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Short Range Air Defence: Operational and Technological Developments

by Ottavia Credi, Michelangelo Freyrie, Alessandro Marrone and Michele Nones

ABSTRACT

The Russian invasion of Ukraine has demonstrated how the evolution of air, missile and artillery threats requires an integrated and multi-layered Short and Very-Short Air Defence. The rapid growth in the use of drones by great and middle powers foreshadows operational scenarios of high-intensity conflicts that will require specific and innovative countermeasures. SHORAD and V-SHORAD represent a pivotal element of Italy's defence, both for homeland protection and the security of units deployed abroad. For this reason, Italy is working on the introduction of new defensive systems, the replacement of obsolete ones, and is reflecting on the appropriate doctrinal and organisational changes in its military structures. Defence procurement programmes involve various companies in the Italian industrial sector, called upon to invest in technologies that can match the threat. Italy is also engaged in several international projects, both in the NATO and EU frameworks, and aims at developing interoperable countermeasures systems to strengthen SHORAD and V-SHORAD capabilities of member states, especially in an anti-drone perspective.

keywords

Defence | *Drones* | *Missiles* | *Artillery* | *Ukraine* | *Missions* | *Infrastructure* | *Armed Forces* | *Industry* | *Procurement* | *EU* | *NATO*

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1. The threat in light of the Russian-Ukrainian war

by Ottavia Credi

1.1 The use of systems in Ukraine and its implications

Operational scenarios in which the Armed Forces of NATO countries are called upon to intervene have significantly changed in the post-Cold War era, and continue to evolve. In today's strategic picture, military contingents potentially find themselves operating in symmetric, asymmetric and hybrid scenarios,[1] and, in some cases, such as the Italian one, supporting security operations on the national territory.

Regarding the air-based threat to ground forces, there are several elements of particular relevance. First, there is a tendency to employ less expensive and sophisticated assets, able to work together and be used simultaneously,[2] alongside systems which are hyper-performing but available in small numbers, making them therefore less expendable. Moreover, technological advancements, investments and, more in general, the growth of the Unmanned Aerial Systems (UAS) sector suggest that, in the near future, there will be platforms specifically designed for the military environment. Therefore, these platforms will be usable even in symmetric scenarios, while at the same time being characterised by a cost similar to that of commercial drones, mainly employed in asymmetric and hybrid scenarios.[3] This will strongly impact on defence systems' resistance to "saturation".

The danger posed by air-based threat was already evident during the last conflict in Nagorno-Karabakh in autumn 2020, which saw high-intensity operations between regular (and irregular) armed forces for a month and a half, and significant use of modern weapon systems also supplied by Israel, Russia and Turkey. The 2022 Russian invasion of Ukraine represented a dramatic watershed in this regard, as it represents a conventional and large-scale conflict with the involvement of nearly half a million soldiers and tens of thousands of victims, characterised by a multi-domain dimension but with a strong terrestrial component. The war started on 24 February has seen the extensive use of the entire spectrum of Russian firepower capabilities, from missiles to bombers, with a growing use of artillery and the return of short and medium range weapons.[4]

Russia had already included UAS among its tactical weaponry during the invasion of Crimea, back in 2014.[5] Since then, the country has significantly developed its

[1] Interview, 26 April 2022.
[2] Interview, 27 May 2022.
[3] Interview, 26 April 2022.
[4] Interviews, 20 and 27 May 2022.
[5] Vikram Mittal, "Puzzling Out the Drone War Over Ukraine", in *IEEE Spectrum*, 25 March 2022, https://spectrum.ieee.org/ukraine-drone-war.

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UAS arsenal, which today includes, among others: Eleron-3SV and Orlan-10 drones – used for surveillance and reconnaissance activities – and loitering munitions ZALA Kub-BLA, better known as Lantset[6] and otherwise known as kamikaze drones. The latter are capable of conducting attack and reconnaissance activities. They can fly for an extended time and are equipped with a warhead built into their apparatus which allows them to explode once the target is reached.

Even from the early stages of the conflict, Russia launched short-range ballistic missiles (SRBM), subsequently employing the multiple launch rocket system (MLRS) BM-21, capable of shooting more than 700 missiles simultaneously.[7]

On the other side Ukraine, which possesses reconnaissance UAS such as A1-SM Fury, the Leleka-100 and the Tu-141, has made extensive use of the Bayraktar TB2, a small Turkish-made drone capable of flying autonomously, of employing small anti-tank weapons and acquiring real-time images for reconnaissance and surveillance activities.[8] Kyiv has operated these systems since 2019. Each system includes six drones, two ground control stations and support equipment.[9] TB2s have a 300 kilometres (km) range, about a day of endurance and can carry up to four laser-guided munitions. However, relative slowness, large size, low-altitude flight and radio control make these systems vulnerable to air attacks conducted with more sophisticated systems, as well as electronic warfare (EW).[10]

Several European countries, as well as the United States, have sent armaments to Ukraine. Equipment delivered in the first four month of the conflict include missile systems apt to urban environments, such as the Next Generation Light Anti-Tank Weapon (NLAW). Deliveries also include the Phoenix Ghost and Switchblade systems, i.e., single-use small-sized assault drones, equipped with a camera and an explosive charge.[11]

Even the US-made M142 High Mobility Artillery Rocket Systems (HIMARS) have been used quite effectively by the Ukrainian armed forces, which exploited the full

[6] Ibid.; Roger McDermott, "Russian UAV Technology and Loitering Munitions", in *Eurasia Daily Monitor*, Vol. 18, No. 72 (5 May 2021), https://jamestown.org/program/russian-uav-technology-and-loitering-munitions.

[7] Gerry Doyle et al., "Weapons of the War in Ukraine", in *Reuters Graphics*, 10 March 2022, https://graphics.reuters.com/UKRAINE-CRISIS/WEAPONS/lbvgnzdnlpq/.

[8] Ibid.

[9] Lauren Kahn, "How Ukraine Is Using Drones Against Russia", in *CFR In Briefs*, 2 March 2022, https://www.cfr.org/node/239903.

[10] Ibid.

