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Israel's Air and Missile Defense During the 2014 Gaza War

Uzi Rubin



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© The Begin-Sadat Center for Strategic Studies
Bar-Ilan University
Ramat Gan 5290002 Israel
Tel. 972-3-5318959
Fax. 972-3-5359195

besa.center@mail.biu.ac.il
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Israel's Air and Missile Defense During the 2014 Gaza War

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EXECUTIVE SUMMARY

In the escalation that precipitated the 2014 Gaza War (Operation Protective Edge) and during the war, Israel was subjected to the fiercest and longest reaching rocket assault in its history, including the rocket fire from Hezbollah in the 2006 Lebanon War. In preparation for the assault against Israel, the Palestinian factions in Gaza amassed more than 10,000 rockets, some with ranges reaching most of Israel's territory. Nearly half of this stockpile consisted of locally produced rockets by the newly established Palestinian military industries, and inspired and supported by Iran. More than 4,500 rockets and mortar bombs were fired from Gaza during the fighting. The rocket fire interrupted civilian air traffic to and from Israel's major international airport and threatened Israel's gas fields in the Mediterranean. The Palestinians added an air threat to their rocket assault, launching armed UAVs toward Israel's main metropolitan centers. In spite of intensive efforts by Israel's Air Force and Navy to destroy the launchers, the Palestinian rocket fire was neither silenced nor reduced in intensity until an agreed cease fire ended the fighting.

The Palestinians' offensive achievement was matched by Israel's defensive success. Israel's Air Defense Command deployed an efficient active defense array consisting of the Iron Dome rocket defense system and the Patriot air defense system. The nine Iron Dome batteries that protected most of Israel's civilian areas shot down nine out of every ten rockets aimed at their defended areas. The Patriot batteries shot down Palestinian armed UAVs and brought their assault to a full stop. Therefore, the casualties and damage from the Gaza rockets were significantly less than in previous rocket assaults. Israel's active defenses provided the sinews for Israel's public resilience, safeguarded Israel's international air and sea

ports, and allowed most Israelis in the threatened localities to continue their daily lives with minimal interruptions.

Skeptics in Israel and the US voiced doubts about the disclosed achievements of the Iron Dome system. US critics used commercial and private videos of rocket interceptions to allege that the system was significantly less successful than claimed. The low number of casualties was attributed by them to the efficiency of Israel's public alert system and extensive shelter network, as well as the supposedly low lethality of the Gaza rocket warheads. However, a comparison of losses and damages in the 2014 Gaza War to those from the 2006 Lebanon War, when no active defense system existed, refute the critics' allegations.

The 2014 Gaza War exposed the powerful war machine that the Gaza Palestinian factions had been building since the middle of the previous decade. In spite of Israel's defensive success, the fighting revealed gaps that require corrective action, including adding Iron Dome systems, improving the capability to shoot down UAVs, countering the mortar bomb threats and providing the Israeli Navy with the means to defend Israel's energy sources in the Mediterranean against rockets.

Israel's Air and Missile Defense During the 2014 Gaza War

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INTRODUCTION

Operation “Protective Edge,” which started in the early morning hours of July 7, 2014 and ended with an unlimited ceasefire on August 26, 2014, was the third and longest round of fighting between Israel and the Palestinian factions in Gaza since Hamas expelled and replaced the Palestinian Authority in 2007.¹

The objective of Operation Protective Edge, as defined by Israeli Prime Minister Benjamin Netanyahu, was to “reestablish the peace and security of Israel’s citizens.”² Hamas dubbed the military operation “the Rotting Straw” and Islamic Jihad called it “the Steadfast Formation.” Hamas’ name may reflect its belief that Israel was disintegrating, like rotting straw, while Islamic Jihad’s choice of a name might reflect its resolve to face off against Israel.³ Both factions had a joint war aim: “lifting the siege of Gaza.” Hamas leader Khaled Mashal clarified repeatedly to the international media that lifting the siege meant obtaining internationally guaranteed free access between Gaza and the rest of the world by an international seaport and airport in the Gaza Strip.⁴ However, from Israel’s perspective, this would be tantamount to the establishment of a sovereign Hamas state in Gaza without any commitment or obligation to live in peace with Israel. The Israeli public perceived Hamas as an inherent threat and regarded Operation Protective Edge as a justified war of national survival.

Uzi Rubin is a researcher at the Begin-Sadat (BESA) Center for Strategic Studies and an aeronautical engineer by profession. During his tenure in Israel's Ministry of Defense, he established and directed the Israel Missile Defense Organization, which is in charge of Israel's missile defense development and production. In this capacity, he directed the development, testing, and production of the Arrow Weapon System.

Israel's leaders warned the nation from the start that it faced a protracted military campaign. The home front's resilience thus played a key role in Israel's war effort. Major General (Res.) Amos Yadlin, former Chief of the IDF Military Intelligence wrote, that the home front's "capability to maintain its resilience in a campaign lasting more than one week... is a key factor in deciding the outcome of the present conflict."⁵ "Resilience" is usually interpreted as the readiness of the public to endure the inevitable loss of life to the military and civilian populations, as well as to sustain damage to property and losses of income. Resilience is a slippery concept that is hard to define or quantify. The degree of resilience is decided by a conscious or unconscious balancing of potential pain versus gain from the fighting. The "pain" side of the equation consists of the anticipated death and destruction from enemy action. Air and missile defense are therefore about reducing this pain. Public confidence (or lack thereof) in the capacity of the government to defend the nation against hostile threats is crucial. The remarkable resilience of Israel's homefront throughout Operation Protective Edge is due in large part to the effectiveness of Israel's air and missile defenses, which include the "Arrow" weapon system (optimized against ballistic missiles from Syria and Iran), the Iron Dome weapon system (optimized against light and medium artillery rockets from Syria, Lebanon, Gaza and the Sinai), and the Patriot PAC 2 system (optimized against manned and unmanned aircraft).⁶

This paper focuses on the role played in Protective Edge by Israel's Air Defense Command, in charge of defending Israel's airspace from rockets, missiles and aircraft. The paper will examine Israeli air capability and defense during the operation. It will first look at the types and ranges of the rockets in the arsenals of the Gaza factions at the eve of the campaign, then the strategy, tactics and the patterns of the Palestinian rocket offensive against Israel's homeland territory. Next, the paper will look at the effectiveness of the Israeli Air Defense Command's responses. This effectiveness was disputed by critics at home and abroad, and the paper will address this dispute. Finally, conclusions will be offered regarding gaps in Israel's defense that were exposed during the operation and potential trends for future conflicts that were revealed from this round of fighting.

All data and information in this paper were compiled from open sources: From Israeli and world media, statements by the IDF spokesperson, information on the IDF website, blogs and personal accounts. Personal interviews included information received from Alon Ben-David, Military Correspondent for Israel's *Channel 10 News* and Israeli Correspondent for *Aviation Week & Space Technology*, who kindly shared data he obtained from local authorities on the number of rockets fired at and intercepted over their cities and towns.⁷ Another important source was Nehemia Gershoni's blog, which provided updated statistics of the rocket attacks.⁸

The detail and precision of the IDF's spokesperson statements and website information fell short of their standard in previous campaigns in terms of the rocket attacks and the performance of Israel's missile defenses. Moreover, both the IDF spokesperson and Israel's press corps used ambiguous language that obscured meaning. Critics within Israel and abroad exploited such ambiguities to trivialize the achievements of Israel's missile defense systems during Protective Edge. Hopefully, lessons will be drawn from these mistakes and the IDF spokesperson will correct and improve its performance in forthcoming cognitive battles.

