A LAWS OF WAR REVIEW OF CONTEMPORARY LAND-BASED MISSILE DEFENCE SYSTEM 'IRON DOME'

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Abstract

Automated precise guided missile defence has been around for some years, and is a modern-day mechanism used frequently since 2011 to defend against rocket attacks penetrating national airspace. Israel's automated Iron Dome Missile Defence System has intercepted over 1 000 rockets during two recent military campaigns, namely Operation Pillar of Defence in 2012 and Operation Protective Edge in 2014. This 'human-in-the-loop' technology may become increasingly normal in urbanised cities as states look to strengthen their aerial defence capabilities. However, the deployment of advanced sensor-based technology on the battlefield was predicted by the International Committee of the Red Cross (ICRC) in its 1987 Commentary to Additional Protocol I to bring about potentially disastrous consequences. Numerous roboticists, lawyers, and scientists have expressed concern, calling for a ban on similar fully autonomous weapon systems. There is no definitive answer yet as to the legality of actively deploying such a weapon system against rocket attacks. This article considers individual technological design choices made by Iron Dome's manufacturer Rafael Advanced Defence Systems (Rafael) and explains trends as military efficiency is enhanced and legal provisions appear to be honoured within separate elements of the weapon system. Assessing the legalities and efficiencies of Iron Dome could inform future missile defence systems like Denel's Cheetah Skyshield. [1]

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[1] South African Government, Media Statement 'Military Veterans on 1st International Conference on Military Law in South Africa' (4 November 2016). The author "examined Israel's automated Iron Dome Missile Defence System to illustrate issues regarding the uncertain legality of automated systems for aerial defence against missiles and rocket attacks and how certain design choices may be utilised to increase

Legal problems behind contemporary land-based missile defence systems

It is thirty years since the comprehensive prediction by the ICRC in the 1987 Commentary to Additional Protocol I that if mankind does not master technology but rather allows the technology of future arms to master him, then the consequences thereof will be that mankind will be destroyed by technology.[2] The South African National Defence Force (SANDF) already carries the pain of this harrowing commentary prediction. Nine local soldiers were killed by a computerised Swiss/German Oerlikon anti-aircraft weapon system during a live fire exercise at the Army Combat Training Centre at Lohatla in the Northern Cape in October 2007.[3] According to a local press release, this malfunction occurred during the SANDF's Exercise Seboka, which is an annual conventional military exercise involving 5 000 soldiers from 18 army units as well as members of the SA Air Force, SA Navy and SA Military Health Service.[4] Against this prediction of doom and failure arising from automation, similar weapon systems are being produced by international aerospace manufacturers with the most high-profile of its kind being Rafael's Iron Dome Missile Defence System, which has been stationed successfully to defend civilian cities from threatening rocket attacks. In a 2013 article, Yiftah Shapir from the Israel Institute for National Security Studies (INSS) noted that a contemporary land-based missile defence system is a weapon system with no like-for-like competitor. According to Shapir, the only other weapon system in the world designed to shoot down short-range rockets and mortars is the American army's Centurion weapon system, which is based on the naval Phalanx system.[5] This article refers to Iron Dome as 'a contemporary land-based missile defence system'. This general terminology acknowledges the unique technological advances of the weapon system, yet strips away its mystique by terming it as a common noun for possible future production by the arms manufacturers of different states. This terminology also excludes a 2016 update as the Israeli Navy

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both military efficiency and legality by States using, or intending to use, such systems". available at https://www.gov.za/speeches/statement-1st-international-conference-military-law-south-africa-4-nov-2016-0000

[2] ICRC *Commentary on the Additional Protocols of 8 June 1977 to the Geneva Conventions of 12 August 1949* (1987) at 1476.

[3] Hosken, G, Schmidt, M & Du Plessis, J '9 Killed In Army Horror' *IOL* (13 October 2007), available at https://www.iol.co.za/news/south-africa/9-killed-in-army-horror-374838.

[4] Ibid.

[5] Shapir, Y 'Lessons from the Iron Dome' (2013) 5 *Military and Strategic Affairs* at 84.

successfully installed an Iron Dome battery onto a moving naval vessel termed a C-Dome.[6]

Daphne Richemond-Barak and Ayal Feinberg noted in a 2016 article the questions pertaining to the legality of deploying contemporary land-based missile defence systems in civilian environments.[7] The Max Planck Institute for Comparative Public Law and International Law touched on this legal problem on an online portal on the Israel–Gaza Wars from 2008 to 2014, which it termed a "Debate Map".[8] Francis Grimal noted in a 2014 article on issues of the *jus ad bellum* for proposed theories of automated and anticipatory self-defence, that discussions on missile defence systems, such as Iron Dome and Patriot, are limited for two naive reasons. Either the lawfulness of an inherently defensive system is taken as a given or the strategic implications of rocket interceptions outweigh general concerns over the legality of the weapon system.[9]

One example in the category of general concern was the angry protests and clashes with the police force in South Korea (Republic of Korea [ROK]) in 2017 against the deployment of Lockheed Martin's American-built THAAD (Terminal High-Altitude Area Defence) missile defence system batteries in the town of Seongju in North Gyeongsang Province. These protests occurred despite the THAAD weapon system being a defensive missile shield against escalating tensions and live ballistic missile tests being undertaken by its direct neighbour North Korea (Democratic People's Republic of Korea [DPRK])[10]. Protestors in the ROK raised their rights to peaceful life, health, a healthy environment and freedom of occupation to argue that the deployment of THAAD would be unconstitutional.[11] This protest action furthermore raised environmental, noise and electromagnetic radiation concerns against the THAAD weapon system and argued

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[6] Israeli Navy 'First Arm of the Sea: The Successful Interception of the Iron Dome Rocket Ship at Sea' (Translated) (18 May 2016), available at https://www.youtube.com/watch?v=OMjOP1jHiSI.

[7] Richemond-Barak, R & Feinberg, A 'The Irony of The Iron Dome: Intelligent Defence Systems, Law and Security' (2016) 7 (2) *Harvard National Security Journal* at 472.

[8] Oxford Public International Law 'Mapping the Debate with Oxford Public International Law Israel-Gaza Wars 2008–2014' (13 November 2014), available at http://opil.ouplaw.com/page/israel-gaza-debate-map.

[9] Grimal, F 'Missile Defence Shields: Automated and Anticipatory Self Defence?' (2014) 19 (2) *Journal of Conflict and Security Law* at 318.