[11] David Hambling, "Phoenix Ghost, Switchblade and More: Why the U.S. Air Force Is Supplying Ukraine's New Loitering Munitions", in *Forbes*, 22 April 2022, https://www.forbes.com/sites/davidhambling/2022/04/22/phoenix-ghost-switchblade-and-more-why-the-us-air-force-is-supplying-ukraines-new-loitering-munitions; Kevin Carboni, "Cosa sappiamo del nuovo drone suicida che gli Stati Uniti invieranno in Ucraina", in *Wired*, 22 April 2022, https://www.wired.it/article/phoenix-ghost-drone-suicida-stati-uniti-ucraina.

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range of short-, medium- and long-range rockets available for the HIMARS.[12]

Regarding countermeasures systems, Russia is able to identify Ukrainian TB2s, and to target both UAS proper and the land infrastructure necessary for their use.[13] Moscow has also made use of electronic warfare systems to neutralise enemy drones, probably through systems such as Borisoglebsk 2 MT-LB and R-330Zh Zhitel, which act through jamming and spoofing, techniques based on the emission of radio frequency (RF) energy that prevents drones from distinguishing between the single signals it receives.[14] Nevertheless, in the operational theatre, Russian Short and Very-Short Range Air Defence (SHORAD and VSHORAD) has turned out to be less effective than its enemy counterpart.[15]

The conflict in Ukraine is showing that one of the main challenges when talking about aerial defence is that of mission planning.[16] This is partly due to the high levels of assets mobility – hence to the great difficulty in understanding where they are – as well as a saturation of short-range threats, which are becoming numerous and therefore more and more difficult to deal with.

Future scenarios will grow increasingly complex, unpredictable, and characterised by various kinds of threats.[17] In this context, advanced armed forces – also within the framework of international organisations – will soon be called to equip themselves with defensive capabilities that, in addition to being effective, will necessarily have to be competitive also from an economic point of view, in order to guarantee sustainability over time.[18] However, on one hand the speed with which new countermeasures systems are being developed is not sufficient to completely eliminate the threat; on the other it requires a continuous and more complex process of doctrinal adaptation.[19] Even before making practical considerations, it is therefore necessary to reflect at a strategic level on the direction towards which Italy, as well as NATO, intend to direct its Short-Range Air Defence.[20]

1.2 The operational context of Italy's international missions

Italy is currently involved in 40 international military missions in three different continents, with 12,060 units deployed in various operational theatres.[21] The areas

[12] John Psaoruopolos, "'The Russians Have Nothing Equivalent': How HIMARS Help Ukraine", in *Al Jazeera*, 26 July 2022, https://aje.io/222bh6.

[13] Lauren Kahn, "How Ukraine Is Using Drones Against Russia", cit.

[14] Vikram Mittal, "Puzzling Out the Drone War Over Ukraine", cit.

[15] Interview, 27 May 2022.

[16] Ibid.

[17] Italian Army General Staff (SME), *Il Concetto Operativo dell'Esercito Italiano 2020-2035*, 2020, p. 97, https://www.centrostudiesercito.it/doc/CONCETTO%20OPERATIVO%20DELL'ESERCITO.pdf.

[18] Interview, 27 May 2022.

[19] Interview, 26 April 2022.

[20] Interview, 30 May 2022.

[21] Italian Chamber of Deputies-Research Department, "Autorizzazione e proroga missioni

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where Italian troops have been deployed present different and peculiar operational scenarios, with some more exposed than others to the danger represented by aircrafts, missile and artillery assets.

It is necessary to guarantee protection to those units operating abroad, be they military bases of any level, convoys, or mobile formations in close contact with the enemy. Mali, Niger, Iraq and Libya are among the operational theatres that deserve more attention in terms of SHORAD and V-SHORAD.

Until 2022, Italian troops deployed overseas have been especially threatened by the presence of non-state armed groups[22] equipped with drones deemed particularly accessible due to their growing availability on the market and their affordability.[23] Such systems can be employed to conduct attacks against military bases or troops on the move, as well as Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) operations.[24]

Mali and Niger are particularly affected by the risks posed by non-state armed groups in the region. These two countries, where the Italian contingent includes around 600 units,[25] are amongst the ones deemed most exposed to air-based threats to troops and military bases.[26] In October 2021, Russia sent helicopters and other types of weapons and ammunitions to Mali.[27] Such equipment was allegedly meant to help local troops fight against terrorist groups such as Al-Qaeda and the so-called Islamic State (IS), alongside international troops – including Italian ones[28] – operating in the context of the European Union Training Mission (EUTM) and the United Nations Multidimensional Integrated Stabilisation Mission in Mali (MINUSMA). In the first three months of 2022, MINUSMA reported twelve mortar attacks conducted against security forces and the civil population by extremist groups.[29] Against this backdrop, the Italian troops currently deployed to Mali and

internazionali nell'anno 2022", in *Documentazione parlamentare*, 8 August 2022, https://temi.camera.it/leg18/provvedimento/autorizzazione-e-proroga-missioni-internazionali-ultimo-trimestre-2019_d_d_d.html.

22 These may include terrorist, subversive, criminal and other groups.

23 Interview, 30 May 2022.

24 Ester Sabatino and Francesco Pettinari, "The Threats of Dual-use Drones and the Implications for Italy: Executive Summary", in *Documenti IAI*, No. 20|05 (March 2020), p. 3, https://www.iai.it/en/node/11411.

25 Italian Chamber of Deputies, *Relazione analitica sulle missioni internazionali in corso e sullo stato degli interventi di cooperazione allo sviluppo a sostegno dei processi di pace e di stabilizzazione, riferita all'anno 2020, anche al fine della relativa proroga per l'anno 2021*, 30 June 2021, https://www.senato.it/leg/18/BGT/Schede/docnonleg/42762.htm.

26 Interview, 30 May 2022.

27 "Mali Receives Helicopters and Weapons from Russia", in *Al Jazeera*, 1 October 2021, https://aje.io/zhh63s.