PALESTINIAN ROCKETS ORIGINS, SPECIFICATIONS AND STOCKPILES

The variety of rockets used by the Palestinians in Protective Edge differed from the rockets launched in the two previous campaigns of 2008-9 and 2012 in two important aspects. First, these hostilities saw the debut of Gaza's own industrialized armament industries (as distinct from earlier, more primitive rockets manufactured in the homes and workshops of Gaza). Second, extra long-range (relatively speaking) rockets were launched that reached as far as Haifa. The Palestinians tailored their use of rockets for geographic location: Short-range rockets to attack Israeli communities near the Gaza border, medium-range rockets to attack Israel's southern cities such as Be'er Sheva and Ashdod, long-range rockets to attack central Israel and the Tel Aviv metropolitan area, and extra long-range rockets to attack Haifa (although no warhead explosion

was reported in the city of Haifa or its suburbs).⁹ Each range category of rocket included imported and locally manufactured rockets, many produced in semi-industrial level production lines.

The initiative to evolve from amateur to industrial-level production methods came from Iran. In the wake of the 2006 Lebanon War, Iran made a strategic decision to provide its clients in Lebanon and Gaza with indigenous manufacturing capabilities, to thwart potential embargoes and sieges.¹⁰ A systematic program of industrial buildup and manpower training was initiated. In the case of Gaza, the machinery was smuggled in through the extensive tunnel system running under the Egyptian border. According to a Turkish media source, Palestinian trainees were flown to Iran to receive on-the-job training in the rocket industry, with the motto “you can’t bomb knowhow.”¹¹ This buildup was accelerated after the toppling of the regime of the Islamic Brotherhood in Egypt and the anticipation that the new regime would be unfriendly to the Hamas-run government in Gaza.

The newly established military industries in Gaza were manufacturing other types of military hardware, including rocket launchers, mortars and mortar bombs.¹² It is possible that Iran’s depot for components, materials and technical assistance destined for Gaza was the Iranian owned “Yarmuk” factory near Khartoum – the same factory whose bombing in 2012 was attributed in the media to Israel. According to international press reports, this factory was bombed again by Israel during Protective Edge.¹³ From the abundant propaganda videos and statements to the press, it appeared that two separate industrial clusters were created, one for Hamas and the other for Islamic Jihad, each producing its own variants of rockets and other weaponry. Despite being divided, these clusters might have shared background information, basic designs and acquisition channels for raw materials such as steel pipes and special chemicals for higher grade rocket propellants.

The short-range rockets (range of up to 10-12 km) include the familiar and still extant homemade types collectively dubbed by Israel as Qassam rockets. Somewhat surprisingly, Islamic Jihad fired a small number of C8K light rockets, which are Russian air-to-ground weapons usually fired from armed helicopters. Such rockets presumably came from Muammar

Gaddafi's looted arsenals in Libya, and had been fired from improvised ground launchers during the Libyan civil war. Another type of short-range rocket – the ubiquitous 107 mm rocket-propelled artillery, familiar from Afghanistan and Iraq – had already been used by the Gaza factions against Israeli border communities in previous campaigns. In Protective Edge, however, many of the 107 mm rockets were locally manufactured, as can be seen in a propaganda video released during the fighting.¹⁴ The video illustrates the priority Islamic Jihad gave to this weapon and its multi-barreled launchers, claiming that it fired 1,500 rounds during the campaign. Giving such a high priority to a short-range rocket seems surprising; however, this reflected an operational requirement for a close-range combat weapon to harass Israeli troop concentrations preparing to cross the Gaza border. In other words, the 107 mm rockets were a military requirement on top of the usual terror campaign. With roughly similar ranges, it is possible that what was perceived in Israel as mortar bomb hits were in fact 107 mm rockets.

Attacks on larger towns and cities in southern Israel – Ashdod, Be'er Sheva, Kiryat Gat – at ranges of 43-45 km, were carried out by medium-range, imported, extended range Grad 122 mm rockets, as well as by locally-made “Grad compatible” rockets with a slightly larger diameter and the roughly the same range as the original design.¹⁵

For attacking central Israel, use was made of locally produced 220 mm rockets, which were probably specially designed for ease of production in the Gaza armament industry. The Palestinians gave them numerous names: M-75, Sejil-55 and J-80 by Hamas and “Al Buraq 70” and “Al Buraq 100” by Islamic Jihad. Despite their different monikers, they all seemed to be minor variations of the same basic 220 mm design. Regardless of the greater ranges implied by their names, they all had a range of 70-80 km. Moreover, they seemed to share the same warhead, which was not much heavier than that of the smaller Grad 122 mm rocket.

Islamic Jihad claimed that it fired a number of Iranian-made Fajr-5, 75 km range rockets with a much heavier warhead of about 150 kg. Such rockets were indeed smuggled in significant numbers into Gaza during 2010-2011, but were largely destroyed by Israel's preemptive strike prior to Operation Pillar of Defense in November 2012. The

small number of Fajr-5 rockets fired at Tel Aviv during Protective Edge were probably the survivors of this attack.

Operation Protective Edge was not the first conflict to see rockets fired from Gaza reach such ranges. In the previous rocket campaign of 2012 the Palestinians fired a small number of these rockets at Tel Aviv and Jerusalem. This time, however, the number was much larger and the same type of long-range 220 mm rockets was used to attack the nuclear reactor in Dimona, as well as the desert city of Mitzpe Ramon.

Hamas achieved cognitive surprise by firing rockets at the Haifa Bay area. The rockets, dubbed “R160”, had a claimed range of 160 km. While such extra long-range attacks were described as a “surprise” by the Israeli media, this was far from the case. Iran’s effort to equip Hamas with long-range rockets to reach Haifa was publicly exposed and advertised when 40 Syrian-produced 302 mm rockets with similar ranges were discovered by Israeli commandoes aboard the Panama-flagged freighter SS Klos-C. The ship was stopped in March 2014 on its way to Port Sudan (for further shipping to Gaza) by the Israeli Navy. The IDF website called these rockets “M-302s”¹⁶ and listed them as part of Hamas’ stockpile at the eve of Protective Edge, thereby hinting that some may have reached Gaza before or after the capture of the Klos-C. However, the limited number of rounds fired toward Haifa during the fighting (Hamas claimed only 11 rockets) may hint that the Haifa-range rockets were of local design.

As for the warheads carried by locally made rockets, from the abundant visual evidence it appears that they all included steel balls, which enhanced lethality against exposed persons in open areas. There is no indication whether the warheads of the locally made “Grad compatibles” were the same size as the original Grad rockets. If the Gaza-made propellant was less energetic than the original formula, it stands to reason that the warhead would be correspondingly lighter to conserve the range. Nevertheless, the visual evidence of the damage from rocket impacts in Ashdod and Be’er Sheva (main targets of Grad and Grad compatible rockets) shows no discernable difference from damage in the same cities during the 2009 and 2012 campaigns, when only Iranian-made Grad 122 mm rockets were used.

Another impressive achievement of the Gaza armament industries was the local production of multiple rocket launchers, some of which were quite sophisticated. Celebrating the anniversary of its “victory” in the November 2012 campaign, Hamas paraded a quadruple barrel launcher for its M-75 long-range rockets. Propaganda videos later revealed that this launcher was hydraulically elevated. It is quite possible that similarly sophisticated launchers were also developed for the smaller Grad compatible rockets.

According to the IDF website, Palestinian factions in Gaza had stockpiled about 12,000 rockets, of which approximately 9,000 had range capabilities of more than 15 km¹⁷ (the remaining 3,000 consisting presumably of the shorter-range rockets, such as the 107 mm). Nearly two-thirds of the total amount of rockets were held by Hamas, slightly less than one-third by Islamic Jihad, and the rest by smaller Palestinian armed factions. About 3,500 of these rockets (38 percent) were produced in Gaza. Since rockets made in Gaza of such ranges hardly existed in the previous campaign of November 2012, the bulk of these 3,500 rockets were therefore produced in just 20 months. This yields an average production rate of about 175 rockets per month. This rate is not significantly different from the peak production rates of Qassam homemade rockets during the late 2000s; the difference is that the newer and bigger rockets were more sophisticated, requiring more accurate machining, the mixing and casting of more energetic composite propellants and rigorous quality control to ensure repeatable performance and to prevent excessive salvo dispersals. Achieving this level of sophistication, coupled with the manufacturing of relatively sophisticated multiple barrel rocket launchers, was a significant achievement for the Gaza engineers and their Iranian mentors.