[10] Hincks, J 'South Koreans Protest US Missile Installation as Tensions Escalate on the Peninsula' *TIME* (26 April 2017), available at http://time.com/4755310/south-korea-protest-thaad-missile/

[11] 'South Koreans Appeal to Court, Say THAAD is Unconstitutional' *Sputnik News* (7 April 2017), available at https://sputniknews.com/asia/201704071052380181-south-koreans-say-thaad-unconstitutional/.

in favour of a large-scale 12- to 15-month strategic environmental assessment to be concluded on the weapon system prior to deployment.[12] These protests imply that a societal burden is arguably placed on civilians when stationing a potentially unsafe yet key military objective, like a contemporary land-based missile defence system, covertly or, in this case, overtly in or near a civilian environment.

Further to these public protests there have been other views expressed. Stephen Hawking, Elon Musk and hundreds of other scientists and technologists signed a Future of Life declaration against Killer Robots. The ICRC published a number of expert meeting reports on autonomous weapon systems in 2014 and 2016 to clarify their legal views on this complex subject matter further. Human Rights Watch (HRW) weighed in on the topic of autonomous weapon systems and reported, "the debate about fully autonomous weapons has continued to intensify since the issue reached the international stage four years ago". They further stated, "lawyers, ethicists, military personnel, human rights advocates, scientists, and diplomats have argued, in a range of venues, about the legality and desirability of weapons that would select and engage targets without meaningful human control over individual attacks" and "divergent views remain as military technology moves toward ever greater autonomy, but there are mounting expressions of concern about how these weapons could revolutionize warfare as we know it". According to HRW, they wish to "inform and advance this debate by further elaborating on the dangers of fully autonomous weapons and making the case for a pre-emptive ban".[13] Accordingly, the first chapter of their report "elaborates on the legal and non-legal dangers posed by fully autonomous weapons".[14] They state, "the weapons would face significant obstacles to complying with international humanitarian and human rights law and would create a gap in accountability" and "the prospect of weapons that could make life-and-death decisions generates moral outrage, and even the expected military advantages of the weapons could create unjustifiable risks."[15] The report is said to "make the case for a pre-emptive

[12] 'Protestors, Activists Delay South Korean THAAD Environmental Impact Survey' *Sputnik News* (10 August 2017), available at https://sputniknews.com/asia/201708101056362003-south-korea-thaad-protests-delays/.

[13] Human Rights Watch 'Making the Case: The Dangers of Killer Robots and the Need for a Preemptive Ban' (9 December 2016) at 1, available at https://www.hrw.org/report/2016/12/09/making-case/dangers-killer-robots-and-need-preemptive-ban.

[14] Ibid.

[15] Ibid 2.

prohibition on the development, production, and use of fully autonomous weapons".[16] Accordingly –

> [O]f the many alternatives proposed, only an absolute ban could effectively address all the concerns laid out in the first chapter. The ban should accordingly be adopted as soon as possible, before this revolutionary and dangerous technology enters military arsenals. Precedent from past disarmament negotiations and instruments shows that the prohibition is achievable and would be effective.[17]

The real-life example of protests in the Korean Peninsula coupled with the debate in academic literature generates a modern-day problem statement of whether or not it is legal to deploy a contemporary land-based missile defence system in or near a civilian environment. This problem statement requires a comprehensive solution on the legal rationale underpinning the deployment of such a weapon system. Following this introductory discussion of the legal problem to be investigated, it is necessary to provide an overview of the functionality of a contemporary land-based missile defence system, Iron Dome, which is done in the next section. Following that, evidence of an existing international military law framework is provided, which can justify the use of contemporary land-based missile defence systems even when deployed within civilian environments generally.

Functionality overview of contemporary land-based missile defence systems

A contemporary land-based missile defence system is a mobile yet statically stationed weapon system. According to Shapir, Iron Dome is a regional weapon system, which is a land-based missile defence system deployed to defend an area of 100 km squared.[18] This weapon system provides dual VSHORAD (very short range air defence) as well as C-RAM (counter rockets, artilleries and mortars) capability, and was designed by Israeli companies Rafael, Elta Systems and mPrest to shield civilian populations from unpredictable rocket attacks with ranges of up to 70 km.[19] Each battery consists of Elta Systems' radar, mPrest's control and command centre housing computer servers, and Rafael's armed automated platform or so-called 'missile firing unit' housing up to twenty missiles.[20] Shapir claims that the weapon system has a confidential unpublished rocket saturation

[16] Ibid.
[17] Ibid.
[18] Shapir op cit 86.
[19] Shapir op cit 81.
[20] Ibid.

point at which it becomes overwhelmed by a finite number of rockets and can no longer respond.[21] The land-based missile defence system is managed by humans; however, due to the number of rockets capable of being fired unpredictably towards local national airspace without prior warning, the weapon system has been designed technologically to respond with an automated setting. The missile defence system targets and engages belligerent rockets entering local airspace by predicting the population density of the region where the rocket is headed. The weapon system then decides whether or not to launch a precise guided interceptor to intercept an incoming rocket in the sky. If it computes that an active rocket interception within the protected region will be necessary, the weapon system responds with a Tamir interceptor that will detonate adjacent to these rockets in the sky to destroy them whilst in flight to minimise civilian casualties. However, the falling debris from the point of interception could be potentially lethal for the civilian population below. Rafael and mPrest's online marketing material states that the target warhead is detonated over a neutral area to reduce the collateral damage done to the protected region.[22] While the weapon system has an exceptionally high claimed rate of accuracy with best reported figures sitting at 84% during Operation Pillar of Defence in 2012 and 91.3% during Operation Protective Edge[23] in 2014, it does not provide 100% protection for its protected region.

Classifying contemporary land-based missile defence systems as automated human-supervised weapon systems

In the 2014 ICRC expert meeting report on autonomous weapon systems, it was stated that there was no internationally agreed definition of autonomous weapon systems at the time. For the purposes of that meeting, autonomous weapon systems were defined as weapons which independently select and attack targets with autonomy in their critical function of acquiring, tracking, selecting and attacking targets.[24] The 2016 ICRC expert meeting report on autonomous weapon systems however established a working definition of autonomous weapon systems as being weapon systems with autonomy in their critical functions meaning that

[21] Ibid 85.
[22] 'Iron Dome Command and Control Centre' *mPrest* (2011), available at mprest.com/images/pdfs/Air-defense-Iron_dome.pdf.
[23] Richemond-Barak & Feinberg op cit 525.
[24] ICRC *Report on the ICRC Expert Meeting on Autonomous Weapon Systems: Technical, Military, Legal and Humanitarian Aspects, Geneva Meeting Highlights* (2014) at 1.

they are designed to select and attack targets without human intervention.[25] This meeting also categorised missile and rocket defence weapons, such as the Israeli Iron Dome and American THAAD weapon systems, as a particular category of autonomous weapon systems.[26] Before delving into the design choices of a contemporary land-based missile defence system, it is necessary to set out the three broad categories of autonomous weapon systems as listed by Markus Wagner in his 2016 article on autonomous weapon systems. Thereafter it is also necessary to classify Iron Dome formally as an automated human-supervised weapon system by legal definition.