28 Italian Ministry of Defence (MoD) website: *Mali - EUTM (European Union Training Mission)*, https://www.difesa.it/OperazioniMilitari/op_intern_corso/MaliEUTM/Pagine/default.aspx; *Mali - MINUSMA - United Nations Multidimensional Integrated Stabilization Mission in Mali*, https://www.difesa.it/OperazioniMilitari/op_intern_corso/MINUSMA/Pagine/default.aspx.

29 UN Secretary-General, *Situation in Mali* (S/2022/278/Rev.1), 13 April 2022, https://undocs.

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Niger in the context of the Task Force Takuba[30] – for consultancy, assistance and mentorship activities to local forces – are potentially exposed to risks. The same is true for the contingent operating in the Bilateral Support Mission in the Republic of Niger (MISIN), aimed to increase competences and capabilities of local security forces.[31]

In Iraq, where Italy took the lead of the NATO Training Mission in May 2022,[32] instability is still spreading, with millions of people in severe humanitarian conditions and a growing terroristic threat posed by the IS.[33] In January 2022, US troops on the field neutralised armed drones flying over an air base in the Western region of the country.[34] Few weeks later, the Kurdish city of Erbil was repeatedly hit by missiles fired by the Iranian Revolutionary Guards, which were trying to attack a Israeli strategic infrastructure.[35] As demonstrated in the context of a Iraqi People's Mobilisation Units' parade in June 2021, the country is equipped with several types of UAS, including the Qods Mohajer-6.[36] The intensification of the conflict in Iraq aggravated the situation of the around 1,200 Italian troops present in the region.[37] They are threatened by islamist extremism on the one hand, and by Iran's military strength on the other hand – the latter clearly manifested during the missile attack on Erbil. Hence, the exacerbation of tensions proved the necessity for an appropriate air defence to protect the military bases present in the region.[38]

In the last few months, Libya has not suffered severe air-based threats. Nevertheless, this might change in the near future. It is therefore paramount that the 400 Italian soldiers involved in the Bilateral Mission for Support and Assistance in Libya (MIASIT)[39] are guaranteed protection, and the same goes for field hospitals

org/S/2022/278/REV.1.

30 Italian MoD website: *Mali - Task Force Takuba*, https://www.difesa.it/OperazioniMilitari/op_intern_corso/Mali_Task_Force_Takuba/Pagine/default.aspx.

31 Italian MoD website: *Missione bilaterale di supporto nella Repubblica del Niger (MISIN)*, https://www.difesa.it/OperazioniMilitari/op_intern_corso/Niger_missione_bilaterale_supporto/Pagine/default.aspx.

32 Ottavia Credi, "L'Italia alla guida della missione Nato in Iraq", in *AffarInternazionali*, 26 March 2021, https://www.affarinternazionali.it/archivio-affarinternazionali/?p=87474.

33 Center for Preventive Action, "Instability in Iraq", in *Global Conflict Tracker*, updated 3 August 2022, https://microsites-live-backend.cfr.org/node/6484.

34 "Two Drones Shot Down Targeting Iraq Base: Anti-IS Coalition", in *The Defense Post*, 4 January 2022, https://www.thedefensepost.com/?p=30680.

35 "Iranian Guards Claim Ballistic Missile Attacks in Erbil", in *Al Jazeera*, 13 March 2022, https://aje.io/ybejz8.

36 Jeremy Binnie, "Iraqi Militias Parade Iranian UAV", in *Janes*, 29 June 2021, https://www.janes.com/defence-news/news-detail/iraqi-militias-parade-iranian-uav; Interview, 30 May 2022.

37 Italian Chamber of Deputies, *Relazione analitica sulle missioni internazionali in corso...*, cit.

38 Alessandro Marrone and Michele Nones, "Le forze italiane in missione all'estero: trend e rischi", in *Documenti IAI*, No. 20|03 (March 2020), p. 5, https://www.iai.it/en/node/11378.

39 Italian MoD website: *Missione bilaterale di assistenza e supporto in Libia (MIASIT)*, https://www.difesa.it/OperazioniMilitari/op_intern_corso/Libia_Missione_bilaterale_di_supporto_e_assistenza/Pagine/default.aspx; Italian Chamber of Deputies, *Relazione analitica sulle missioni internazionali in corso...*, cit.

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such as the one in Misurata. Especially given the lack of an American protective umbrella on the one hand, and recent domestic conflict[40] on the other. Between 2019 and 2020, Tripolitania witnessed a military campaign characterised by a clash between the Government of National Accord (GNA), officially recognised by the international community, and Libyan National Army (LNA). The two factions, competing for the control over Tripoli, made extensive use of drones and combat aircrafts.[41] Such systematic use of UAS demonstrates how in modern conflicts has been largely normalised, due to their high availability to both state and non-state actors.[42]

Other operational theatres may appear more stable, but are nevertheless subject to air-based threats. In Lebanon, Italy has been part of the United Nations Interim Force in Lebanon (UNIFIL) from the beginning. It repeatedly took the lead of the mission, and contributed, with approximately 1,300 units.[43] Rome also participates in the Italian Bilateral Military Mission in Lebanon (MIBIL), with around 300 troops.[44] Israel as well as the Lebanese paramilitary islamist organisation Hezbollah – both of which are equipped with drones, rockets and auto-propelled grenade launchers – conduct reciprocal air raids in the country, exacerbating tensions across the so-called Blue Line.[45] In February 2022, Hezbollah leader Sayyed Hassan Nasrallah declared that the organisation was able to build military drones and to convert hundreds of Lebanese missiles into UAS and precision-strike munitions, which could potentially be used to hit critical infrastructures such as ports and power plants.[46]

In the context of two other international missions, Italy deployed anti-air assets that successfully contributed to the protection of the operational theatre. Within

[40] Interview, 30 May 2022.

[41] Andrea Mottola, "Si mette male per Haftar?", in *Portale Difesa*, 27 June 2019, https://www.rid.it/shownews/3121.

[42] Douglas Barrie, quoted in Tom Kington, "Libya Is Turning into a Battle Lab for Air Warfare", in *DefenseNews*, 6 August 2020, https://www.defensenews.com/smr/nato-air-power/2020/08/06/libya-is-turning-into-a-battle-lab-for-air-warfare.