PATTERNS OF THE GAZA ROCKET OFFENSIVE

Once the fighting was over, Israeli media reports published that a total of 4,564 rockets and mortar bombs were fired at Israel during Operation Protective Edge. Of this total, 188 exploded within the Gaza Strip, 3,417 landed in open areas within Israel, 244 landed inside urban areas and 735 were destroyed by Iron Dome.¹⁸ Significantly different figures are

cited by other sources.¹⁹ To confuse the issue further, Hamas and Islamic Jihad claimed a significantly larger number of 6,870 rockets and mortar bombs fired during the campaign.²⁰ There is no explanation for this huge discrepancy between the Israeli and Palestinian numbers. In fact, the discrepancy should be even larger since the 6,870 figure does not include the rockets and mortar bombs fired by the smaller Palestinian factions.

Some of the discrepancy could perhaps be explained by the smaller Palestinian rockets such as the lightweight “C8K” that might have eluded Israel’s early warning sensors. Or, discrepancies could come from doctoring the books by the Palestinians, either for propaganda purposes or to collect financial benefits from their sponsors.

Neither the Palestinian nor the Israeli sources distinguish between rockets and mortar bomb attacks. Some Israeli sources provide “guesstimates” of 1,300 or 1,600 mortars fired during the campaign. No explanation is offered about this ambiguity. Perhaps it was difficult to distinguish during the campaign between the very short-range rockets, such as the 107 mm, and the mortars.

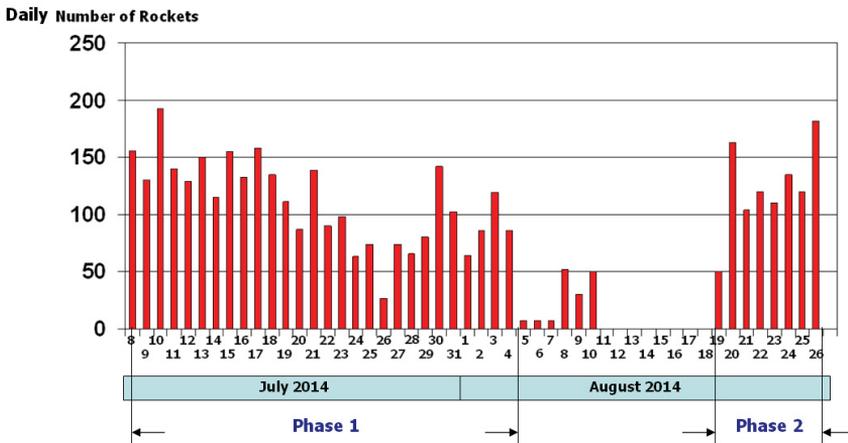
The data on the daily number of rockets and mortars fired from Gaza is also characterized by discrepancies between various Israeli sources. Figure 1 shows a bar graph of the daily number of rockets and mortars fired.²¹ Nevertheless, in spite of the discrepancies, the data from all Israeli sources exhibit a similar two-phase pattern, punctuated by a period of partial and total cease fires. In the first phase (July 8-August 5, 2014) the rate of fire slowly declines over time. In the second phase (August 19-26, 2014) the rate of fire returns to its previous intensity and remains steady until the end of the fighting. The average rate of fire was the same in both phases – about 100 rockets and mortar bombs per day. On the last day of the fighting (August 26, 2014), the Palestinians increased the tempo of the rocket fire and achieved a peak rate of 180 rounds in an obvious effort to create a “victory image,” familiar from previous campaigns in 2006, 2009, and 2012.

Remarkably, the average daily rate during Protective Edge – about 100 rounds per day – was significantly lower than that of Pillar of Defense when the average intensity of fire was more than double (215 rounds per day).

Some Israeli sources reported a shift in Palestinian fire policy during the second phase of Protective Edge: A sharp decrease in rocket fire with a corresponding increase in mortar fire against the Israeli communities abutting Gaza. This increase was to frighten the residents into mass evacuations. However, since the available information does not differentiate between the number of rockets and the number of mortars, such reports cannot be confirmed. Nevertheless, the death toll increased among the Israeli civilians living in the communities surrounding Gaza during the second phase of Protective Edge. This raises additional questions: If the rate of Palestinian mortar fire was ratcheted up, then why did they decrease their longer-range rocket fire? Were the Palestinians running out of long-range rockets? The available information does not provide any answers.

FIGURE 1

Daily Number of Rocket and Mortar Bomb Attacks July 8 - August 26, 2014



Source: Nehemia Gershuni Blog

No information has been released about the distribution of the Gaza rocket fire on specific localities within Israel. The unofficial distribution data provided is shown in Table 1. The total number of rockets and mortar bombs (3,947) is significantly lower than that of the sources cited above (4,564). No explanation for this discrepancy is offered. However, Table 1 provides what seems to be a reliable indication of the Palestinian targeting policy: More than half of the rockets and mortars fell in the

communities around Gaza. Presumably this is where the majority of the Palestinians' mortars and 107 mm rockets fell. In Israel's interior, the cities of Ashdod, Be'er Sheva and Ashkelon – all about 40 km from Gaza – absorbed one-third of the rockets. This ratio reflects the proportion of the various types of ordnance in the Palestinian stockpiles.

If we take for granted that the total number of attacks on Israeli territory was 4,564 and on the communities around Gaza was 2,248, then the number of 15-km range rockets and above fired during Protective Edge was 2,316. This number is about one-quarter of the IDF's initial estimation of 9,000 rockets. Thus, if the Palestinians experienced shortages in rocket availability toward the end of the campaign, it was not due to the depletion of their stockpiles, but rather due to the destruction of storages and production plants in Gaza as reported by the Israel Air Force.

TABLE 1

Distributon of Rockets / Mortar Fire and Interceptions

Region	Number of Rocket and mortars	Number of Interceptions
Ashdod	371	170
Ashkelon	302	142
Beer Seva	302	81
Netivot/Ofakim	214	70
Shderot	182	47
Tel aviv Metropolitan	134	66
Qiryat Mal'achi	82	35
Qiryat Gat	57	24
Coastal Plain	37	25
Jerusalem Metropolitan	10	5
Haiifa Metropolitan	4	-
Eilat	4	1
Gaza Envelope	2,248	67
Total	3,947	733

Source: Alon Ben-David, Nehemia Gershuni, Others

Note: The total of interceptions is close to the IDF's statement, but the total number of rockets and mortar bombs differs considerably from what was reported by Israeli media.

STRATEGIC AND TACTICAL ASPECTS OF THE PALESTINIAN ROCKET OFFENSIVE

The strategic objectives of the Palestinian rocket offensive emerged from a review of their targeting policy and the tempo of their operations. Two strategic objectives were discerned: To disperse and dilute Israel's missile defenses, and to hurt Israel's economy and demoralize its homefront. The two objectives were interlinked: Weakening Israel's missile defense would increase losses and damage from rockets, thereby hurting the economy and demoralizing the public.

