases, the home front became the principal battlespace, and the capacity of the state to maintain functional continuity under persistent aerial attack proved decisive for wartime resilience. Hybrid, cyber, and cognitive operations, therefore, operate as force multipliers to aerial strike pressure rather than as independent domains of coercion.

This may suggest the need to revisit the concept of total defense in a way that places the air domain at its conceptual core. Total defense can no longer be defined primarily as the mobilization of population and armed forces in anticipation of territorial invasion or informational subversion. It must also be understood as an integrated, multi-layered defensive architecture designed to absorb and withstand persistent, high-volume, and geographically distributed aerial attacks. The ongoing expansion of active air and missile defense networks, shelter and early-warning modernization, and continuity-of-government planning in Sweden, Finland, the Baltic states, and Germany reflects the initial institutionalization of this shift, even if the doctrinal implications remain only partially articulated.

However, this argument requires further comparative validation. The centrality of the air domain may represent either a general structural feature of contemporary conflict, driven by the diffusion of precision-strike complexes and inexpensive autonomous aerial systems, or a contingent effect specific to states facing adversaries with substantial strike production capacity. Extending the analysis to strategic contexts such as Taiwan, South Korea, Finland, and Estonia would enable systematic evaluation of whether the reconfiguration of total defense around the air domain constitutes an emergent global paradigm or a regional adaptation to specific threat environments.

Acknowledgments

We would like to thank Dr. and Col. (res.). Assaf Heller, Director of Research at the Elrom Center for Air & Space Studies, for his invaluable guidance and feedback. We also extend our appreciation to our interviewees in Ukraine and Israel, most of whom remain anonymous, for generously sharing their time and insights on wartime defense dynamics. We are grateful to peers and colleagues for their comments and suggestions, particularly to Mr. Daniel Rakov. Finally, we wish to express our sincere thanks to Or Amini, Research Assistant at Elrom, for his outstanding research support and assistance throughout the preparation and publication of this article, and to Carmel Zisman Peleg for her assistance with design and preparation of the figures.

References

Adams, P. (2025, July 10). Russia's intensifying drone war is spreading fear and eroding Ukrainian morale. *BBC*. https://www.bbc.com/news/articles/c0m8gn7grn2o

Alman, D., & Venable, H. (2020, September 15). Bending the principle of mass: Why that approach no longer works for airpower. *War on the Rocks*. https://warontherocks.com/2020/09/bending-the-principle-of-mass-why-that-approach-no-longer-works-for-airpower/

Ångström, J., & Ljungkvist, K. (2023). Unpacking the varying strategic logics of total defence. *Journal of Strategic Studies, 47*(4), 498–522. https://doi.org/10.1080/01402390.2023.2260958

Antebi, L., & Adar, O. (2024). *FPV drones: From the Ukrainian battlefield to the Middle East* (INSS Insight No. 1825). INSS. https://www.inss.org.il/wp-content/uploads/2024/02/No.-1825-1.pdf

Antebi, L. & Yanko-Avikasis, M. (2023). *Life and Death in the Hands of the Drone: The Small, Cheap Devices Early in the Swords of Iron War* (INSS Insight No. 1772). INSS. https://www.inss.org.il/wp-content/uploads/2023/10/No.-1772.pdf

As drone warfare expands in Africa, Turkey increases share of the market. (2025, February 11). *ADF*. https://adf-magazine.com/2025/02/as-drone-warfare-expands-in-africa-turkey-increases-share-of-the-market/

Arkin, D. (2025, February 24). *Ukraine develops civilian alert system for missiles and drones*. Israel Defense. https://www.israeldefense.co.il/en/node/64454

Atalan, Y., Tiersten-Nyman, E., & Jensen, B. (2025, November 14). *Russia's intense air campaign in October*. Center for Strategic and International Studies. https://www.csis.org/analysis/russias-intense-air-campaign-october

Atalan, Y., & Jensen, B. (2025). *Breaking down Russian missile salvos: What drives neutralization?* CSIS. https://www.csis.org/analysis/breaking-down-russian-missile-salvos-what-drives-neutralization