Proving an automated nature

Wagner utilised a modern clustered classification in 2016 when he outlined three categories of autonomous weapon systems. He explains that autonomous weapon systems are unmanned in nature and the three categories of autonomous weapon systems span from a high degree of human control to a lack of human control in operation. The three categories are accordingly remote-controlled, automated and autonomous.[27] These categories cluster the previous categorisations of the US Department of Defence Directive 3000.09 of November 2012 – which is freely accessible online – as well as categorisations used by the ICRC in their 2014 expert meeting report on autonomous weapon systems.

Wagner's categories differentiate between semi-autonomous (human targeting coupled with computerised engagement) and fully autonomous (computerised targeting coupled with computerised engagement) as a first sub-categorisation. This is followed by the weapon system being either automated (the machine is unable to learn further or make dynamic discretionary decisions) or artificially intelligent (the machine is able to learn further and is able to make dynamic discretionary decisions) as a second sub-categorisation. According to Wagner's clustered classification, a contemporary land-based missile defence system is an automated weapon system. It is a fully autonomous weapon system utilising machine targeting coupled with machine engagement, which is

[25] ICRC *Report on the ICRC Expert Meeting on Autonomous Weapon Systems: Implications of Increasing Autonomy in the Critical Functions of Weapons* (2016) at 8.
[26] Ibid 10.
[27] Wagner, M 'Autonomous Weapon Systems' (2016) *Max Planck Encyclopedia of Public International Law* at 2. Available at http://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e2134?rskey=yfEgx9&result=1&prd=EPIL

furthermore automated in nature as the weapon system is unable to learn or make dynamic discretionary decisions.[28]

The 2014 ICRC expert meeting report on autonomous weapon systems states that such automated weapons exist on the battlefield and they tend to be very constrained in the tasks they perform as they are defensive target vehicles or objects as opposed to humans and are deployed in simple, static and predictable environments.[29] This report also emphasises that military capability advantage, necessity for autonomy, and reliability of communication links are the major factors for desiring autonomy in weapon systems. However, the report thereafter lists criteria to determine whether a level of autonomy will be acceptable in existing weapon systems. These criteria – many of which justify the level of autonomy of contemporary land-based missile defence systems – are:

- a defensive task or an offensive task;
- object targets or human targets;
- kinetic or non-kinetic force;
- a simple environment or a cluttered environment;
- the ease of target discrimination in a particular context;
- the degree of human interaction and oversight;
- limited freedom to move in space or large freedom to move in space;
- a small time frame of an attack or a long time frame of an attack; and
- the predictability, reliability and trust in the weapon system.[30]

Proving a human-supervised nature

Schmitt states that Iron Dome is human-supervised in nature.[31] This is echoed by Kenneth Anderson and Matthew Waxman who state that human supervisors can activate and override such a weapon system.[32] A human-supervised weapon system is expressly defined in the US Department of Defence Directive 3000.09 of 2012. This is defined as an autonomous weapon system, which is designed to provide human operators with the ability to intervene and terminate

[28] Wagner op cit 6.
[29] ICRC (2014) op cit 1.
[30] Ibid 7.
[31] Schmitt, M 'Autonomous Weapon Systems and International Humanitarian Law: A Reply to the Critics' (2013) (2) *Harvard National Security Journal* at 4.
[32] Anderson, K & Waxman, M *Law and Ethics for Autonomous Weapon Systems: Why a Ban won't Work and How the Laws of War Can* (Hoover Institute, Stanford University 2013) at 1.

engagements, including the event of a weapon system failure before unacceptable damages occur.[33]

mPrest illustrates this setup as the command and control centre of a contemporary land-based missile defence system which allows for a battle-situation picture officer, two interception officers, a commander as well as a system officer.[34] This is in line with section 4(a)(2)(b) of US Department of Defence Directive 3000.09, which calls for prudent human interaction with the weapon system as well as section 4(a)(3)(a–c) of US Department of Defence Directive 3000.09, which calls for understandable feedback and instructions from the platform interface.

Proving weapon system by definition

The definitions listed in the 2009 *HPCR Manual on International Law Applicable to Air and Missile Warfar*e (HPCR Manual) can prove that a contemporary land-based missile defence system is a weapon system. Richemond-Barak and Feinberg state that there is an absence of definition in terms of whether an automated missile defence system is indeed a weapon system. and this prevailing situation would leave the law governing the use and deployment of the weapon system to be dependent on context and interpretation.[35] While the HPCR Manual does not constitute a binding source of law, its rules are seen to be of strong academic weight. The 2009 HPCR Manual however is an expert academic compilation and restatement of law applicable to air and missile warfare excluding issues of the *jus ad bellum* and recourse.[36] It has been cited as being authoritative by multiple authors including Bruno Demeyere and Yoram Dinstein who not only co-ordinated and supervised the drafting of the HPCR Manual but also authored the Max Planck Institute's encyclopaedia entries on missile warfare and air warfare respectively.