To achieve the first objective of diluting Israel's missile defense, the Palestinians targeted small and sparsely populated Israeli communities even when the prospect of causing damage was low. Rockets fell in Bedouin communities and Mitzpe Ramon, a small and isolated town deep in the Negev desert. Palestinian allies and supporters abroad were mobilized to this effort and fired rockets from Lebanon, Syria and the Sinai Peninsula.²² The Palestinians achieved partial success in this objective when rockets were fired from Sinai at Eilat, compelling Israel to redeploy a sorely needed Iron Dome battery for its defense. This battery remained mostly idle.

To achieve the second strategic objective of hurting Israel's economy and demoralizing the population, a mix of tactics was employed. First, Palestinians targeted vital national infrastructures including Ben Gurion International Airport, the seaports in Ashdod and Haifa, an Israeli offshore gas rig in the Mediterranean Sea²³ and the Dimona nuclear reactor. Second, rocket attacks were synchronized with Israel's prime time TV news shows. Third (perhaps an improvisation during the second phase of the campaign), mortar fire on Israel's civilian communities near the Gaza border was concentrated to force demoralizing mass evacuations.

The rocket attacks on vital infrastructures were trumpeted by the Palestinians in their propaganda campaign, leaving no doubt that this was a deliberate policy. Especially noticeable was in the case of the attacks on Ben Gurion International Airport, Israel's main air gateway to the rest of the world. Hamas announced early in the campaign that it intended to "besiege the besiegers" and sent daily warning to all 120 airlines serving

Ben Gurion Airport to stop their service. On July 22, 2014, a rocket aimed at the airport exploded in the nearby community of Neve Monoson, about one mile (1.6 km) from the nearest runway.²⁴ A few hours later, the US Federal Aviation Authority (FAA) banned all flights of US airlines to Ben Gurion Airport. The European Civil Aviation Authority followed suit with a recommended ban on flights to Israel. Following intense efforts by Israel's Ministry of Transportation and Civil Aviation Authority, both bans were lifted hours later.²⁵ The Palestinians regarded this temporary blockage of Israel's air traffic as a glowing achievement. The attacks on Haifa were accompanied by similar propaganda flourishes.

The Palestinians attempted to dominate the cognitive battlefield by synchronizing simultaneous rocket attacks on Israel's cities during prime time news shows. Israel's TV channels cooperated enthusiastically by placing TV cameras on high rise buildings to broadcast dramatic action scenes against the backdrop of cityscapes. Perhaps the most outstanding episode occurred when Hamas issued a warning that "the Izz al-Din al-Qassam Brigades will attack Tel Aviv and its southern suburbs with J-80 rockets at approximately 21:00 hours tonight, Saturday, July 12, 2014,"²⁶ challenging Israel to put its Iron Dome system in readiness for the momentous event. This tactic of coopting Israel's own media to Palestinian propaganda efforts largely backfired because Israel's public were not treated to scenes of death and destruction, but rather to spectacular interceptions by the Iron Dome. After a while, the Palestinians gave up and gradually ceased their prime time synchronizations.

During the second phase of Protective Edge (August 19-26, 2014), the Palestinians shifted the bulk of their fire to Israeli communities abutting the Gaza border and used synchronized mortar fire to inflict a growing number of casualties there. The resultant mass evacuations were described by Israel's media in dramatic, highly emotional terms, handing the Palestinians a cognitive victory. It was not clear, however, whether this Palestinian tactic was deliberate or an improvisation following their success in inflicting serious casualties to IDF troop concentrations by mortar fire earlier in the campaign.

On a tactical level, the Palestinians attempted to overwhelm Israel's missile defense and to protect their rocket launchers against Israeli counter fire. The impression was that in the first few days of the campaign there was a significant Palestinian effort to break through the defensive shield by launching large synchronized salvos, as can be judged by the large number of Iron Dome interceptions seen in video records from this period. Soon, however, the Palestinian salvos grew thinner, perhaps once they realized that the campaign might be longer than anticipated and decided to conserve ammunition.

Much more successful was the Palestinian's ability to conceal their rocket launchers. It seems that the overwhelming majority of rockets were fired from buried launch sites. Launcher survivability relied on two measures: Meticulous camouflaging of the buried sites to prevent both pre and post-firing identification and location by Israeli reconnaissance and using human shields by locating the launchers adjacent to civilian objectives. These combined measures were portrayed in a video report by the Indian NDTV network²⁷ which showed a Hamas team loading a buried launched site virtually under the window of the Indian reporter's hotel room. To hide the activity from Israel's UAVs, Hamas operatives used a commercial outdoor pergola. When rocket loading was completed, Hamas operatives strung electrical cables to a nearby house and covered the site with freshly cut brush before rolling away the pergola. The rockets were subsequently fired remotely with no Hamas operatives in the vicinity. Even if Israel discovered the launcher in time, the proximity to the hotel (and other civilian residences) would discourage Israel from destroying it.

Another significant example of human shielding can be seen in a European network report documenting a destroyed buried launch site near a kindergarten.²⁸ Israel could locate each and every launcher after it fired a rocket. However, the extensive use of human shielding made it difficult to exploit this information due to the concern by the international community (particularly the US Administration) over the growing death toll among Gaza's civilians.

Despite optimistic reports by the IDF and convincing photographic evidence of launcher location and destruction, the cumulative effect of

Israel's counter fire on the Palestinian's capacity to continue the rocket fire was negligible, if any. It can be assumed that the Palestinians prepared for Israel's counter fire by constructing redundant launching capacity to compensate for the destroyed launchers – a comparable tactic to that used by Hezbollah in the 2006 Lebanon War. In 2006, Hezbollah was able to maintain a steady rate of rocket fire up to the end of the fighting, in spite of the massive launcher hunting and destruction by the Israel Air Force.

Another remarkable feature of the offensive was the lull in rocket fire during the late night hours. Almost invariably, the rocket fire from Gaza ceased about midnight and resumed fairly punctually at 06:00. Perhaps the Palestinians felt the prospects of catching Israelis in the open in the middle of the night were too low for profitable attacks. Alternatively, the lull might have been necessary for launcher replenishments and for crew rest. Hezbollah too muzzled its rocket launchers during the night hours in the 2006 Lebanon War, although its timing was noticeably different: From sunset to dawn (about 9 hours).

ISRAEL'S MISSILE DEFENSE IN ACTION

The burden of defense against Palestinian rockets fell exclusively on the Iron Dome rocket defense system, the capabilities of which were already amply demonstrated in the November 2012 campaign and previously in minor rocket attacks. Iron Dome is specified against rockets ranging from 4 km to 70 km.²⁹ However, during Protective Edge, Iron Dome was not used against mortars with ranges of up to 4 km. Whether this reflected a technical limitation or a deliberate policy of refraining from using Iron Dome against relatively low lethality threats remains unclear. However, Iron Dome could and did intercept rocket-assisted mortar bombs with ranges of 7 km.³⁰ The net result was that Iron Dome played no part in the mortar attacks against civilian communities and IDF troop concentrations near the Gaza border.

At the start of Operation Protective Edge, the Air Defense Command had six operational Iron Dome batteries available. Within one week, following a crash program, three more Iron Dome batteries were completed and manned, bringing the total number of operational systems

to nine. For obvious reasons, details about their geographical locations was not released, but from the news on successful interceptions it could be deduced that they were deployed to defend Sderot, Ofaqim, Netivot and Be'er Sheva in southern Israel; Ashkelon, Ashdod, Qiryat Gat, Qiryat Malachi, Rechovot and Rishon LeZion in the coastal plain; Modi'in, Jerusalem and the Tel Aviv metropolitan areas in central Israel; and Eilat in the southern tip of the country. It is not clear whether Iron Dome was deployed in Haifa, which was overtly targeted by Hamas. Nor were there any reports of Iron Dome interceptions over that city.

In spite of the widespread deployment of Iron Dome, it did not protect every population center under attack. In addition to population centers, it was tasked to defend military installations and vital national infrastructure, such as Ben Gurion International Airport.