[43] Italian MoD website: *Libano - UNIFIL (United Nations Interim Force in Lebanon)*, https://www.difesa.it/operazionimilitari/op_intern_corso/unifil/pagine/default.aspx; Italian Chamber of Deputies, *Relazione analitica sulle missioni internazionali in corso...*, cit.

[44] Italian MoD, *La missione militare bilaterale italiana in Libano (MIBIL) addestra le Forze Speciali Libanesi*, 3 November 2017, https://www.difesa.it/OperazioniMilitari/op_intern_corso/MIBIL/notizie_teatro/Pagine/MIBIL_addestra_Forze_Speciali_Libanesi.aspx; Italian Chamber of Deputies, *Relazione analitica sulle missioni internazionali in corso...*, cit.

[45] Italian MoD website: *Libano - UNIFIL*, cit.; see also: "Hezbollah Claims Downing Israeli Drone over Southern Lebanon", in *Al Jazeera*, 1 February 2021, https://aje.io/zkncs; "Israel Fires Missiles at Hezbollah Drone Flown from Lebanon", in *AP News*, 18 February 2022, https://apnews.com/article/d6af7e14d815952c22f3670397623568. For more information on the most recent Israeli violations of Lebanese airspace and incidents involving air systems, see: UN Secretary-General, *Implementation of Security Council Resolution 1701 (2006) during the Period from 19 February to 20 June 2022* (S/2022/556), 14 July 2022, https://undocs.org/S/2022/556.

[46] "Hezbollah Can Turn Rockets into Precision Missiles, Make Drones -Nasrallah", in *Reuters*, 16 February 2022, https://www.reuters.com/world/middle-east/hezbollah-making-drones-can-turn-rockets-into-precision-missiles-nasrallah-2022-02-16.

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the "Inherent Resolve" Operation in Kuwait, the Italian Army stationed the Advance Party of the Task Group *Sol-Air Moyenne Portée/Terrestre* (SAMP/T) at the Ali Al Salem air base.[47] By doing so, the Italian contingent reached the Full Operational Capability (FOC) of its own aerial defence missile system. Lastly, within the Kosovo Force (KFOR) mission, the Italian Army's anti-aircraft artillery resorts to a Counter Unmanned Aerial System (C-UAS) asset aimed at opposing potential threats by employing drones.[48] With this C-UAS system, Italy was able to increase the security level of both military structures located in the theatre and operations conducted in the area.

1.3 Risks for Italian critical infrastructures

Even critical infrastructure on the national territory could be subjected to an air attack, particularly if conducted with a UAS. The consequences of a potential air raid against critical infrastructure could be extremely severe in terms of civilian victims and social and economic implications.[49] For this reason, such an attack would be greatly profitable in terms of cost-effectiveness for both non-state actors, like terrorist groups, and states willing to wage hybrid warfare. On the national level, protection of critical infrastructures from air-based threats is guided by the Anti-Air Artillery Command (COMACA).[50] The Command is responsible for the protection of civilian events, such as sports matches and cultural events. In this context, the Armed Forces are called to cooperate with law enforcement agencies within a framework of public security.[51]

Potential raids against Italian critical infrastructures would likely be conducted by using small-sized and medium-sized UAS.[52] These systems are easily purchasable on civilian markets and are hard to identify with regular radar systems due to their low radar signature.[53]

Beyond the ability to conduct kinetic attacks, drones could also be used to release nuclear, biological, chemical or radiologic (NBCR) substances over critical

[47] Italian MoD, *Kuwait: raggiunta la FOC del sistema SAMP/T dell'Esercito*, 10 July 2022, https://www.difesa.it/OperazioniMilitari/op_intern_corso/Prima_Parthica/notizie_teatro/Pagine/Kuwait_raggiunta_la_FOC_del_sistema_SAMPT_di_Esercito.aspx.

[48] Italian MoD, *Missione in Kosovo: tecnologia C-UAS a supporto della KFOR*, 4 February 2021, https://www.difesa.it/OperazioniMilitari/op_intern_corso/KFOR/notizie_teatro/Pagine/Missione_in_Kosovo_tecnologia_C_UAS_a_supporto_della_KFOR.aspx.

[49] Ester Sabatino and Francesco Pettinari (eds), "La minaccia dei droni duali e le sfide per l'Italia", in *Documenti IAI*, No. 20|04 (March 2020), p. 18, https://www.iai.it/en/node/11410.

[50] See Chapter 2.

[51] Interview, 20 May 2022.

[52] Scott Crino and Conrad Dreby, "Drone Attacks against Critical Infrastructure: A Real and Present Threat", in *Atlantic Council Issue Briefs*, May 2020, p. 6, https://www.atlanticcouncil.org/?p=250570.

[53] Paolo Crippa, "Droni civili contro obiettivi sensibili e infrastrutture critiche: Una nuova tipologia di minaccia", in *CeSI Focus Report*, March 2019, p. 3, https://www.cesi-italia.org/it/articoli/droni-civili-contro-obiettivi-sensibili-e-infrastrutture-una-nuova-tipologia-di-minaccia.

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infrastructure.[54] Similar types of attacks have been conducted in Syria by the self-styled Islamic State.[55]

The concreteness of such a threat is proven by several incidents which took place over the last years. In December 2018, a group of small-sized drones violated the Gatwick Airport (London) safety perimeter, causing a 36 hours long interruption of airport activities, the cancellation of 800 flights and an overall damage of 23 million euro.[56] Similar accidents, even if on a smaller scale, have occurred in the following months in the airports of Heathrow (London) and Malpensa (Milan).[57]

Airports are not the sole critical infrastructures susceptible to air-based threats, as proved by several events on the international stage. In 2019, in a typical scenario of hybrid warfare, the Houthi Yemenite armed group hit two Saudi oil installations by using commercial UAS.[58] The attack severely impacted the global energy market, since the installations were, respectively, the world's most important oil treatment facility and an oil extraction camp of the Saudi company Aramco. In 2020, a DJI Mavic 2 commercial drone has been spotted dangerously approaching a power plant in Pennsylvania (USA), before crushing into a nearby building.[59]

[54] Ottavia Credi, Paola Tessari and Karolina Muti, "Evolution of Radiological and Nuclear Threats: Intermediate Note for Task 3.1", in *Zenodo*, 26 August 2020, p. 23-27, https://doi.org/10.5281/zenodo.4001777.