In an air and missile context, a weapon system in its totality does indeed constitute a means of warfare per Rule 1(t) of the HPCR Manual, as 'means of warfare' is defined to mean weapons, weapon systems or platforms employed for the purposes of attack. The 2010 HPCR Manual Commentary elaborates on this point as a weapon system consists of one or more weapons with all related equipment, materials, services, means of delivery and means of deployment

[33] US Department of Defence *Directive 3000.09 Autonomy in Weapon Systems* (2012) at 14.
[34] mPrest op cit.
[35] Ibid 499.
[36] HPCR *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* (2010) at 5.

required for the self-sufficiency of the weapon system. Furthermore 'means of warfare' is explained by the HPCR Manual to be a broader concept than weapon, for it extends also to platforms and equipment that make an attack possible.[37]

Outlining an existing international law framework for contemporary land-based missile defence systems

In October 2017, HRW argued for a ban on lethal fully autonomous weapon systems, which could closely resemble contemporary land-based missile defence systems set on automated mode (potentially lacking meaningful human control) causing collateral damage to civilians. In both potential instances, a machine would be deciding which humans would live and which humans would die. HRW inferred that new law could be created to regulate or ban these weapon systems. In a statement made to the United Nations General Assembly First Committee on Disarmament and International Security, HRW stated,

> The Group of Governmental Experts has been tasked with further exploring the issue and agreeing, if possible, on recommendations on options. Identifying such options at the CCW [Convention on Conventional Weapons] should be a swift exercise as there are only three real outcomes: 1) a ban protocol, or 2) a protocol containing restrictions (regulation), or 3) no new protocol. Since 2013, 19 countries have endorsed the call to ban fully autonomous weapons, which is a goal shared by our Campaign to Stop Killer Robots. Dozens more have affirmed the importance of retaining meaningful or appropriate or adequate human control over critical combat functions. This level of interest in taking action shows there is likely a strong foundation of support for creating new international law.[38]

Richemond-Barak and Feinberg argue that International Humanitarian Law does not address defence systems or the reflexive dilemmas that their deployment and use may create.[39] However, Article 49 of Additional Protocol I could serve as the fundamental logical backdrop for active interceptions of a contemporary land-based missile defence system. An 'attack' is defined therein as an act of violence against the adversary, which could be either offensive or defensive in nature. This provision expressly refers to offensive or defensive land, air and (or even) sea

[37] HPCR (2010) op cit 55.
[38] HRW 'Statement to the UN General Assembly First Committee on Disarmament and International Security' (10 October 2017), available at https://www.hrw.org/news/2017/10/10/statement-un-general-assembly-first-committee-disarmament-and-international-security.
[39] Richemond-Barak & Feinberg op cit 480–1.

attacks, which may affect the civilian population, individual civilians or civilian objects on land. According to Additional Protocol I Commentary, the word 'attack' is unrelated to aggression, and simply refers to the use of armed force to carry out a military operation at the start of or during armed conflict.[40] The 2010 HPCR Manual Commentary furthermore asserts that the phrase 'international armed conflict' as expressly utilised in Additional Protocol I, does not only cover wars but also situations falling short of war irrespective of intensity and duration, such as a single cross-border rocket attack.[41]

Two further fundamental legal premises for an active interception also exist. Rule 22(a) of the HPCR Manual clearly shows a rocket to be a legitimate military objective for interception by its very nature of being a weapon. Furthermore, Article 58(b) of Additional Protocol I is a provision, which requests that parties to a conflict avoid locating military objectives within or near densely populated areas. According to the 1987 ICRC Commentary on Additional Protocol I, this provision is open-ended as it does not affect a party's freedom to organise its national defence to the best of its ability in the most effective way. In this regard, a party to a conflict cannot be expected to arrange its armed forces and installations in such a way as to make them conspicuous to the enemy.[42]

In simple English, these provisions demonstrate an existing international law framework for contemporary land-based missile defence systems. These provisions prove that international law applies to defensive actions on land, which are not aggressive and which actually fall short of war – irrespective of intensity or duration – when targeting rockets, even when placed in a civilian environment

Having established this existing international law premise, it is necessary to evaluate each design choice of contemporary land-based missile defence systems. A positive trend will be proved in the weapon system as it will be argued that as many as seven component design choices within the weapon system all honour a legal provision and make the military operation even more efficient.

The first design choice

The first design choice comprises a mobile unit with a limited geographical radius. This links to Article 40 of the Hague Rules of Air Warfare and enhances efficiency by eliminating illegal interceptions in neutral airspace and controversial interceptions in enemy airspace. Israel's missile defence technology is staggered in

[40] ICRC (1987) op cit 1882.
[41] HPCR (2010) op cit 39.
[42] ICRC (1987) op cit 2243–6.

three geographic levels, starting with Iron Dome for short-range attacks, David's Sling (also known as 'Magic Wand') for longer-range attacks, and the third-generation Arrow missile defence system, which is the world's first nationwide missile defence system. Iron Dome is therefore a regional weapon system designed to intercept aerial threats of an unpredictable and asymmetric nature. The name 'Iron Dome' is a loose English translation of the Hebrew name *Kipat Barzel*, which literally means 'Iron Skullcap'. This name alludes to a defined and robust circumference of three-dimensional protection afforded by a contemporary land-based missile defence system. In 2012, this name was paired with the Hebrew name *Amud Anan* literally meaning 'Pillar of Cloud' – a reference to biblical protection afforded to the Israelites during the Exodus (13:21). Accordingly, "The LORD went before them by day in a pillar of cloud to lead them the way and by night in a pillar of fire to give them light." Iron Dome's manufacturer, Rafael, expressly states that its weapon system is mobile yet produces a protective region of 70 km against rocket fire.[43] As mentioned before, Shapir notes that the weapon system is regional in nature with a closed protective footprint of about 100 kilometres squared.[44] In his 2013 article on autonomous weapon systems, HPCR core expert Michael Schmitt generally refers to maximum range and human operator pre-programming as limiting features of autonomous weapon systems.[45]

This limited geographical radius is important to note for a contemporary land-based missile defence system, as the initial issue that needs to be assessed when examining an active missile-to-rocket interception is the nature of airspace and its subsequent limits. Stephan Hobe explains that airspace is the space above the earth's surface and the medium which facilitates international air and missile law. Airspace is essentially the medium through which missiles are launched and aircraft fly.[46] While Hobe acknowledges that airspace is not entirely conclusive it is different to the concept of territory in Public International Law.[47] Airspace is formally defined by Rule 1(a) of the HPCR Manual as the air up to the highest altitude at which an aircraft can fly and below the lowest possible perigee of an

[43] Rafael Advanced Defence Systems 'Iron Dome Defence against Short Range Rockets' (2014), available at http://www.rafael.co.il/Marketing/186-1530-en/Marketing.aspx?searchText=iron+dome.

[44] Shapir op cit 86.

[45] Schmitt op cit 13–4.