The number of stockpiled Iron Dome interceptors at the start of Protective Edge was highly classified. When it became clear that the campaign was going to last longer than envisaged, concerns about the size of the remaining stockpile were aired both in Israel and the US. This prompted the IDF to assure the public that the stockpile of Iron Dome interceptors was sufficient for any future challenge.³¹ Videos aired by Israel's TV networks as well as private YouTube uploads indicated a general policy of single fire (i.e., one interceptor per target) except in the case of the Tel Aviv metropolitan area where ripple fire (i.e., two interceptors per target) was used.

Iron Dome is a selective system that only engages rockets aimed at its defended zones. The measure of effectiveness of any active defense system is its score, namely the number of destroyed rockets in proportion to the number of rockets that should have been destroyed. A score of 90 percent means that out of 100 rockets that were about to hit a defended zone, 90 were destroyed before impact and 10 leaked through. Iron Dome is not designed to provide an airtight defensive shield, and its 84 percent score in the 2012 campaign was regarded as more than satisfactory.

Inexplicably, the IDF refrained from disclosing specific scores for each of the major defended population centers. Instead, the overall score for the entire country was "nearly 90 percent." There is no way to corroborate this claim from open sources. The information in Table 1 is incomplete.

While it lists the number of rockets fired at each locality as well as the number of interceptions, it does not provide any information on how many rockets should have been intercepted or how many leaked through Iron Dome's defense.

Nevertheless, indirect evidence tends to support the IDF's claim. An article from August 4, 2014 stated that 112 rockets had been fired toward the Tel Aviv metropolitan area up to that date, of which 60 were intercepted and 52 hit "not only in non-residential areas."³² Three rocket impacts in residential areas in the Tel Aviv metropolitan area were documented on that date: One hit Neveh Monoson and caused the partial suspension of service to Ben Gurion Airport, another hit near an apartment building in Petah Tikva, and the third landed in "the Rosh Ha'ain area." That increased the number of rockets that should have been intercepted to 63, of which 60 were destroyed, yielding a score of over 95 percent. Twenty-two more rockets were fired at the Tel Aviv metropolitan area between August 4, 2014 and the end of the campaign on August 26, 2014, of which six were intercepted, and none were known to have hit residential areas. After these dates, the final score of the Iron Dome interception rate in the Tel Aviv metropolitan area was 96 percent.

The August 7 issue of the Ashdod municipality website reported that 222 rockets were fired at the Ashdod region: 141 were intercepted and 13 hit residential areas.³³ That yielded an interim score of close to 92 percent. From August 7 until the end of the campaign on August 26, 2014, 149 additional rockets were fired at the city: 29 were intercepted and 2 hit residential areas. That also yielded a final score of 92 percent. The lower score relative to Tel Aviv can be attributed to the policy of single fire in Ashdod versus ripple fire in Tel Aviv.

In summary, while Iron Dome did not prevent all casualties and damages within its defended zones, it did provide robust defense to Israel's population centers and vital installations. Its final score of 90 percent is higher than the previous record of 84 percent two years ago. Considering that the 90 percent was mainly achieved by single fire interceptions – a single chance to hit the incoming rocket – the result can be regarded as an outstanding technical success. While the achievements of Operation Protective Edge (or lack thereof) are hotly debated in Israel, the

achievements of Israel's missile defense are universally lauded. In the words of Major General (Res.) Shlomo Gazit, former Chief of Israel's Military Intelligence, "I believe there aren't words enough to praise the performance of 'Iron Dome.' I shudder to think of what could have happened without it."³⁴

NEGATING THE SKEPTICS: THE EFFECTIVENESS OF IRON DOME

Skepticism over the roles and capabilities of missile defense systems have accompanied them since their inception, both abroad and within Israel. The operational debut of Iron Dome in April 2011 elicited both public admiration and skepticism in Israel and the US. Criticism increased during Operation Protective Edge. Until recently, the main source of skepticism in Israel arose from the Homeland Defense Association, which was established to expedite a chemical laser alternative to Iron Dome. Over the years, the Association published scathing critiques of the selection of Iron Dome instead of a chemical laser solution for short range missile defense, accompanied by pessimistic predictions about its costs and performance.³⁵ Even the visible achievements of Iron Dome in Protective Edge did not change the minds of the chemical laser proponents. This was expressed in a critical Op Ed article by the Homeland Defense Association Chairman, Dr. Oded Amichai.³⁶

Harsher criticism was expressed by Dr. Mordechai Shefer, formerly of Rafael (and a winner of the prestigious Israel Defense Prize for his role in air-to-air missile development). He forcefully argued that Iron Dome was a hoax perpetrated by the Israeli government. He claimed that Iron Dome was nearly incapable of intercepting any rocket and that its true score was abysmally low.³⁷ Shefer's claims received some attention abroad and were exploited in Hamas' propaganda videos.

The most significant criticism was voiced in the US by Theodore Postol, an MIT professor (and long-time critic of US missile defense) and the late Richard Lloyd, a respected expert in air-to-air missile warheads. In a series of publications before and during Protective Edge, the

two argued that Iron Dome performance was radically lower than the IDF's claims. Their arguments were based on their own analysis of television and YouTube video clips, from which they deduced that in the overwhelming majority of cases, the interception geometry (i.e., the relative attitudes of interceptors and targets) could not result in target destruction. While acknowledging the low number of casualties from rocket fire, they attributed the success to Israel's efficient civil defense system and its timely public alerts and to the small size and low lethality of the Palestinian rockets. Their aim was to dissuade the US Congress from allocating further funds to the Iron Dome program. Their criticism gained worldwide attention.

A detailed discussion of the errors and fallacies in their analysis is beyond the scope of this paper. For our purpose, it is enough to demonstrate that it was Iron Dome rather than civil defense or Hamas' purported incompetence that reduced casualties and damages in Protective Edge – and to do so with reliable quantitative information on losses and damages rather than smartphone video clips.

For a benchmark, we can take the Hezbollah rocket offensive during the 2006 Lebanon War, when Israel already had a robust civil defense system with timely population alerts, but no active defense. This can be compared to the 2012 rocket offensive during Pillar of Defense when Israel first deployed 5 Iron Dome batteries, and then to Protective Edge with its 9 Iron Dome batteries. The level of population sheltering remained essentially the same in all three campaigns because Israel has not invested in extensive sheltering since 2006 (except in the communities around Gaza). Instead, Israel invested in active defense (i.e., Iron Dome batteries). The mix of hostile Palestinian rockets in all three campaigns were about the same, with the bulk consisting of 122 mm Grad rockets of various provenances, accompanied by numerous short-range rockets and a relatively small number of long range, heavier rockets such as the 330 mm Fajr-5 (used in 2006 and 2012), the unnamed 302 mm rocket (used in 2006 and perhaps in 2014), and a plethora of 220 mm rockets (used in 2006, 2012 and 2014).

Given that the lethality of the hostile rockets, the level of passive defense, and the effectiveness of Israel's early warning and public alert systems were about the same in all three cases, Iron Dome's effectiveness can be judged

by comparing losses and damages in the 2006 Lebanon War – when it did not yet exist – to those of the 2012 and 2014 campaigns, when it did.

Israel’s media – broadcast, print and electronic – accentuates deaths from enemy action in great and emotional detail, providing information on each victim’s identity, biography and circumstances of death. This provides reliable, well corroborated data on the number of fatalities from rockets in each of the three campaigns. In the 2006 Second Lebanon War, Hezbollah rockets killed 53 civilians and soldiers. In the 2012 Operation Pillar of Defense, Palestinian rockets killed 5 civilians and soldiers. In Protective Edge, Palestinian rockets killed 2 persons, a civilian and a soldier. Since the number of rockets fired at each campaign is on record, their relative lethality, measured by how many rockets were needed to cause one death, is easily calculated. Obviously, the greater number of rockets in relation to the number of deaths, the lower is the lethality.