[55] Claude A. Lambert, "The Chemical and Biological Attack Threat of Commercial Unmanned Aircraft Systems", in *AUSA Spotlight*, No. 20-5 (October 2020), https://www.ausa.org/node/9769.

[56] Paolo Crippa, "Droni civili contro obiettivi sensibili e infrastrutture critiche", cit., p. 1.

[57] "Drone a Malpensa, 4 voli dirottati", in *Ansa*, 1 April 2019, https://www.ansa.it/sito/notizie/topnews/2019/04/01/drone-a-malpensa-4-voli-dirottati_d2c67922-9099-4236-a4dd-eab753e4f857.html; Antonello Guerrera, "Drone a Heathrow, voli in partenza sospesi per quasi un'ora", in *Repubblica*, 8 January 2019, https://www.repubblica.it/esteri/2019/01/08/news/heathrow_droni_voli_sospesi-216113648.

[58] "Attacco al petrolio dell'Arabia Saudita, colpito dai droni l'impianto di lavorazione più grande al mondo", in *Repubblica*, 14 September 2019, https://www.repubblica.it/esteri/2019/09/14/news/arabia_saudita_attacco_petrolio_droni-235972943.

[59] Brian Barrett, "A Drone Tried to Disrupt the Power Grid. It Won't Be the Last", in *Wired*, 5 November 2021, https://www.wired.com/story/drone-attack-power-substation-threat.

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2. Roles and perspectives of UAS

by Ottavia Credi

2.1 Classification methods

Attention toward UAS has increased over the last few years, mainly due to the implications of their proliferation for air defence and, more broadly, homeland security. Attention has kept growing over the last months as well, mainly due to the heavy use of these systems in the Russian-Ukrainian conflict.[60] The classification of UAS is a hotly debated topic: they can range from models with a 25 metres wingspan to mini-, micro- and nano-drones. Even small-sized drones can be a serious threat, as they can equip and launch, with surgical precision, explosive charges or NBCR payloads.[61] Moreover, UAS have far-reaching capabilities in terms of ISTAR activities. Swarms represent an even greater threat, as they would be able to attack multiple targets simultaneously, leading to a saturation of the identification capabilities air defence systems.

NATO classifies UAS by considering the following parameters (see Table 1): category, deployment uses, operating altitude, mission radius and supported command levels.[62] On the basis of these criteria, the Alliance groups UAS in three different classes, which primarily consider the assets' weight.

The main, distinctive parameter used is thus the UAS' weight. Nevertheless, UAS classification should also refer to more operational criteria, such as speed, autonomy, payload and autonomous flight capabilities.[63]

It is also important to distinguish between remotely controlled systems and systems capable of flying autonomously, for instance by being configurated to follow pre-set trajectories. This capability is particularly useful to patrol swaths of territory and in order to guard infrastructure.[64] Furthermore, a UAS capable of following pre-set trajectories, i.e., with the ability to operate whether or not it retains contact with its control station, effectively renders those countermeasures based on cutting the drone's communications ineffective.

The growing complexity of operational theatres (e.g., in terms of target types and quantities) has led to an increasing level of automatisation in air-defence systems,

[60] Interview, 28 July 2022.

[61] See Chapter 1.

[62] Dave Ehredt, "NATO - Joint Air Power Competence Centre", in *2010-2011 UAS Yearbook. UAS: The Global Perspective*, 8. ed., June 2010, p. 61-62, http://www.dcabr.org.br/download/eventos/eventos-realizados/2010/seminario-vant-27-10-2010/cd-uvs-yearbook/pdf/P061-062_NATO_Dave-Ehredt.pdf.

[63] Interview, 26 April 2022.

[64] Francesco Flammini, *Artificial Intelligence (AI) applicata agli autonomous systems*, Rome, Centro Alti Studi per la Difesa (CASD), November 2018, p. 24, https://www.difesa.it/SMD_/CASD/IM/CeMiSS/Pubblicazioni/ricerche/Pagine/Ricerca_AN_SMD_02.aspx.

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as well as the use of innovative technologies (e.g., artificial intelligence) to assess the aerial situation and decrease reaction times. Whilst the use of AI is increasing, it is also debated how to guarantee a human-in-the-loop approach in every phase of the OODA (Observe-Orient-Decide-Act) loop, both when seeking to employ or counter these assets.[65]

Table 1 | NATO classification of UAS

Class	Category	Normal employment	Normal Operating Altitude	Normal Mission Radius	Primary Supported Commander	Example platform
CLASS I (less than 150 kg)	SMALL >20 KG	Tactical Unit (employs launch system)	Up to 5K ft AGL	50 km (LOS)	BN/Regt, BG	Hermes 90 Luna
	MINI 2-20 kg	Tactical Sub-unit (manual launch)	Up to 3K ft AGL	25 km (LOS)	Coy/Sqn	Aladin DH3 DRAC Eagle Raven Scan Skylark Strix T-Hawk
	MICRO <2 kg	Tactical PI, Sect, Individual (single operator)	Up to 200 ft AGL	5 km (LOS)	PI, Sect	Black Widow
CLASS II (150 kg to 600 kg)	TACTICAL	Tactical Formation	Up to 10,000 ft AGL	200 km (LOS)	Bde Comd	Aerostar Hermes 450 iView 250 Ranger Sperwer
CLASS III (more than 600 kg)	Strike/ Combat	Strategic/National	Up to 65,000 ft	Unlimited (BLOS)	Theater COM	
	HALE	Strategic/National	Up to 65,000 ft	Unlimited (BLOS)	Theater COM	Global Hawk
	MALE	Operational/theater	Up to 45,000 ft MSL	Unlimited (BLOS)	JTF COM	Predator B Predator A Harfang Heron Heron TP Hermes 900

Fonte: Dave Ehredt, "NATO - Joint Air Power Competence Centre", cit., p. 61.