Bales, M., & Mutschler, M. (2025). A new autocratic way of war? Autocracy, precision strike warfare and civilian victimization. *Defence Studies*, 1–24. https://doi.org/10.1080/14702436.2025.2522052

BICOM. (2019, October). *Hezbollah's precision missile project* [Briefing]. https://www.bicom.org.uk/wp-content/uploads/2024/12/Precision-Project-Paper-Oct-2019-1.pdf

Bērziņa, I. (2020). From 'total' to 'comprehensive' national defence: The development of the concept in Europe. *Journal on Baltic Security, 6*(2), 1-9, https://journalonbalticsecurity.com/journal/JOBS/article/2/text

Bērziņš, J. (2023). Latvia: From total defence to comprehensive defence. *PRISM, 10*(2), 38–53, https://ndupress.ndu.edu/Portals/68/Documents/prism/prism_10-2/prism_10-2.pdf

Bronk, J., Reynolds, N., & Watling, J. (2022). The Russian Air War and Ukrainian Requirements for Air Defence. *Royal United Services Institute*. https://doi.org/10.1515/sirius-2023-1013

Brun, I. (2022). *From aerial superiority to a multi-dimensional blow: The utility of aerial force and its place in Israel's total war* [Hebrew] (INSS Publication No. 219). INSS. https://www.inss.org.il/he/wp-content/uploads/sites/2/2022/01/Memo219_AerialPower_e.pdf

Bureau of Political-Military Affairs. (2025, April 25). *U.S. security cooperation with Israel* [Fact sheet]. U.S. Department of State. https://www.state.gov/u-s-security-cooperation-with-israel

Chang, A., & Granados, S. (2025, June 16). How missile defense works (and why it fails). *The New York Times*. https://www.nytimes.com/interactive/2024/11/02/world/middleeast/missile-defense-israel-iran.html

Collett-White, M., Dutta, P. K., & Zafra, M. (2025, June 4). How Ukraine pulled off an audacious attack deep inside Russia. *Reuters*. https://www.reuters.com/graphics/UKRAINE-CRISIS/DRONES-RUSSIA/mypmjzayyvr/

Cronin, A. K. (2019). *Power to the people: How open technological innovation is arming tomorrow's terrorists*. Oxford University Press.

Daly, J. (2025, April 24). The most lethal missiles Russia uses against Ukraine's civilians. *United24 Media*. https://united24media.com/war-in-ukraine/the-most-lethal-missiles-russia-uses-against-ukraines-civilians-7794

David's Sling vs. SAMP/T air and missile defense systems comparison. (2025, March 18). *Norsk Luftvern*. https://norskluftvern.com/2025/03/18/davids-sling-vs-samp-t-air-and-missile-defense-systems-comparison/

Dmytriieva, D. (2024, November 21). Russia launches intercontinental ballistic missile, Kinzhal and Kh-101 at Ukraine in the morning. *RBC-Ukraine*. https://newsukraine.rbc.ua/news/russia-launches-kinzhal-and-kh-101s-at-ukraine-1732177685.html

Elran, M., Mizrahi, O., Heimann, A., & Shapira, A. (2024, July 7). *How would a full-scale war with Hezbollah affect the resilience of Israel's civilian front?* (INSS Insight No. 1872). INSS. https://www.inss.org.il/wp-content/uploads/2024/07/No.-1872.pdf

Epstein, J. (2025, May 25). Russia's attack drones are flying higher and faster. *Business Insider*. https://www.businessinsider.com/ukrainian-air-defender-guns-arent-enough-kill-russian-drones-anymore-2025-5

Fabian, E. (2024, June 10). Over 19,000 rockets fired into Israel since start of war, IDF says. *The Times of Israel*. https://www.timesofisrael.com/liveblog_entry/over-19000-rockets-fired-into-israel-since-start-of-war-idf-says/

Fainberg, S., & Matania, E. (2025). Ad Hoc or Enduring? A Dynamic Taxonomy of Strategic Partnerships in the Middle East and North Africa. *Aerospace & Defense*, 2(1), 65-94. https://www.researchgate.net/publication/397653129