The results are presented in Table 2. In 2006, when Israel was not protected by Iron Dome, the ratio was 79 rockets to one Israeli death. In 2012, with five Iron Dome batteries in action, the ratio was 320 rockets to one Israeli fatality – a fourfold decrease in the rockets’ lethality. In 2014, with 9 Iron Dome batteries deployed, the ratio was 1,500 rockets to one fatality – a twenty fold decrease in lethality. Simply put, the rockets’ lethality in 2014 dropped to 5 percent of its level in 2006.

TABLE 2

Number of Israeli Deaths From Rockets

Campaign	Iron Dome Batteries	Rockets	Fatalities from Rockets	Ratio
2006 Lebanon	0	4,200	53	1/79
2012 Gaza	5	1,600	5	1/320
2014 Gaza	9	3,000*	2	1/1,500

*Assuming that out of the total of approximately 4,500 rounds fired from Gaza, about 1,500 were mortar bombs.

Critics in the US argued that this dramatic decrease in lethality could be attributed to the small size of the rocket's warhead and to improvements in Israel's civil defense. Regarding the first argument, the visual evidence does not indicate any reduction in weight or effectiveness of hostile warheads compared to previous campaigns. The amount of damage caused to buildings hit by rockets seems to be the same. Evidence of the power of the Grad rockets used by Hamas can be seen in a video from a security camera in which a Grad warhead explodes in Qiryat Gat on July 31, 2014 and hurls a commercial light truck into the air.³⁸

The second argument might convince only those who did not live through all three campaigns. The sense of security imparted by Iron Dome's nearly perfect defense caused an adverse effect of public laxity. Instead of taking shelter, many Israelis rushed into the open to capture the action on their smartphones. Of the five victims in 2012, at least three deaths were preventable because they ignored civil defense instructions (one was killed by the very rocket he was trying to record). In Protective Edge, several civilians were wounded by rocket debris while videoing the spectacle. For observers within Israel, it was clear that the effectiveness of the country's civil defense did not increase over time. If anything, especially due to human curiosity, the opposite was true.

Therefore, the only possible explanation for the sharp decline in the rockets' lethality was the success of Iron Dome. This can be corroborated by looking at property damages. Passive defense can save lives, but it cannot prevent material damages to structures and vehicles. Thus, comparing the level of material damage from rockets in all three campaigns could provide another indication as to Iron Dome's effectiveness.

Israel insures its citizens against property damage from hostile action. The insurance is funded from a tax on property transactions, a portion of which is allocated by law for this purpose. There is no minimum threshold – even scratched paint on a car warrants compensation. The Israeli government urges its citizens to file damage claims as soon as possible, and often sends Treasury officials to stricken areas to help residents complete the appropriate forms. The public exploits the government's generosity with gusto. The number of filed claims on record is a reasonable indicator of the extent of material damage in each of the three campaigns.³⁹

The results are presented in Tables 3 and 4. In the 2006 Lebanon War, Israel did not have a missile defense system and each rocket generated more than six damage claims. In the 2012, Israel had the Iron Dome and the number of damage claims dropped precipitously to about 2 claims per rocket. During Protective Edge the number dropped even further to one claim per rocket. The Palestinians were not chivalrously scaling down the lethality of their own rockets; therefore, the sharp drop in damage claims must be attributed to the success of Iron Dome in preventing rockets from hitting their targets.

TABLE 3

Number of Damage Claims

Campaign	Iron Dome Batteries	Rockets	Damage Claims	Ratio (Claims/ Rockets)
2006 Lebanon	0	4,200	26,653	6.35
2012 Gaza	5	1,600	3,921	2.45
2014 Gaza	9	4,500*	4,525	1.01

* Compensations are paid for damage from mortars as well as from rockets.

TABLE 4

Compensations for Property Damages Paid by Israel's Treasury

Campaign	Iron Dome Batteries	Rockets	Damage Paid*	Ratio (Claims/ Rockets)
2006 Lebanon	0	4,200	478,950,000	114,000
2012 Gaza	5	1,600	57,456,000	36,000
2014 Gaza	9	4,500**	89,563,000	20,000

* In NIS, rounded to the nearest '000 in then year shekels.

** Compensations are paid for damage from mortars as well as from rockets.

A similar pattern emerges when we compare the actual compensations paid for property damages in all three campaigns. In the 2006 Lebanon War, each rocket fired by Hezbollah (regardless of where it impacted) required compensation by the Israeli Treasury for the payment of 114,000 NIS (about \$29,500). This rate dropped down to roughly 35,000 NIS (about \$9,000) per rocket during Operation Protective Edge in 2012, and continued to decline down to about 20,000 NIS (about \$5,100) per rocket in the 2014 campaign. This means that in 2014, the compensation received per rocket was approximately one-sixth of the compensation received in 2006.

In summary, the facts refute the skeptics' claims, leaving no reasonable doubt that Iron Dome worked effectively, preventing extensive material damages and saving lives. Had the "per rocket" rate of compensation payment remained at \$29,500 as in the 2006 Lebanon War, the total amount of damage compensation in Operation Protective Edge would have totalled \$132 million, instead of the actual amount paid of \$23 million. Hence, the success of Iron Dome saved approximately \$109 million, a sum equivalent to the cost of about 1,200 Iron Dome interceptors.⁴⁰

Even more significant, had the lethality ratio of the Gaza rockets remained at 79 rockets per fatality as in the pre-Iron Dome 2006 Lebanon War, the number of fatalities as based on a total of 4,600 rockets fired from Gaza in 2012 and 2014 would have been 60 Israelis (and not the 7 that were actually killed). Thus, about 50 Israelis – men, women, and children – owe their lives today to Iron Dome.

HAMAS' AIR CAMPAIGN

Already during Pillar of Defense in 2012, the IDF disclosed that Hamas acquired UAVs. An IDF-released video clip showed a Hamas UAV practicing takeoff runs in an abandoned airstrip in Gaza. At the conclusion of Pillar of Defense, the IDF declared that the Hamas UAV force was "destroyed." In spite of this optimistic statement, the IDF announced on July 14, 2014 that its Patriot air defense system destroyed a Hamas UAV flying over the Mediterranean on its way to

central Israel. Three days later on July 17, 2014, another Hamas UAV was shot down by Patriot.

In the wake of the first UAV incident, Hamas revealed the existence of its UAV fleet and released videos of their aircraft training and flying over Israel.⁴¹ According to Hamas disclosures, they were operating three types of UAVs for reconnaissance, level bombing, and dive bombing. They further claimed that their UAVs had already made several reconnaissance sorties and photographed the IDF headquarters in Tel Aviv. Israeli sources estimated that Hamas operated a “substantial” number of UAVs smuggled from Iran and that the two vehicles destroyed by Patriot were in attack missions against targets in central Israel. No more UAV sorties were announced by Israel or Hamas following the destruction of the second one on July 17.

Combining rocket and UAV attacks is not a new phenomenon. During the 2006 Lebanon War, Hezbollah launched 4,200 rockets and at least four attack UAVs (later identified from recovered debris as the Iranian Ababil B). Two of these UAVs were shot down by air-to-air missiles fired from Israel Air Force F-16s. About one month before Defensive Shield, another Hezbollah UAV was shot down by a fighter aircraft over southern Israel. A senior Iranian official bragged that Iran received images of IDF installations photographed by that UAV before it was shot down.⁴² In August 2013, another UAV was destroyed by an Israel Air Force fighter over Haifa Bay (Hezbollah denied responsibility for this UAV sortie).⁴³

The short air assault by Hamas during Protective Edge established two precedents: The battlefield debut of Hamas UAVs and the successful use of air defense missiles to shoot them down (when previously combat aircraft fulfilled this mission). These were the first ever operational kills by the Israeli Patriot systems, and perhaps the first Patriot kills ever of hostile aircraft anywhere (in the Iraq War Patriots shot down two friendly aircraft, a British Tornado and a US F-16).