2.2 Components

New "systems of systems" are composed by a multitude of sensors and effectors.[66] While the term "sensor" indicates an element capable of measuring a parameter, an "effector" refers to a component capable of modifying its surrounding

[65] Interview, 20 May 2022.

[66] See: Alessandro Marrone and Karolina Muti, "Next Generation Soldier. Executive Summary", in *Documenti IAI*, No. 21|16 (November 2021), https://www.iai.it/en/node/14376.

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environment.[67]

Active sensors such as radars remain fundamental instruments in the detection phase. Nevertheless, the performances of traditional radars are not adequate to detect new UAS threats, in particular those characterised by very low cross-radar sections and speeds under 10 metres per second. Such is the case with mini- and micro-UAS, whose characteristics make them essentially non-traceable for traditional systems that have been developed for very different operational scenarios. Hence, the detection of such threats requires modern radar systems, equipped with state-of-art technologies. These systems should not only be capable of recognising such types of threat, but also to precisely categorise them, since mini- and micro-UAS can be easily be confused with birds.[68]

Nowadays, we observe a marked trend toward cost-effectiveness.[69] Some affordable "smart" sensors are equipped with wireless and hardware communication systems, allowing them to resist even in extreme environmental conditions. These qualities, when combined with autonomy, allow the employment of such sensors for surveillance activities in the military context.[70] Smart sensors represent the very basis of wireless sensor networks (WSN), which are especially used for remote monitoring.[71]

Tracking and intercepting UAS is not an easy task, since the systems can be small and capable of rapidly changing their trajectory.[72] When it comes to the various types of effectors, the ones which are collecting more and more interest from the Armed Forces are those which fall under the category of directed energy weapons (e.g., lasers). This is due to their affordable cost-per-interception ratio, which also renders them useful to counter high numbers of small-sized commercial UAS. Direct energy effectors are also capable of destroying electronic components inside the target itself, disabling it without causing the collateral damage one would incur into by destroying the UAS with kinetic countermeasures. Still, even a disabled UAS could cause some damage falling to the ground. Kinetic effectors, still, remain pivotal as a weapon thanks to their resistance against the enemy's electromagnetic impulses and due to their reliability as a defence of last resort.

2.3 Countermeasures and collateral damages

An increasing trend in countering drones is that of relying on soft kill methods, such as on jammers and spoofers, which disrupt the drone's controls and communications. Even if those methods are considered useful in a national

[67] Francesco Flammini, *Artificial Intelligence (AI) applicata agli autonomous systems*, cit.
[68] Interview, 26 April 2022.
[69] Ibid.
[70] Francesco Flammini, *Artificial Intelligence (AI) applicata agli autonomous systems*, cit., p. 18.
[71] Ibid.
[72] Interview, 28 July 2022.

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setting, in low intensity settings and in urban contexts, they could still turn out to be ineffective in different scenarios, such as in operational theatres abroad.[73] In such cases, hard kill solutions, i.e., kinetic assets like hunting drones, mini-missiles, guns and directed energy weapons, are preferable.[74] It is important to emphasise that SHORAD and V-SHORAD approaches that employ a single type of system have become ineffective and counterproductive, especially against UAS. This is due to the fact that neutralisation techniques are strongly correlated to the type of target and to operational scenarios in which they operate, which can change suddenly and rapidly.[75] In this context, MBDA Italia and Rheinmetall Italia have jointly presented a national and European roadmap towards the development of directed energy weapons to the Italian General Secretariat of Defence (SGD), and, more specifically, to the III Department for Industrial Policy and International Relations.[76]

Autonomous systems are still in an early stage of development, with broad perspectives for improvements and enhancements over the next few years.[77] An issue which still needs to be addressed is that of collateral damage – that is, for instance, civilian victims and material damages caused by the downing of a drone above residential areas. This problem remains unsolved, both on the operational and technical levels.[78] The employment of AI-based algorithms represents a promising option, which would give a preeminent role to Command and Control (C2) capabilities. The implementation of predictive models to elaborate potential collateral effects stemming from SHORAD and V-SHORAD actions would improve decision processes and thus reduce collateral damages.[79]

[73] Ibid.
[74] Interview, 20 May 2022.
[75] Interview, 26 April 2022.
[76] Interview, 27 May 2022.
[77] Jeremy Kahn, "A.I. Is on the Front Lines of the War in Ukraine", in *Fortune*, 1 March 2022, https://fortune.com/2022/03/01/russia-ukraine-invasion-war-a-i-artificial-intelligence.
[78] Interview, 26 April 2022.
[79] Interview, 27 May 2022.

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3. The situation in Italy

by Michelangelo Freyrie and Alessandro Marrone

3.1 Military context

In the context of the Italian military, responsibility for SHORAD and V-SHORAD against drones, artillery, mortar shells and other short-range threats is shouldered both by the Army and the Air Force. Historically, ground-based air defence has within been purview of the Army, and, from 2009, of COMACA, located in Sabaudia. COMACA commands three anti-aircraft artillery regiments, two of which – the 121st Ravenna and the 17th Sforzesca – operate Stingers man-portable air-defence systems (MANPADS). Up until 2021, they also fielded Skyguard systems equipped with Aspide missiles.[80] The 17th regiment's Stingers batteries are also integrated within the National Sea-Projection Capabilities (CNPM) framework, in order to provide anti-air cover during amphibious operations.[81]

COMACA holds primary responsibility over the protection of critical infrastructures on the national territory and for Italian forces abroad. However, it also cooperates with law enforcement agencies during large events, such as the 2021 European Football Championship.