Fisher, J. (2024, October 14). Drone attack on Israel puts spotlight on Iron Dome's limitations. *BBC*. https://www.bbc.com/news/articles/c4g9wx2q09ko

Foreign Policy Council "Ukrainian Prism." (2025). *Blue and Yellow Annex: To the White Paper on the future of European defence*. https://prismua.org/wp-content/uploads/2025/04/Blue_and_yellow_annex_on_defense.pdf

Foundation for Defense of Democracies (FDD). (2024, August 25). *Israel hits strategic Hezbollah launchers preemptively* [Flash brief]. https://www.fdd.org/analysis/2024/08/25/israel-hits-strategic-hezbollah-launchers-preemptively/

Gilead, A. (2025, June 19). Can Israel handle all of Iran's ballistic missiles? *Globes*. https://en.globes.co.il/en/article-can-israel-handle-all-of-irans-ballistic-missiles-1001513313

Goldberg, D. (2024, October 14). Hezbollah's trick, the contact that worked and the interception that failed | Investigation on the drone disaster. [Hebrew]. *JDN*. https://www.jdn.co.il/news/2284447/

Government Offices of Sweden. (2024, July). *National security strategy*. https://www.government.se/contentassets/dee95d002683482eba019df49db2801f/national-security-strategy_.pdf

Government of the Republic of Estonia. (2023, February 22). *National security concept of Estonia* [Framework document]. https://www.kaitseministeerium.ee/sites/default/files/eesti_julgeolekupoliitika_alused_eng_22.02.2023.pdf

Hammes, T. X. (2016, October 18). The democratization of airpower: The insurgent and the drone. *War on the Rocks*. https://warontherocks.com/2016/10/the-democratization-of-airpower-the-insurgent-and-the-drone/

Harding, L. (2025, August 13). 'It's a robot war': Eastern Ukraine faces onslaught of Russian glide bombs, rockets and kamikaze drones. *The Guardian*. https://www.theguardian.com/world/2025/aug/13/eastern-ukraine-russian-glide-bombs-rockets-kamikaze-drones

Healey, J. (2024). *Cyber effects in warfare: Categorizing the where, what, and why. Texas National Security Review, 7*(4), 37–50. https://doi.org/10.26153/tsw/56029.

Hecht, E., & Shabtai, S. (Eds.). (2023). *The war in Ukraine: 16 perspectives, 9 key insights.* BESA Center. https://besacenter.org/wp-content/uploads/2023/08/201-4.pdf

Hinz, F. (2025). Israel's attack and the limits of Iran's missile strategy. *IISS*. https://www.iiss.org/online-analysis/online-analysis/2025/06/israels-attack-and-the-limits-of-irans-missile-strategy/

Hoehn, J. & Courtney, W. (2024). *How Ukraine Can Defeat Russian Glide Bombs*. RAND Corporation. https://www.rand.org/pubs/commentary/2024/06/how-ukraine-can-defeat-russian-glide-bombs.html

Hollenbeck, N., Altaf, M. H., Avila, F., Ramirez, J., Sharma, A., & Jensen, B. (2025). *Calculating the cost-effectiveness of Russia's drone strikes*. CSIS. https://www.csis.org/analysis/calculating-cost-effectiveness-russias-drone-strikes

Horowitz, M. C., & Reiter, D. (2001). When does aerial bombing work? Quantitative empirical tests, 1917–1999. *Journal of Conflict Resolution, 45*(2), 147–173. https://doi.org/10.1177/0022002701045002001

Hubbard, B., Karasz, P., & Reed, S. (2019, September 14). Two major Saudi oil installations hit by drone strike, and U.S. blames Iran. *The New York Times*. https://www.nytimes.com/2019/09/14/world/middleeast/saudi-arabia-refineries-drone-attack.html

Hundreds of Iranian drones intercepted 'around the clock' by IAF during Op. Rising Lion. (2025, June 25). *The Jerusalem Post*. https://www.jpost.com/israel-news/defense-news/article-859015