CONCLUSION

Operation Protective Edge exposed the powerful war machine that the Palestinian factions – mainly Hamas – had been building in Gaza since chasing away the Palestinian Authority in 2007. The Palestinian war machine was comprised of a sophisticated smuggling tunnel system, large stockpiles of imported and locally made rockets with reach throughout Israel, an array of camouflaged buried launchers, a growing fleet of aggressive UAVs, assault tunnels that provide access to cross-border commando raids, and a force of naval commandos. The rocket offensive from Gaza in Protective Edge was the most extensive and most protracted, and reached deeper in Israel than any of the preceding wars – including that with Hezbollah in 2006. Moreover, for the first time, the Palestinian offensive targeted not only population centers, but also strategic installations. In 2012, Israel succeeded in preempting and destroying most of the Palestinians' long range rockets at the start of the campaign. However, in Protective Edge, Hamas and Islamic Jihad rockets and launchers survived the heavy Israeli counter fire in sufficient numbers to maintain a reasonably steady rate of fire up until the last minutes of fighting. As in each campaign before it, the rocket fire died only when an agreed cease fire came into force.

Against this backdrop of Palestinian achievements, Israel can chalk up its success in deploying mature, battle-tested missile defense systems that provided a satisfactory defensive shield to most of its threatened population centers as well as to vital national installations. This robust defense was the sinews of Israel's homefront resilience in one of the longest military campaigns in its history. Israel's Air Defense Command, operating Iron Dome against rockets and Patriots against UAVs, enabled the county's economy to continue functioning, safeguarded its air and maritime links to the world and allowed most Israelis to maintain their daily routines with minimal disturbance. Iron Dome shot down nearly nine out of ten rockets fired at its defended assets and Patriots cleared the skies of hostile aircraft – outstanding achievements by any standard. Israel's successful air defense system thus provided the government with adequate abilities to persevere in military and diplomatic actions until an acceptable termed ceasefire was achieved.⁴⁴ It may well be that the decades-long debate in Israel between proponents and critics of missile defense has now been laid to rest.

RECOMMENDATIONS

Operation Protective Edge exposed gaps in Israel's defense and highlighted trends which are likely to become significant in future conflicts. Israel should make its military and organizational preparations accordingly.

The most significant gap in Israel's defenses during Protective Edge was its inability to protect citizens against mortar fire (which was only marginally treated in this paper). Mortar fire is not a new threat: Over the course of the decade-long rocket offensive from Gaza, approximately 3,500 mortar bombs killed scores of Israeli civilians and soldiers. Yet mortar bombs had a more pronounced impact in Protective Edge. This could be the result of more effective Palestinian tactics (such as concentrating heavy mortar fire on single Israeli communities one at a time) and of poor management of Israeli troop concentrations near the Gaza border (crowding of soldiers and visiting families within mortar range). It is reasonable to assume that better management of troop concentration areas would reduce vulnerability to mortar attacks. Government-organized evacuation of non-essential residents from the communities closest to the border should also be considered. Finally, the feasibility of a cost effective mortar interception system should be investigated.

No less significant, the gaps in Israel's active defense array should be plugged. In spite of the impressive increase in the number of Iron Dome batteries, numerous population centers remained undefended, most noticeably against Palestinian allies in Lebanon and Syria. Hamas and Islamic Jihad will surely try to increase the range of their rockets even further, putting more Israeli communities under threat and necessitating the extension of the defensive umbrella.

The ongoing race between offense and defense is far from over. The number of Iron Dome batteries deployed in Protective Edge will not be sufficient for future conflicts. Therefore, increasing the number of batteries and enlarging the defensive footprint of each is essential.

As the “battle of the narrative” is assuming a growing role in the outcome of wars, it is important to improve the IDF spokesperson’s performance regarding the quality and precision of released information. The reputation of Israel’s missile defense success was as crucial as its actual score in persuading international air and shipping lines to keep serving Israel’s air and sea ports during the fighting. Lack of clarity and conflicting information from the IDF is grist to the mills of critics at home and abroad and might thereby erode international confidence in Israel’s defensive capacity with significantly adverse results to Israel’s economy and its capability to see the conflict to a satisfactory conclusion.

Several trends from Protective Edge serve as harbinger of future conflicts. While Hamas’ air capabilities only played a marginal role in Protective Edge, this should not be trivialized. Action from the air is likely to feature conspicuously in any future campaigns. The Gaza factions’ force structure copies – albeit with a time lag – that of Hezbollah. Hezbollah is already operating a large number of Iranian second and third-generation UAVs in Syria for reconnaissance and ground attack missions. In any future war in Israel’s North, Hezbollah is bound to make copious use of its UAV fleet for location and designation of national infrastructures, military installations and troop concentrations, which will then be attacked by its newly acquired pinpoint accuracy smart rockets.

The Israel Air Force wisely transferred the counter UAV mission from its manned combat aircraft arm to its ground-based Air Defense Command. However, it is not clear whether the Patriot, a costly missile designed against even costlier manned combat aircraft, is the optimal weapon against low-cost UAVs. Several cheaper options should be considered. It would be advisable to adapt a cheaper ground-based weapon for that purpose.

No less significant, Protective Edge saw the first “strategic bombing” of Israel’s vital infrastructures. This should ring an alarm bell. While “strategic bombing” was no more than a side show in Protective Edge (save perhaps in the case of Ben Gurion Airport), it is sure to become the main show in any future war.

Particular attention should be paid to the targeting of Israel's offshore gas rigs. The defense of the newly discovered gas fields was tasked to Israel's Navy, which will protect them against terror attacks and surface skimming anti-ship missiles. It would be advisable to add the capability of intercepting ballistic targets including rocket and missile to the Israel Navy's warships.

Finally, Protective Edge, like its predecessor Pillar of Defense, provided what could be a sneak preview into future wars, in which home fronts become the decisive battlefields – home front versus home front – while the frontlines between contending armies are relegated to a secondary, supportive role. Are Israel's wars going to look like this? Only the future will tell.

¹⁰ Week In Review, “Iran Boosts Hamas Rocket Capacity,” *Al Monitor*, July 18, 2014, <http://www.al-monitor.com/pulse/originals/2014/07/iran-hamas-rockets-gaza-mosul-isis-regypt.html>

¹¹ Ali Hashem, “Did Iran Train Gaza Rocket Makers?” *Al Monitor*, July 17, 2014, <http://www.al-monitor.com/pulse/originals/2014/07/gaza-rockets-palestine-iran-self-sufficient.html>

¹² Doron Peskin, “Mortar Bombs: The Knowhow Comes from Iran, Production is in Sudan,” *Calcalist*, August 27, 2014, <http://www.calcalist.co.il/local/articles/1,7340,L-3639316,00.html>.

¹³ Roi Keis, “Reports: IAF struck Sudan Weapon Stockpile,” *Ynet*, July 21, 2014, <http://www.ynetnews.com/articles/0,7340,L-4547369,00.htm>.

¹⁴ “A new Hamas video shows continued rocket manufacturing in Gaza during Protective Edge” (probably an Islamic Jihad rather than Hamas video) posted on YouTube on August 23, 2014, <https://www.youtube.com/watch?v=9GzNDcaFn5k>.

¹⁵ These Grad compatibles had a simplified design. From the video cited in note 14, it can be seen that the Grad compatible rocket has fixed air vanes rather than the spring-loaded, wrap-around air vanes of the original design, making it impossible to fire the local Grad version from standard Grad launch tubes.