Since 2019, COMACA has also stared operating the Centre of Excellence (CoE) for mini- and micro- UAS, an inter-force body which conducts operational, training, conceptualisation, experimentation and study activities. These activities address the challenge of presenting integrated and adequate countermeasures against both commercial and non-commercial drones, such as the ones deployed in Ukraine. The CoE also contributes to the elaboration of SHORAD and V-SHORAD doctrines for national stakeholders and within the NATO framework. This is done by analysing recent developments such as the Ukrainian conflict and the Nagorno-Karabakh war. Moreover, the Centre is the main referent in Italy for the C-UAS project under the umbrella of the EU's Permanent Structured Cooperation (PESCO).[82]

The Air Force also fields important SHORAD and V-SHORAD units, whose main mission is the protection of national air bases and assets in deployments abroad. The Air Force is equipped with Spada systems produced by MBDA, as well as Aspide missiles, both of which Italy is currently phasing out. The Air Force has also started to take pursue C-UAS capabilities in 2020, thanks to the Survive To Operate/Force Protection (STO-FP) Training Group of the 16th Squadron Force Protection, under

[80] Italian Army, *Conclusa campagna lanci Stinger*, 10 October 2020, https://www.esercito.difesa.it/comunicazione/Pagine/Conclusa-campagna-lanci-Stinger201010.aspx.

[81] Tiziano Ciocchetti, "La situazione delle forze armate italiane: il 17° reggimento artiglieria contraerea 'Sforzesca'", in *Difesa Online*, 6 August 2019, https://www.difesaonline.it/node/12261.

[82] Interview, 20 May 2022.

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the Mobility and Support Force Command.[83]

The first operational deployment of Italian C-UAS capabilities was carried out by the Army in Afghanistan in 2020. The Air Force, on the other hand, has made use of such capabilities during the 2021 Inherent Resolve – Prima Parthica mission, when a task force was deployed during the FIFA Arab Cup to provide countermeasures against mini- and micro-drones. The Italian Armed Forces have also made efforts to integrate its SHORAD and V-SHORAD forces within NATO's Integrated Air and Missile Defence (IAMD), for instance during Ramstein Guard Italy 2021.[84] Further operational deployments include Kosovo (since 2020) and the protection of high-profile events, such as the Russian president's visit in Italy in 2019.

Overall, the military is reflecting on the possibility of including anti-drone capabilities in every combat unit, for instance integrating a C-UAS unit in every regiment. This would extend C-UAS capabilities to the protection of single tactical units, complementing the classic centralisation of forces typical of anti-aircraft capabilities.[85]

3.2 Procurement programmes and industrial base

Currently, the SHORAD and V-SHORAD capabilities of Italian Armed Forces find themselves in a transitional phase, characterised by the update or substitution of aging anti-missile systems, as well as the introduction of new C-UAS systems. In this context, the integration between sensors and effectors, both national and international, is pivotal in the organisation of Italy's SHORAD and V-SHORAD capabilities, and interoperability with other NATO's systems remains a top priority.[86]

Relevant procurement programmes involve the Italian industrial environment, and in particular two important actors such as MBDA Italia and Rheinmetall Italia.

MBDA Italia is the Italian subsidiary of the MBDA Missile Systems group – whose shareholder basis includes BAE Systems (37.5 per cent), Airbus (37.5 per cent) and Leonardo (25 per cent) – the European leader in missile sector. The Italian company has a workforce of around 1,600 employees, a share capital of around 120 million euro and a turnover of around 685 million euro in 2021. The company has three industrial sites in Italy and activities which range from software development,

[83] Cosimo Corona, "Prosegue il potenziamento della capacità COUNTER-Uas nella basi dell'A.M.", in *Notizie Aeronautica Militare*, 16 December 2020, https://www.aeronautica.difesa.it/comunicazione/notizie/Pagine/Prosegue-il-potenziamento-della-capacità-COUNTER-Uas-nella-basi-dell'A-M.aspx.

[84] Fulvio Mallardi, "NATO, conclusa in Italia l'esercitazione Ramstein Guard 2021", in *Notizie Aeronautica Militare*, 16 December 2021, https://www.aeronautica.difesa.it/comunicazione/notizie/Pagine/20211223_NATO,-conclusa-in-Italia-l-esercitazione-Ramstein-Guard-2021.aspx.

[85] Interview, 30 May 2022.

[86] Interview, 20 May 2022.

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mechanical production and ceramics for missiles, to RF systems, e.g., proximity fuses and data links. The ability to leverage its European dimension makes MBDA Italia an important national interlocutor for the Italian Armed Forces. The Common Anti-Air Modular Missile Extended Range (CAMM-ER), the above-mentioned Aspide missile, the Aster missile, and finally the Teseo Mk2/E and Marte ER anti-ship systems are among MBDA Italia's main products.

While originally founded to produce firing stations for short air defence, today Rheinmetall Italia has a workforce of around 1,200 employees and a share capital of around 20 million euro.[87] In 2020, the company registered a turnover of around 150 million euro.[88] It is a leading company in the field of radar and short- and very short-range air defence systems. It is renowned for having developed the AESA Multi-Mission Radar (AMMR) and the X-TAR3D, which is also compatible with MANPADS systems. Each of these products is integrated in the Skyguard system developed by its Swiss twin Rheinmetall Air Defence AG.[89] The X-TAR3D is currently part of the Module Engagement Command Post (PCMI), which is being acquired by the Italian Army.

3.2.1 SHORAD systems' replacement

The progressive replacement of Rheinmetall's Skyguard mobile systems,[90] as well as the Spada fixed system, figure among the ongoing procurement programmes. Both systems are equipped with the semi-active radar-guided missile Aspide produced by MBDA Italia. The vector has an effective range of 25 km in its latest iteration thanks to an enhanced single-stage rocket engine.[91] Skyguard and Spada, operated respectively by the Army and the Air Force, are similar in terms of fire sections number – up to four, from two launchers each.[92] The Ministry of Defence's (MoD) plans to replace Aspide-based air defence missile systems with a new national solution against medium- and short-range threats.[93]

Moreover, the MoD's 2021 Multiannual Planning Document (*Documento programmatico pluriennale*, DPP) indicated the intention to move forward with the procurement of the Grifo system, based on MBDA's CAMM-ER missile,[94] from

[87] "Rheinmetall potrebbe espandere le attività in Italia", in *Agenzia Nova*, 18 March 2022, https://www.agenzianova.com/news/rheinmetall-potrebbe-espandere-le-attivita-in-italia.

[88] Gianandrea Gaiani, "Leonardo, Rheinmetall e non solo, tutti i rapporti Italia-Germania nella difesa", in *Analisi Difesa*, 14 April 2021, https://www.analisidifesa.it/?p=142920.