IAI. (n.d.). *From ambitious concepts to groundbreaking air and missile defense systems*. Israel Aerospace Industries. https://www.iai.co.il/news-media/iai-action/ambitious-concepts-groundbreaking-air-and-missile-defense-systems

Israeli Ministry of Defense. (1951). Civil Defense Law [Hebrew]. *Nevo*. https://www.oref.org.il/media/3x2huqvl/%D7%97%D7%95%D7%A7-%D7%94%D7%92%D7%90.pdf

Jensen, B., & Atalan, Y. (2025). *Drone saturation: Russia's Shahed campaign*. CSIS. https://www.csis.org/analysis/drone-saturation-russias-shahed-campaign

Jensen, B., Atalan, Y., & Tiersten-Nyman, E. (2025). *The new salvo war: Russia's evolving punishment campaign*. CSIS. https://www.csis.org/analysis/new-salvo-war

Jordan, J. W. (2024). Evolution of the concept of total defence in the Baltic States. Rozprawy Społeczne/Social Dissertations, 18(1), 315–344. https://doi.org/10.29316/rs/188761

Kalisky, Y. (2025). *The Israel–Iran war: Air defense performance*. INSS. https://www.inss.org.il/social_media/the-israel-iran-war-air-defense-performance/

Karlin, M. (2024, October 22). *The return of total war.* Foreign Affairs. https://www.foreignaffairs.com/ukraine/return-total-war-karlin

Khoroshko, V., Artemov, V., Brailovskyi, M., & Kozura, V. (2024). Modern Network Wars. *Scientific and Practical Cyber Security Journal (SPCSJ), 8*(3), 53-64. https://journal.scsa.ge/wp-content/uploads/2024/11/0034_modern-network-wars.pdf

Klein, D. (2008). Defense of the home front in the Gaza periphery: Examining the national investment. *Strategic Assessment, 10*(4), 6–11. https://www.inss.org.il/wp-content/uploads/2022/12/fe-1451416010.pdf

Kofman, M. (2025). Russian airpower in context: The first year of the war. In D. Henriksen & J. Bronk (Eds). *The Air War in Ukraine. First Year of Conflict* (pp. 12-30). Routledge.

Kramarenko, D., & Vialko, D. (2024, December 20). Ballistic and cruise missiles, drones, and other weaponry: What Russia uses to attack Ukraine. *RBC-Ukraine*. https://newsukraine.rbc.ua/analytics/ballistic-missiles-drones-and-cruise-missiles-1734721150.html

Kreuzer, P. (2024). *Beyond air superiority: The Growing Air Littoral and Twenty-First Century Airpower. Æther: A Journal of Strategic Airpower & Spacepower, 3*(3). https://www.airuniversity.af.edu/Portals/10/AEtherJournal/Journals/Volume-3_Number-3/Kreuzer.pdf

Kubovich, Y. (2024, June 20). Hezbollah’s drone threat is growing, and the IDF are looking for an effective solution [Hebrew]. *Ha’aretz*. https://www.haaretz.co.il/news/politics/2024-06-20/ty-article/.premium/00000190-369e-d700-a7f0-bffe957d0000

Kullab, S., & Novikov, I. (2025, August 22). Russian attack on western Ukraine hits an American factory during the US-led push for peace. *AP*. https://apnews.com/article/russia-ukraine-war-zelenskyy-putin-trump-security-92ee89feba2224f140429bcb573e61f9

Kunertova, D. (2025). *Embracing drone diversity: Five challenges to Western military adaptation in drone warfare* (Paper No. 29). Freeman Air & Space Institute. https://www.kcl.ac.uk/warstudies/assets/paper-29-dr-dominika-kunertova.pdf

Lifshitz, I., & Meents, A. (2020, November 17). The paradox of precision: Nonstate actors and precision-guided weapons. *War on the Rocks.* https://warontherocks.com/2020/11/the-paradox-of-precision-nonstate-actors-and-precision-guided-weapons/