[46] Hobe, S 'Airspace' (2008) *Max Planck Encyclopedia of Public International Law* at 1. Available at http://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e1138?rskey=W6qIIO&result=1&prd=EPIL

[47] Ibid 4.

earth satellite in orbit.[48] This rule further acknowledges two airspace categories of national airspace and international airspace, which are not subject to the sovereignty of any state. It is necessary to examine the horizontal and vertical limits of national airspace to understand the need for a geographical restriction on the weapon system as well as the military efficiency which it creates. Hobe states that the horizontal limit of national airspace is set at national borders that surround state territory, territorial seas and archipelagic waters.[49] According to Jan Wouters and Bruno Demeyere, the vertical limit of airspace is academically disputed;[50] however, Hobe states that it is generally agreed to exist at a point called the Von Karman line, which is situated at the edge of space 100 km above sea level.[51] Article 40 of the 1923 Hague Rules of Air Warfare is the legal provision, which is honoured by the geographical limit of a contemporary land-based missile defence system. This legal provision expressly prohibits belligerent military aircraft from entering the jurisdiction of a neutral state. However, upon a deeper look into the literature, Article 40 of the 1923 Hague Rules of Air Warfare was said by HPCR core expert Michael Bothe in 2011 to prohibit flight objects such as rockets and missiles from entering neutral airspace.[52]

Demeyere analytically defines the three regular regions in which missile operations may take place, namely a belligerent's own national airspace, the enemy's national airspace and international airspace. Demeyere further states that missile transmissions through outer space (even over neutral states) are also valid as a fourth region due to a loophole in the wording of the 1967 Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including The Moon and Celestial Bodies.[53] Demeyere further emphasises the absolute inviolability of neutral state airspace for missile transmissions. Missile

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[48] Program on Humanitarian Policy and Conflict Research at Harvard University (2013), *HPCR: Manual on International Law Applicable to Air and Missile Warfare*. Cambridge: Cambridge University Press.

[49] Ibid 2.

[50] Wouters, J & Demeyere, B 'Overflight' (2008) *Max Planck Encyclopedia of Public International Law* at 2. Available at http://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e1204?rskey=kkTRol&result=1&prd=EPIL

[51] Hobe op cit 9–13.

[52] Bothe, M 'Neutrality, Concept and General Rules' (2011) *Max Planck Encyclopedia of Public International Law* at 91. Available at http://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e349?rskey=pc0GAi&result=1&prd=EPIL

[53] Demeyere, B 'Missile Warfare' (2011) *Max Planck Encyclopedia of Public International Law* at 16. Available at http://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e339?rskey=JrpjVR&result=1&prd=EPIL

transmissions through neutral airspace are prohibited if they are launched from within a neutral state or even pass through neutral airspace for a short period of time.[54] Missile transmissions through neutral airspace are also prohibited even if the military target is located outside the neutral state. This prohibition cannot be waived even if the neutral state consents to such an unlawful penetration of its airspace.[55]

While a mobile geographical limit facilitates Article 40 of the Hague Rules of 1923, it also enhances military efficiency as air force commanders can control the interception circumference to affect early warning, evacuation and extra protective measures, such as bomb shelters, within the local state civilian population as per Article 57 of Additional Protocol I and Article 58 of Additional Protocol I avoiding controversial civilian casualties in enemy territory as well as illegal civilian casualties in neutral territory.

The second design choice

The second design choice is selective targeting. This links to Article 51 of the Charter of the United Nations, and enhances efficiency by saving ammunition. Rafael expressly states that the Iron Dome weapon system provides robust yet selective defence, meaning that a contemporary land-based missile defence system does not fire an interceptor to eliminate every single rocket entering its protected region.[56] The Iron Dome has been programmed with the ability to predict when rockets will fall into populated areas, such as urban city centres, within its protected area versus rockets headed towards empty areas, such as the ocean or open fields.[57] In 2013, Shapir discussed the number of ignored rocket threats faced by Iron Dome during Operation Pillar of Defence in 2012 noting that Iron Dome intentionally ignored 875 out of 1 506 rockets during this military operation.[58]

In this regard, in 2011, Demeyere highlighted a proportional relationship between the distance a missile could be launched and the accuracy that a missile possesses versus its economic cost. He explained the economic reality that high-end missiles remain out of reach of many states and it is these high costs that create asymmetries in an air and missile context.[59] Shapir explains that a contemporary land-based missile defence system utilises incredibly expensive interceptors, which

[54] Ibid.
[55] Ibid 13.
[56] Rafael Advanced Defence Systems op cit.
[57] Ibid.
[58] Shapir op cit 83.
[59] Demeyere op cit 3.

may cost between 45 000 and 50 000 US dollars (USD) apiece. To compound the issue of high cost, Shapir acknowledges that on occasions, Iron Dome may need to launch two missiles in order to guarantee a successful rocket interception, which implies that the cost of one rocket interception may be close to 100 000 USD.[60] While Rafael markets the selective targeting feature Iron Dome proudly as being cost-effective, this weapon system design choice is seemingly necessitated by a legal provision as it honours Article 51 of the United Nations Charter in terms of individual self-defence.

As a starting point to explain this relationship, Wagner expressly stated in 2016 that the use of an autonomous weapon system does not render a military operation illegal as per the *jus ad bellum* and that an enquiry into a breach of the *jus ad bellum* is generally conceptually separate from the inquiry into the weapons used to attack.[61] In 2014, Grimal stated that the mere stationing of a missile defence system does not violate the *jus cogens* norm of the prohibition of the use of force as per Article 2(4) of the United Nations Charter implying that an active missile launch would indeed trigger a violation of this provision.[62] This idea is re-enforced by Oliver Dorr who stated in 2011 that the prohibition against the use of force is determined by what is meant by force, and that force can only be interpreted to mean a military force much like a missile launch.[63] Therefore, whilst a conceptually separate enquiry exists between the *jus ad bellum* and *jus in bello*, on a case-by-case and unique basis, Rafael was seemingly legally obligated to programme a selective targeting feature to honour Article 51 of the United Nations Charter on the occasion of every active interception.