¹⁶ “Rocket Threat,” Infographics. “These Hamas Rockets Threaten the MAJORITY of Israel’s Population,” Special Report, Operation Protective Edge. *Israel Defense Forces*, <http://www.idfblog.com/operationgaza2014/#Rockets>.

¹⁷ “Rocket Threats - Articles - “Special Report: The Deadly Rocket Arsenal of Hamas””: Special Report, Operation Protective Edge, *Israel Defense Forces*, July 10, 2014. <http://www.idfblog.com/blog/2014/07/10/6-million-lives-in-danger-the-deadly-rocket-arsenal-of-hamas/>.

¹⁸ Ron Notkin, “50 Days of Fighting, Roger and Out?” (in Hebrew), *Ynet*, August 27, 2014, <http://www.ynet.co.il/articles/0,7340,L-4564529,00.html>.

¹⁹ According to the Meir Amit Intelligence and Terrorism Information Center, only 3,452 rockets and mortar bombs landed within Israel, <http://www.terrorism-info.org.il/he/articleprint.aspx?id=20709>. According to information gathered by the defense correspondent of *Israel Channel 10 TV*, Alon Ben-David, only 3,956 rockets and mortar bombs were fired at Israel, of which 738 were destroyed by Iron Dome.

²⁰ Hamas reported firing 3,621 rockets and mortar bombs and Islamic Jihad reported a total of 3,249 firings. See note 9

²¹ Nehemia Gershuni, "Protective Edge Stats – Israel Gaza War 2014", <https://docs.google.com/spreadsheets/d/1AqLhz84IMCcvopizH52MPKb8gsbLEuBF7U2rk51tFXw/edit?pli=1#gid=0>

²² The Izz al-Din al-Qassam Brigades (Hamas' military wing) bragged in its Twitter account that "for the first time Israel has been assaulted on every front – Gaza, Lebanon, the Golan Heights and Sinai." "Streaming Updates," *Haaretz*, July 15, 2014 at 03:16, <http://www.haaretz.co.il/news/politics/1.2375937>.

²³ Reuter's news agency reported on 8 August 2014 that the Palestinians fired two rockets to the Noah Mediterranean gas field. This caused a several percent drop in the index of energy shares in the Israeli stock market. "Streaming Updates," *Haaretz*, August 21, 2014 at 13:42, <http://www.haaretz.co.il/news/politics/1.2410598>.

²⁴ It was later publicized that the rocket could have been intercepted but was allowed to hit the ground due to flawed rules of engagement. Amir Oren, "The Rocket that Caused Flight Cancellations: An Erroneous Decision by the Air Force," *Haaretz*, July 26, 2014, <http://www.haaretz.co.il/news/politics/.premium-1.2388066>.

²⁵ Some saw the US flight ban to Israel as politically motivated to signal the US administration's dissatisfaction from what was seen as an excessive Israeli aggressive action, in particular due to an alleged attack on a UNRWA school in Gaza the preceding day. See for example Natasha Mosgobia, "The Pressure on Obama's Administration to Lift the Flight Ban is Intensifying.," *Walla Internet News*, July 24, 2014, <http://news.walla.co.il/item/2768683>.

²⁶ "A Heavy Salvo on Israel – Successful Interception by Iron Dome," *Globes*, July 12, 2014, <http://www.globes.co.il/news/article.aspx?did=1000953866>.

²⁷ "NDTV Exclusive: How Hamas Assembles and Fires Rockets," *NDTV*, August 5, 2014, <http://www.ndtv.com/article/world/ndtv-exclusive-how-hamas-assembles-and-fires-rockets-571033>.

²⁸ "Exclusive: Hamas Rocket Pad Revealed Near Gaza Homes," *France 24 TV*, August 5, 2014, http://www.youtube.com/watch?v=uE3feo_b8Cg

²⁹ Ranges are not from the border, but from the rocket launch sites. An advanced version of Iron Dome was developed and tested, but no details about its performance were disclosed. See Idan, Yoav. "An Additional Iron Dome Battery to Be Delivered to the IDF," *NEWS 1*, November 4, 2011, <http://www.news1.co.il/Archive/001-D-313371-00.html>.

³⁰ Yoav Zaitun, "90 Percent Success Rate for Iron Dome, 10 Mortar Bombs Intercepted in the Gaza Envelope," *Ynet*, August 13, 2014, <http://www.ynet.co.il/articles/0,7340,L-4558376,00.html>.

³¹ Amir Oren, "Senator McCain: The Stockpile of Interceptors Available to Israel is Diminishing," *Haaretz*, August 4, 2014, <http://www.haaretz.co.il/news/politics/.premium-1.2396961>.

³² *Ibid*, note 31.

³³ Information found on the Ashdod municipality's website: <http://www.ashdodnet.com/mobile/article/53832>.

³⁴ Shlomo Gazit, "Protective Edge – Three Levels." *Israel Defense*, 30 August 2014, <http://www.israeldefense.co.il/?CategoryID=534&ArticleID=6886>.

³⁵ See the Homeland Defense Association website: <http://www.magenlaoref.org.il/about.html>.

³⁶ Oded Amichai, "Iron Dome's Main Value Is Public Morale," *Haaretz*, August 19, 2014 <http://www.haaretz.co.il/opinions/.premium-1.2410066>.

³⁷ For a detailed interview with Dr. Shefer on this issue see Ran Adelist, "Israel Defense Prize Winner States that 'Iron Dome Is a Hoax'," *Maariv This Week*, March 31, 2013, <http://www.maariv.co.il/news/new.aspx?pn6Vq=E&0r9VQ=IELI>.

³⁸ "The 23rd day of Protective Edge: Watch a Rocket Impact Today in Qiryat Gat," Youtube upload, July 31, 2014, <https://www.youtube.com/watch?v=CxgV1WCUHoc>.

³⁹ For the number of damage claims in the 2006 Lebanon War, <http://www.ynet.co.il/articles/0,7340,L-3994879,00.html>.
For the number of damage claims in Operation Defensive Shield in 2012, <http://www.ynet.co.il/articles/0,7340,L-4315337,00.html>.
For the number of damage claims in Operation Protective Edge in 2014, <http://www.ynet.co.il/articles/0,7340,L-4563165,00.html>.

⁴⁰ According to the CEO of Rafael, Yededia Yaari, the cost of each interception is between \$77,000 and \$90,000 USD, <http://rotter.net/forum/scoops1/161972.shtml>.

⁴¹ Asaf Gibor, " Hamas Confirms: We Have Attack UAVs," *NRG News*, <http://www.nrg.co.il/online/1/ART2/596/246.html>.

⁴² "Reuters: We Have Images of Israeli Bases Taken by the UAV," *Haaretz*, October 10, 2012, <http://www.haaretz.co.il/news/politics/1.1852355>.

⁴³ According to a report, Hamas operatives in the West Bank attempted to carry out a terror attack by UAV, but it was foiled by the Palestinian Authority. See Reuven Salomon, "UAVs in the Hands of Hamas," *Israel Defense*, July 14, 2014, <http://www.israeldefense.co.il/?CategoryID=483&ArticleID=6635>.

⁴⁴ Some in Israel faulted Iron Dome for its success. Right-wing commentators argued that it served as an excuse to avoid a full-scale invasion and reoccupation of the Gaza Strip. Left-wing commentators argued that the security it provided to the home front allowed the government to deliberately prolong the campaign and to use excessive force against Gaza's civilian population. For an example of left-wing commentary, See Uri Misgav, "The Damages from Iron Dome," *Haaretz*, July 11, 2014, <http://www.haaretz.co.il/opinions/.premium-1.2372842>. For an example of right-wing commentary, see Nadav Ha'etzni, "Look Reality in the Eye," *NRG News*, November 21, 2012, <http://www.nrg.co.il/online/1/ART2/417/127.html>.

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