Ljungkvist, K. (2025, August 13). *Participatory war and its challenges for total defense*. Carnegie Endowment for International Peace. https://carnegieendowment.org/research/2025/08/participatory-war-and-its-challenges-for-total-defense?lang=en

Mahnken, T. G. (2011). Weapons: The growth & spread of the precision-strike regime. *Daedalus, 140*(3), 45-57. https://www.jstor.org/stable/23047347

Maurer, J. D. (2023). The future of precision-strike warfare: Strategic dynamics of mature military revolutions. *Naval War College Review, 76*(2), 13-38. https://digital-commons.usnwc.edu/cgi/viewcontent.cgi?article=8342&context=nwc-review

Matlack, J. W., Schwartz, S., & Gill, O. (2025, April). *Ukraine’s drone ecosystem and the defence of Europe: Lessons lost can’t be learned* (Research Report). LSE IDEAS. https://www.lse.ac.uk/ideas/Assets/Documents/Research-Reports/2025-04-05-DRONES-MatlackSchwartzGill-FINAL-WEB.pdf

McCurry, J. (2025, April 25). From ammunition to ballistic missiles: How North Korea arms Russia in the Ukraine war. *The Guardian*. https://www.theguardian.com/world/2025/apr/25/how-north-korea-arms-russia-in-ukraine-war

McKernan, B. (2024, June 12). Hezbollah fires big salvo of rockets at Israel after senior commander killed. *The Guardian*. https://www.theguardian.com/world/article/2024/jun/12/hezbollah-fires-big-salvo-rockets-israel-senior-commander-killed

Michael, K. (2022). *Rocket fire into the heart of the country: Another component of Hamas's new strategy*. INSS. https://www.inss.org.il/social_media/rocket-fire-into-the-heart-of-the-country-another-component-of-hamass-new-strategy/

Miroshnichenko, K. (2025). *Wartime Ukraine Defence Innovation Ecosystem Formation through Drone Technologies* [Master's thesis, University of Gothenburg, Sweden). https://gupea.ub.gu.se/bitstream/handle/2077/89195/IIM%202025-32.pdf?sequence=1

Molloy, O. (2024, August 1). How are drones changing modern warfare? Lessons learnt from the war in Ukraine. *Australian Army Research Centre*. https://researchcentre.army.gov.au/library/land-power-forum/how-are-drones-changing-modern-warfare

National Emergency Portal. (n.d.). *Iron Swords War*. https://www.oref.org.il/eng

Nicolle, D., & Ali Gabr, G. (2024). *Air Power and the Arab World, 1909-1955*. Casemate Group. https://www.torrossa.com/it/resources/an/5870036

Pape, R. A. (1996). *Bombing to win: Air power and coercion in war.* Cornell University Press.

Plichta, M. (2025). Precise mass in action: Assessing Ukraine's one-way attack drone campaign. *The RUSI Journal*, *170*(4), 42-48. https://www.tandfonline.com/doi/full/10.1080/03071847.2025.2527923

Podestà, A. (2024). The concepts of mass and surprise in future air wars. *Æther: A Journal of Strategic Airpower & Spacepower, 3*(4), 41-55. https://www.jstor.org/stable/48809075

Rakov, D., & Fainberg, S. (2023). *The Growing Impact of the Civilian Population on the Modern Battlefield: A Glimpse into the Russia–Ukraine War* (Research Report 0123E). ELROM Center for Air & Space Studies, Tel Aviv University / ELNET, https://elnetwork.eu/policypaper/the-growing-impact-of-the-civilian-population-on-the-modern-battlefield-a-glimpse-into-the-russia-ukraine-war/

Rakov, D., & Fainberg, S.M. (2025). Civilian resistance as a cornerstone of national resilience: Insights from Ukraine and Israel. *Mūsų žinynas: karo mokslo, karinio rengimo ir ugdymo žurnalas*, 40(2), 5–32, https://journals.lka.lt/journal/mz/article/2250/info.