Christopher Greenwood explained in 2011 that there is a specific rule as per the International Court of Justice (ICJ) in the Nicaragua Case according to which self-defence only warrants measures that are both proportional to the armed attack and necessary for response.[64] Rocket attacks headed towards a populated area would necessitate a missile launch, which could be justified by the inherent right of a state to individual self-defence as per Article 51 of the United Nations

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[60] Shapir op cit 85.
[61] Wagner op cit 11.
[62] Grimal op cit 333.
[63] Dorr, O 'Use of Force, Prohibition of' (2011) *Max Planck Encyclopedia of Public International Law* at 11. Available at http://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e427?rskey=wU8voz&result=1&prd=EPIL
[64] Greenwood, C 'Self Defence' (2011) *Max Planck Encyclopedia of Public International Law* at 25. Available at http://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e401?rskey=hdRrpE&result=1&prd=EPIL

Charter if an armed attack was to occur against a member state of the United Nations. Alternatively, according to Alan Baker (2014), the 1837 Caroline Case established a customary international law right to self-defence in the face of necessity which is instant, overwhelming, leaving no choice of means and no moment of deliberation. This case was cited by Baker on the Max Planck Debate Map arguably to cut and paste this legal principle into the contemporary era of cross-border rocket attacks.[65]

As to whether or not a rocket attack is an armed attack for purposes of justifying the military force of an Iron Dome missile launch, HPCR core expert Arne Willy Dahl stated in 2014 on the Max Planck Debate Map that the cross-border launching of rockets, which carries explosive payloads is a clear example of an armed attack. Accordingly, if the rocket launch is an isolated or uncommon event then countermeasures may be taken as long as they remain within the realm of self-defence necessity and proportional counterforce.[66] An armed attack can further be proved by definitions as Grimal stated in 2014, that an imminent missile launch would qualify as an armed attack[67] and a missile can be proved to be a rocket by definition within the Commentary on the HPCR Manual.[68] Accordingly, a rocket refers to any object which utilises a propellant to create thrust by expelling exhaust gas to move the object forward, and the term 'rocket' includes but is not limited to missiles.[69]

The scale and effect of rocket attacks qualifying as an armed attack, as opposed to a mere frontier incident, when headed towards a civilian environment as per Karl Zemanek's 2009 commentary on the Nicaragua Case,[70] are also outlined in the 2015 Israeli Foreign Ministry Report on the 2014 Gaza Conflict. The Israeli Foreign Ministry cited long-term physical, social and psychological trauma to Israeli civilians[71] while Shapir cited intensive economic loss from

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[65] Baker, A 'The Latest Hamas-Israel Confrontation Some Pertinent Legal Points' (Jerusalem Centre for Public Affairs Israeli Security Regional Diplomacy and International Law 2014), available at http://jcpa.org/article/hamas-israel-confrontation-legal-points/.

[66] Dahl, AW 'International Laws Apply To Gaza as Well' (Europe Israel Press Association 30 July 2014), available at http://eipa.eu.com/2014/07/international-laws-apply-to-gaza-as-well/.

[67] Grimal op cit 336.

[68] Baker op cit.

[69] HPCR (2010) op cit 50.

[70] Zemanek 'Armed Attack' (2009) *Max Planck Encyclopedia of Public International Law* at 7. Available at http://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e241?rskey=jgZGxh&result=1&prd=EPIL

[71] Israel Ministry of Foreign Affairs 'The 2014 Gaza Conflict: Factual and Legal Aspects' (2015), available at http://mfa.gov.il/MFA/ForeignPolicy/Issues/Pages/Special-Report-by-Israel-The-2014-Gaza-Conflict-Factual-and-Legal-Aspects.aspx.

standstills and stay-ins in every individual rocket attack.[72] Selective targeting is therefore both a very important and an innovative technological design choice as it is not sufficient merely to build an automated missile launcher which targets and engages every single incoming aerial threat. Selective targeting is a design choice, which honours Article 51 of the United Nations Charter for self-defence in terms of necessity as well as the customary international law right to self-defence as stated in the Caroline Case of 1837. The saving of interceptors enacted through selective targeting further enhances military efficiency in terms of both monetary cost and increased air force resources.

The third design choice

The third design choice is a precise guided surface-to-air C-RAM interceptor. This links to the St Petersburg Declaration as well as Article 57 of Additional Protocol I and enhances efficiency by creating safer aerospace conditions for aircraft. Rafael expressly states that its interceptor missiles approach aerial targets such as rockets, artilleries and mortars in the sky. In doing so, radar is used to guide the missiles within passing distance of aerial targets for interceptions.[73] In order to explain what is meant by a guided missile, it is first necessary to contextualise missiles within Public International Law.

In assistance thereof, one must analyse the St Petersburg Declaration of 1868. The St Petersburg Declaration bans bursting ammunition with a weight below 400 grams. However, against this set legal threshold, Bruno Demeyere expressly states that missiles weigh more than this and that missiles, such as bullets, also constitute bursting ammunition.[74] For the purpose of contemporary military law, an interceptor could be viewed as an applied version of a bullet. Article 18 of the Hague Rules of Air Warfare further reinforces the use of missiles generally stating that the use of tracer, incendiary or explosive projectiles by or against air is not prohibited. Demeyere explains that until recently – unlike other weapons which are used in international armed conflicts – missiles had not even been defined in legal literature. Missiles were not defined in any treaty and therefore, according to Demeyere, it was not actually possible to view missiles from anything more than the point of view of military doctrine.[75] Demeyere goes so far as to say that no treaty addresses missiles nor have states ever attempted to address missiles in a treaty. This however does not place missiles into a black hole

[72] Shapir op cit 85.
[73] Rafael Advanced Defence Systems op cit.
[74] Demeyere op cit 18.
[75] Ibid 11.

or vacuum as they are still weapons whose use must be regulated by and judged against the laws of war, especially the *jus in bello*.[76] In 2009, Rule 1(z) of the HPCR Manual closed this gap with an expert manual-based definition for missiles, defining missiles as self-propelled unmanned weapons – launched from aircraft, warships or land-based launchers that are either guided or ballistic,[77] forming a mutually exclusive classification.

Demeyere outlines the main characteristic of ballistic missiles stating that these missiles rely solely on gravity once fired.[78] The HPCR Manual explains the difference between a guided missile and a ballistic missile, stating that a guided missile is technologically designed with a built-in contingency or second-chance mechanism to divert the missile if civilians come between the missile and the legitimate military target.[79] Demeyere however notes that there is no actual difference in legality between guided missiles and ballistic missiles and that no statement can be made generally that a guided missile will perform in a more legal manner than a ballistic missile. Accordingly, both types of missiles are fundamentally legal but both could be utilised in a legal or illegal manner.[80] The HPCR Manual Commentary emphasises this point by stating that there is no express obligation in either treaty or customary law to utilise expensive precision-guided weapons.[81] Therefore, apart from being precise or imprecise in nature as well as being either guided or ballistic, the HPCR Manual Commentary further classifies missiles as being surface-to-surface, surface-to-air, air-to-surface or air-to-air.[82]