Ran, H., & Yagana, Y. (2025, March 18). Cities in the center are opening shelters: "We experienced volleys before, better to be ready in advance" [Hebrew]. *Walla*. https://news.walla.co.il/item/3735265

Ringel, S. (2024, August 4). Home Front Command's new warnings that will take control of your cell phone screen [Hebrew]. *N12*. https://www.mako.co.il/news-money/tech12/Article-6a6223795ad1191027.htm

Russian drone strike on Odesa injures four and causes power outages. (2025, March 4). *Euronews*. https://www.euronews.com/my-europe/2025/03/04/ukraine-says-four-injured-as-russian-strikes-hit-odesa-overnight

Sabbagh, D. (2025, July 11). The Shahed blitz: Can Russian drone onslaught break Ukraine's resolve? *The Guardian*. https://www.theguardian.com/world/2025/jul/25/russia-record-attacks-ukraine-struggles-defend-itself

Santora, M. (2025, March 7). Russia hits Ukrainian power and gas facilities in widespread attack. *The New York Times*. https://www.nytimes.com/2025/03/07/world/europe/ukraine-russia-attack.html

Sauer, P. (2025, August 27). Frustrated Russians grapple with fuel crisis as Ukraine attacks oil refineries. *The Guardian*. https://www.theguardian.com/world/2025/aug/27/frustrated-russians-grapple-with-fuel-crisis-as-ukraine-attacks-oil-refineries

Saunders, R., & Souva, M. (2020). Air superiority and battlefield victory. *Research & Politics*, *7*(4). https://doi.org/10.1177/2053168020972816

Schütz, T., Mölling, C., & Stanley-Lockman, Z. (2019). *A new dimension of air-based threats: Germany, the EU, and NATO need new political initiatives and military defense systems* [Policy brief]. DGAP. https://dgap.org/en/research/publications/new-dimension-air-based-threats

Shiferman, Y. (2023). The Russian Air Force in the war- Issues for review. In E. Hecht & S. Shabtai (Eds.), *The War in Ukraine: 16 Perspectives, 9 Key Insights* (pp. 39–50). BESA Center. https://besacenter.org/wp-content/uploads/2023/08/201-4.pdf

Simmill, K. (2025). Air defence insights from the Ukraine-Russia conflict. *Contemporary Issues in Air and Space Power, 3*(1). https://doi.org/10.58930/bp51798635

Singer, M. (2016). *The new threat of very accurate missiles* (Perspectives Paper No. 356). BESA Center. https://besacenter.org/new-threat-accurate-missiles/

Shaishmelashvili, G. (2023, August 2). *Total defense: The strategy on how to defeat strong* [Policy Paper]. PMC Research Center. https://pmcg-i.com/publication/total-defense-the-strategy-on-how-to-defeat-strong/

Slusher, M. N. (2025). *Lessons from the Ukraine conflict: Modern warfare in the age of autonomy, information, and resilience*. CSIS. https://csis-website-prod.s3.amazonaws.com/s3fs-public/2025-05/250501_Slusher_Ukraine_Conflict.pdf?VersionId=01UUwSkCxsWGAU5vOtwYQHmtq3F1.XKM

Solutions to win: Iron Shelter website debuts in Ukraine, providing vital information on shelter conditions. (2023, October 21). *Rubryka*. https://rubryka.com/en/2023/10/21/v-ukrayini-zapustyly-portal-zalizne-ukryttya/

State Comptroller. (2021). *Annual report 70C*. Office of the State Comptroller and Ombudsman. https://library.mevaker.gov.il/sites/DigitalLibrary/Documents/2020/70c/2020-70c-TAKTZIRIM-EN.pdf

Stewart, R. (2025, May 22). The shifting battlefield: Technology, tactics, and the risk of blurring lines in warfare. *Humanitarian Law & Policy*. https://blogs.icrc.org/law-and-policy/2025/05/22/the-shifting-battlefield-technology-tactics-and-the-risk-of-blurring-lines-of-warfare

UK Parliament, House of Commons Library. (2024, July 25). *Israel–Iran April 2024: UK and international response (Research Briefing No. 10002)*. https://researchbriefings.files.parliament.uk/documents/CBP-10002/CBP-10002.pdf

Ukraine strikes Russia with missiles and drones in one of largest air attacks. (2025, January 14). *Reuters*. https://www.reuters.com/world/europe/ukraine-strikes-russia-with-massive-drone-atacms-attack-russian-telegram-2025-01-14/

Ukraine residents sheltering in subway stations, basements and purpose-built bunkers as Russia invades. (2022, February 25). *ABC News*. https://www.abc.net.au/news/2022-02-25/ukraine-schools-and-subways-become-bomb-shelters-and-gun-ranges/100860338

Vogt, K., & Haider, A. (2024, August). Challenged air superiority: Adapting to the drone and missile age. Joint Air & Space Power Conference 2024, https://www.japcc.org/essays/challenged-air-superiority/

Yan, O. (2025, March 11). Mexican cartel attacks competitors with drones. *Militarnyi*. https://militarnyi.com/en/news/mexican-cartel-attacks-competitors-with-drones/

Zitun, Y. (2023, November 9). About 10 thousand rockets were launched since the beginning of the war: The attack on October 7th the largest since the founding of the state [Hebrew]. *Ynet*. https://www.ynet.co.il/news/article/b1j9rp9qt

Zitun, Y. (2024, August 30). 10 drones and 35 rockets in a combined volley: This is how Hezbollah tried to overwhelm Iron Dome [Hebrew]. *Ynet*. https://www.ynet.co.il/news/article/yokra14057755

Zitun, Y. (2025, June 16). The Zik's hunting trip in Tehran's skies: This is how elimination drones work [Hebrew]. *Ynet*. https://www.ynet.co.il/news/article/yokra14408610

Zitun, Y., Ben Ari, L., Eichner, I., El-Hai, L., & Kraus, Y. (2024, August 25). The plan: Launching hundreds of rockets, side by side with drones | IDF: Most of the attack was foiled, no base was hit [Hebrew]. *Ynet*. https://www.ynet.co.il/news/article/sjl4hwoo0

Appendix 1: List of Interviews

- Interview with two senior military officials involved in drone warfare, Kyiv, August 2023.
- Interview with a former Staff Officer, Armed Forces of Ukraine, Kyiv, August 2023.
- Interview with the policy think tank ANTS Team (Ukrainian NGO promoting national defense initiatives and post-war reconstruction through advocacy, expert networks, and youth empowerment), Kyiv, August 2023.
- Interview with Joseph Zyssels, Head of the *Vaad* of Ukraine (Jewish organization), Kyiv, August 2023.
- Interview with Leonid Finberg, Director of *Duh i Litera* (academic publishing house), Kyiv, August 2023.
- Interview with Dmytro Ivanov, CEO of *Dobrobat* (main Ukrainian NGO involved in grassroots reconstruction), Kyiv, August 2023.
- Interview with Mikhaelo Bryzhko, Regional Head of Dobrobat, Kyiv, August 2023.
- Interview with Oleksandra Rubina, former Project Manager, Ministry of Digital Transformation of Ukraine, via Zoom, August 5, 2025.
- Interview with a mid-level Home Front Command officer, Tel Aviv, October 15, 2025.
- Interview with a senior Ukrainian diplomat, via Zoom, July 3, 2025.
- Interview with two former senior IAF officials, Israel, July 2025.

Appendix 2: Ukraine's Air Defense Response and Adaptation to Russia's Air Attacks By Phase (February 2022-August 2025)