With regard to Article 57 of Additional Protocol I, the design choice of such an advanced guided and precise surface-to-air interceptor honours the principle of precaution.[83] As both ballistic missiles and guided missiles are equally legal in nature, this is a design choice, which facilitates precaution as Rafael's Tamir interceptors can be diverted if a non-enemy aircraft intervenes. Demeyere confirms this idea when he states that a guided missile launch would be terminated

[76] Ibid 5–7.
[77] Ibid 11.
[78] Ibid 12.
[79] HPCR (2010) op cit 50.
[80] Demeyere op cit 25.
[81] HPCR (2010) op cit 80.
[82] Ibid 50.
[83] Demeyere op cit 26.

by a man-in-the-loop overseeing guidance control if a civilian object intervenes[84] or, alternatively, such could even be done by a computer.[85]

Guided interceptors are more expensive and technologically advanced when compared to ballistic interceptors. However, despite their cost and operational complexity, their very nature leads to a safer airspace environment by adopting a design which facilitates the principle of precaution. Military efficiency is enhanced by this design choice as air force commanders can control the airspace within the protected area of the contemporary land-based missile defence system far more safely by diverting or aborting any active situation in which a civilian aircraft intervenes between missile and rocket. This design choice is paired with specially designated civil aviation flight routes, which also facilitate the principle of precaution through Article 57 of Additional Protocol I.

According to the Israeli Defence Forces, dangerous aerial situations are controlled by using advanced surveillance systems allowing for rocket interceptions moments after civilian aircraft had cleared these designated three-dimensional routes.[86] These advances ensure a far safer aerial environment than ballistic interceptors which, if fired inaccurately through either negligence or intent, cannot be diverted.

The fourth design choice

The fourth design choice is all-weather capability. This links to Article 51(4)(b) of Additional Protocol I and enhances efficiency through increased opportunity for interceptions. Rafael claims that in developing Iron Dome, they have manufactured the world's first day and night, all-weather missile defence system designed to function effectively in all weather conditions, including low clouds, rain, dust storms and fog.[87] The Israeli Defence Forces took this concept to the Instagram social media platform as they publicly posted a photo of an Iron Dome battery claiming its continued full functionality in heavy snow conditions.[88] A contemporary land-based missile defence system can be deployed in adverse weather conditions without affecting its accuracy negatively and threatening civilian aircraft.

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[84] Ibid 26.
[85] HPCR (2010) op cit 50.
[86] 'How Do Passenger Airplanes Fly Through Rockets' *IDF Blog* (14 January 2015), available at https://www.idfblog.com/blog/2015/01/14/passenger-airplanes-fly-rockets/.
[87] Rafael Advanced Defence Systems op cit.
[88] IDF Instagram Account, available at https://www.instagram.com/idfonline/.

Article 51(4)(b) of Additional Protocol I is a generally phrased provision prohibiting indiscriminate attacks, which employ a method (or means) of combat, which is unable to be directed at a specific military objective. The simplest method of combat to conceptualise and which cannot be directed at a specific military objective is sabotaging a weapon directly in order for it to fire inaccurately. The important thing to keep in mind is that in simple conceptual scenarios, the illegal method of combat, which is unable to be directed at a specific military objective, is enacted prior to pulling the trigger. If one uses a weather-vulnerable missile defence system in adverse conditions then this is the applied equivalent of sabotaging a gun before the targeting and engaging of the enemy on the battlefield. This design choice of all-weather capability honours the legal provision of Article 51(4)(b) of Additional Protocol I by eliminating the possibility of an indiscriminate attack by eliminating a method of combat that cannot be directed at a specific military objective. This design choice insulates the system from illegality and also quite logically enhances the military efficiency of the weapon system. This enhanced military efficiency is quite dramatic as a contemporary land-based missile defence system can be deployed accurately to protect a civilian population throughout the day, throughout the night and seemingly throughout even the most adverse weather conditions.

The fifth, sixth and seventh design choices

The fifth, sixth and seventh design choices, namely distinction sensors, proportionality algorithms and single-state production/deployment are unresolved in the literature. These design choices link to Article 48 of Additional Protocol I, Article 51(5)(b) of Additional Protocol I, and the requirements of the Nicaragua Case for collective self-defence. These design choices enhance efficiency by increasing the accuracy of target discrimination, reducing collateral damage in the protected region and eliminating delay for the initial interception.

Rafael expressly states that they have installed sensors in the Iron Dome weapon system.[89] These sensors are utilised much like human eyes to honour the principle of distinction as per Article 48 of Additional Protocol I, which obligates the parties to a conflict to distinguish between the civilian population and combatants and between civilian objects and military objectives at all times and to direct their operations against military objectives only accordingly. Target discrimination between civilian aircraft and enemy militant rockets utilises colour-blind sensors. HPCR core expert Schmitt stated in 2013 that sensors of this type

[89] Rafael Advanced Defence Systems op cit.

distinguish the shape, size and speed and material of an object.[90] Distinction sensors are paired with proportionality algorithms, which make a calculation to intercept rockets over empty areas to honour Article 51(5)(b) of Additional Protocol I.[91] This provision forbids an attack which may be expected to cause incidental loss of civilian life or injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated. These two design choices arguably also follow the overarching trend in the weapon system by honouring legal provisions and enhancing military efficiency. Target discrimination and interception decisions are made quickly and efficiently by the weapon system. Similar decisions cannot be made in time by a human on the ground under the pressure of a rapid rocket attack.

The controversy, however, is whether the initial view of transitioning these human discretionary elements to a weapon system via coding is legitimate and in line with human cognitive function as per Wagner in 2014.[92] Alternatively, the secondary view of human discretion and recourse being traceable back to human commanders, manufacturers and programmers as per the 2014 ICRC expert meeting report on autonomous weapon systems,[93] the 2016 ICRC expert meeting report on autonomous weapon systems,[94] Schmitt in 2013[95] and Rebecca Crootof in 2015, could be conceptually correct.[96] Crootof, for example, expressly states that autonomous weapon systems are weapons (not commanders), which are capable of being used in compliance with the principle of proportionality. The latter view of discretion and legal recourse drawing back to humans is probably most likely, as Iron Dome was only built by Israeli companies as aforementioned, namely –

- Rafael Advanced Defence Systems (based in Haifa), the main weapon system manufacturer;
- Elta Systems (based in Ashdod), the radar manufacturer; and

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[90] Schmitt op cit 11.
[91] Rafael Advanced Defence Systems op cit.
[92] Wagner 'Dehumanization of International Humanitarian Law: Legal, Ethical, and Political Implications of Autonomous Weapon Systems' (2014) 47 (5) *Vanderbilt Journal of Transnational Law* at 1388.
[93] ICRC (2014) op cit 2.
[94] ICRC (2016) op cit 82.
[95] Schmitt op cit 33.
[96] Crootof, R 'Autonomous Weapon Systems and Proportionality' *Volkerrechtsblog* (15 April 2015), available at http://voelkerrechtsblog.org/autonomous-weapon-systems-and-proportionality/.