	Russian Strategy	Ukrainian Air Defense Response	Key Outcomes & Constraints
Phase 1- Failed Opening Strike [Feb 24, 2022]	Russia launched concentrated salvos against command-and-control airbases and communication nodes to create a "shock and awe" effect.	**Soviet-legacy layered Ground-Based Air Defense (GBAD):** – **Short-range:** Man-portable air defense systems (MANPADS), AAA, Osa-AKM (SA-8B). – **Medium-range**[9]: Buk-M1 (SA-11). – **Long-range**: S-300 variants (S-300PS, S-300V1, S-300PT-1). – **Complementary**: Early-warning radar network, MiG-29 and Su-27 interceptors (partially modernized).	Overlapping short-range and long-range ground-based air defense systems denied Russia rapid air dominance, foiling plans for a "Crimea 2.0"-style campaign. MANPADS played a significant role in maintaining the airspace as a mutually denied environment, making the use of helicopters and low-flying fixed-wing aircraft forward of the line of troops prohibitive for the Russians. The Ukrainian air defense architecture remained static, resource-intensive, and not designed for protracted multi-domain strikes.
Phase 2- Bombing to Win [Summer–Fall 2022]	Precision strikes on defense industry, logistics hubs, and government communications. In the summer and fall of 2022, introduction of **Iranian Shahed131/136-drones**, used in swarms from Belarus and Russia-occupied territories, added a low-cost, high-pressure vector to saturate Ukraine's already overstretched defenses and target the energy grid and urban centers.	**Decentralized** mobile GBAD deployments to sustain resilience. Severe depletion of interceptors. No domestic manufacturing capacity for timely replacement. Emergence of **civilian-led innovation,** especially in drone and counter-drone warfare. Establishment of the "Drone Line" initiative and of the "Sky Sentinel" project.	Energy grid heavily degraded, command infrastructure manufacturing targeted. Traditional radar-based defenses struggled against low-flying Shaheds. Ukraine's inventory of interceptors was severely depleted, and there was no domestic capacity to manufacture timely and effective replacements.

9 Ukraine's primary SAM assets, such as the long-range NPO Almaz S-300 (RS-SA-10 Grumble) and medium-range NIIP Tikhomirov 9K37 Buk (RS-SA-11 Gadfly) were deployed to intercept Russian land-attack cruise missiles like the air-launched Kh-101 (RS-AS-23A Kodiak), sea-launched 3M14 Kalibr (RS-SS-N-30A Sagaris), and short-range ballistic missiles such as the Iskander-M (RS-SS-26 Stone) and Tochka-U (RS-SS-21B Scarab).

	Russian Strategy	Ukrainian Air Defense Response	Key Outcomes & Constraints
Phase 3- Attritional Punishment [2023-2025]	As of late 2023 and early 2024: shift to massive drone and missile barrages. As of August 2024: Increased and sustained integration of cruise missiles with Shahed swarms, linked to Ukrainian Kursk counteroffensives and diplomatic milestones. Since mid-2024, an average of over 1,000 missile and drone attacks per month, transitioning to over 2,400 since September 2024. 2025: Increased intensity of strikes, with monthly figures approaching 3,000.	**Influx of Western systems – Short-, mid-, and long-range:** Gepard: German self-propelled anti-aircraft system initially delivered in September 2023. Zu-23-2: Initially delivered to Ukrainian troops starting in January 2024. UK modified MBDA ASRAAM missiles mounted on Supacat HMT 600 vehicles ("Raven"): first deployed in 2022. Gravehawk: Improvises R-73 missiles to be launched from a standard shipping container; 2 prototypes delivered in September 2024, with standard deliveries in 2025. OSA SAM system upgraded with R-73 missiles. Delivery of Poland's S-200 systems in June 2024. Involvement of civilian actor "Come Back Alive Foundation" in the modernization of existing air defense systems in December 2024. **– High-end:** Deployment of U.S.-made **Patriot batteries** (6 by mid-2025: 2 US, 2 Germany, 1 joint DE/NL, 1 Romania; partial system from NL). **– Integration:** Gradual layering of Western platforms with surviving Soviet assets.	Patriots significantly enhanced defense of Kyiv, Odesa, Dnipro, and high-value targets. Yet coverage remained below Ukraine's minimum requirement (10–25 systems). Patriots constrained by cost, limited availability, and logistical demands. Ukraine's reliance on U.S./European supply chains introduced structural vulnerability; political delays in Washington/Brussels slowed replenishment. Demonstrated NATO commitment but underscored asymmetry between Ukraine's needs for nationwide defense and the Alliance's lack of comprehensive and sustainable solutions.

Source: Elrom Center for Air and Space Studies