- mPrest (based in Petach Tikva), the control and command system manufacturer.[97]

Single-state build production is a curious design choice for contemporary land-based missile defence systems, which are technologically advanced. This design choice, however, most likely honours the timeous requirements of collective self-defence. According to the Nicaragua Case, these require a state not only to be entitled to individual self-defence but also to declare itself a victim of an armed attack and also to request assistance from a state for its assistance. In a case of collective security, it appears necessary to receive authorisation from the United Nations Security Council, which is an even more time-intensive requirement.[98]

If the secondary outlook were to be followed, then discretion and recourse for the actions of the weapon system would draw back to the human commanders and human programmers linked to the rocket interception in question. Co-producing or purchasing a contemporary land-based missile defence system would therefore mix the military operation of the missile-to-rocket interception, which would constitute a combined operation in the form of an ad hoc coalition in an air and missile context per Rule 160 of the HPCR Manual. The HPCR Manual Commentary importantly notes that even a mere degree of co-operation between forces is enough to constitute a combined operation.[99]

These requirements for collective self-defence quite logically cannot be met by the time an initial rapid rocket attack or initial rocket barrage is identified in national airspace. This could seemingly create an inefficient and dangerous delay especially if the declaration is to be made to the international community and the request for assistance from another state is formal or timeous. Single-state production therefore also appears to be a design choice, which acknowledges the legal requirements for collective self-defence and makes the weapon system operationally most efficient. It therefore appears that a contemporary land-based missile defence system's autonomous platform (the brains of the weapon system) ideally ought to be built without assistance from another state and it ideally should not be purchased from another state for active deployment.

This collective self-defence dilemma may similarly hold true for the United States THAAD plan for South Korea. The THAAD weapon system is primarily built by the American company Lockheed Martin and is mentioned to function autonomously, much like Iron Dome in the 2016 ICRC expert meeting report on

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[97] Shapir op cit 81.
[98] Greenwood op cit 36–40.
[99] HPCR (2010) op cit 301.

autonomous weapon systems, as its interception is said to be totally autonomous.[100] This inefficiency may similarly hold true but to a far more dangerous and inefficient extent for the collective security missile defence plans of the North Atlantic Treaty Organization (NATO) for Spain, Romania and Poland using American-built Aegis warships[101] unless such could be overcome by some sort of pre-authorisation agreement. A foreign platform paired with a local missile is in fact the converse of the current Iron Dome setup, as American company Raytheon won the contract to produce the Tamir interceptors for use with Israel's locally built platform in September 2014.[102] Raytheon further notes that the United States tested their Tamir interceptors in a local American platform in April 2016.[103] This co-deployment problem underlines a call from the ICRC to reach out and participate with developing countries on the topic of autonomous weapon systems as the majority of countries have not voiced their opinions on this topic.[104]

Concluding thoughts on contemporary land-based missile defence systems

The modern-day concept of contemporary land-based missile defence systems is premised on an existing international law framework. Like the Iron Dome Missile defence system, such a weapon system would not only honour many existing legal provisions but would actually also operate most efficiently. Such a weapon system cannot be the subject of a pre-emptive ban, as seven legal design choices mitigate the one contentious design choice of automation. Autonomy as a concept is not yet catered for under public international law but is rather the subject of a 2012 United States policy directive to which it has been proved that this type of weapon system can comply.

In September 2016, South African aerospace manufacturer Denel Dynamics unveiled plans for an anti-rocket and mortar air defence system to accompany the SANDF through Africa. These plans, which were unveiled at the Africa Aerospace and Defence expo, entailed the pairing of Rheinmetall's

[100] ICRC (2016) op cit 32.
[101] NATO 'Defending our Nations from Ballistic Missile Threats Opinion Piece by NATO Secretary General Jens Stoltenberg' (12 May 2016), available at http://www.nato.int/cps/en/natohq/opinions_130662.htm?selectedLocale=enhttp://www.nato.int/cps/en/natohq/opinions_130662.htm?selectedLocale=en.
[102] Raytheon Company 'Raytheon Awarded $149 Million Contract by Rafael for Iron Dome Interceptor Components' (30 September 2014), available at http://raytheon.mediaroom.com/index.php?s=43&item=2648.
[103] Raytheon Company 'Iron Dome Weapon System: Defence against Rockets, Artillery and Mortars' (c2017), available at http://www.raytheon.com/capabilities/products/irondome/.
[104] ICRC (2016) op cit 42.

unmanned Swiss-built Skyshield platform with a Denel Dynamics South African built Cheetah interceptor missile. In February 2017, this plan appeared to materialise further through Rheinmetall's presentation of its Skynex concept at IDEX 2017 in Abu Dhabi, which further illustrates the fact that these two companies wish to integrate the two components to construct an air defence weapon system.

The seven design choices are crucial as guidance and all-weather capability would be of great operational importance for the Cheetah Skyshield plan if the SANDF intends to deploy such a weapon system within developing countries. Unsophisticated air traffic control and adverse weather conditions will accordingly be prevalent environmental and operational factors to be negotiated. The Cheetah Skyshield will seemingly be mobile (design choice 1), all-weather (design choice 4) and will employ a guided missile (design choice 3). However there is still a gap of research knowledge as to whether this weapon system will utilise selective targeting (design choice 2). The Cheetah Skyshield should by all accounts utilise distinction sensors and proportionality algorithms (design choices 5 and 6) but it seems to lose some legality and efficiency with regard to single-state production/deployment – unless such can be rectified by some sort of pre-authorisation (design choice 7).

While the overarching trend theory presented does not grow the law per se – as an existing international law framework has been argued to have been utilised in an applied manner by Rafael – the positive trend in the weapon system may give a new spin to the economic school of thought in jurisprudence. Law as a tool for efficiency usually relates to commodity purchasing and economic transactions but in contemporary times, this seems to relate to a very smart and combat-proven rocket interceptor also.

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