[89] Rheinmetall website: *Stationary Air Defence*, https://www.rheinmetall-defence.com/en/rheinmetall_defence/systems_and_products/air_defence_systems/stationary_air_defence/index.php.

[90] Italian Army General Staff, *Nuove tecnologie per l'Esercito Italiano*, 13 January 2020, https://www.esercito.difesa.it/comunicazione/Pagine/Nuove-tecnologie-per-l-Esercito-Italiano20200113.aspx.

[91] MBDA website: *ASPIDE 2000*, https://www.mbda-systems.com/product/aspide-2000.

[92] Ibid.

[93] Interview, 14 July 2022.

[94] Italian MoD, *Documento programmatico pluriennale della Difesa per il triennio 2021-2023*, 2021,

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2023 onwards. PCMI Grifo had already been selected within the effort to digitise Italian weapon systems, Forza Network Enabled Capabilities (Forza NEC), and will be equipped with Rheinmetall Italia's X-TAR3D X-band radar. CAMM-ER comes with a radiofrequency-active seeker and a soft vertical launch system. its ability to start the engine after exiting from the launcher has several advantages: it minimises the weight put on the launcher, as well as smoke and disturbance to system sensors.[95] A budget of 350 million euro to procure the system up until 2032[96] has been approved by the Defence committees of the Chamber of Deputies[97] and the Senate[98] on 15 and 13 September 2022 respectively.

The choice of CAMM-ER reflects the need to counter a greater number of threats than those Aspide was designed to counter forty years ago, in a technological environment that was completely different.[99] CAMM-ER is considered particularly versatile in countering classical aerial threats such as Air Breathing Threats (ABT), i.e., ramjets and turbojets which require air ignition for propellent combustion, anti-radiation missiles, UAS and others. Its range is almost double that of Aspide, reaching beyond 45 km compared to its precursor's 25 km. This is also considered an advantage as it allows to identify and eliminate air-based threats from farther away, which bears benefits in terms of reaction times and allows to destroy incoming targets further away from its objectives, which are likely to be friendly military or civil personnel.[100]

Moreover, an initial phase of the 2022 DPP procurement programmes is especially dedicated to hardware modernisation, using the CAMM-ER missile to develop a Medium Advanced Air Defence System (MAADS) for the Air Force and close the gap caused by Spada's obsolescence.[101]

3.2.2 Anti-drones capabilities and V-SHORAD

The 2022 Multiannual Planning Document points to anti-drone capabilities and V-SHORAD as another top priority which is currently without an allocated

p. 85, https://www.difesa.it/Content/Documents/20210804%20DPP%202021-2023%20-ult.pdf.

[95] Tamir Eshel, "Soft Launch Delivers a Hard Fist", in *Defense Update*, 4 April 2019, https://defenseupdate.com/20190404_soft-launch-delivers-a-hard-fist.html.

[96] Italian MoD, *Documento programmatico pluriennale della Difesa per il triennio 2021-2023*, cit., p. 62.

[97] Italian Chamber of Deputies website: *Atti del governo sottoposti a parere: Schema di decreto ministeriale di approvazione del programma pluriennale di A/R n. SMD 17/2022... (Atto del Governo 417). Dibattiti in Commissione*, https://www.camera.it/leg18/682?atto=417&tipoAtto=Atto&idLegislatura=18&tab=3#inizio.

[98] Italian Senate website: *Atto del Governo sottoposto a parere parlamentare n. 417*, https://www.senato.it/leg/18/BGT/Schede/docnonleg/45259.htm.

[99] Interview, 20 May 2022.

[100] Ibid.

[101] "Medium Advanced Air Defence System per l'Aeronautica Militare", in *Ares Osservatorio Difesa*, 31 January 2022, https://aresdifesa.it/?p=28321.

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budget.[102] The lack of funding represents a step back from the 2021 Planning Document, which emphasised the intention to complete the Armed Forces' conventional and direct energy anti-drone capabilities by allocating 197 million euro up to 2035.[103] The Armed Forces also acquired ten CPM-DJI-120-4B models produced by Elettronica.[104] These systems have a range of 700 metres and have a longer-lasting battery compared to more portable models by the same company.

The MoD has promoted a multitude of C-UAS projects. In 2019, programmes have been funded to evaluate the use of swarms of micro-drones equipped with jammers (Proactive C-UAS)[105] to protect ground forces in urban environments. Italian industry is also engaged in the development of systems capable to counter UAS applying AI and machine learning, exploiting both kinetic and direct energy effectors.[106] Among those projects, there is also research to counter swarms with Radio Frequency Directed Energy Weapons (RF-DEW).[107] MBDA is currently developing new direct energy effectors, including continuous and pulsating laser waves,[108] but research also exists in the field of RF-based directed-energy weapons.

The Air Force too has cooperated with industry to acquire C-UAS capabilities, especially Black Knight, produced by IDS Ingegneria Dei Sistemi. Black Knight has a maximum operating weight of 100 kg and is capable of identifying mini-UAS in a radius of 2 km; the neutralisation range is over 1 km.[109] The Air Force organises its capabilities in a "system of systems" composed of radars and electro-magnetic measures called AMI Counter UAS System (ACUS).[110]

The preference for soft-kill systems, which unlike hard-kill systems don't lead to the total destruction of the target. is probably due to limited collateral effects

[102] Italian MoD, *Documento programmatico pluriennale della Difesa per il triennio 2022-2024*, 2022, p. 107, https://www.difesa.it/Il_Ministro/Documents/DPP_2022_2024.pdf.

[103] Italian MoD, *Documento programmatico pluriennale della Difesa per il triennio 2021-2023*, cit., p. 69.

[104] Italian MoD, *Determina a contrarre n. 042/19/0469 del 10/09/2019*, https://www.difesa.it/Amministrazionetrasparente/segredifesa/armaereo/Documents/Documenti/Commissionigiudicatrici2018/DAC_469_DEL_10_09_2019.pdf; *Determinazione n. TER 20/029*, 31 March 2020, https://www.difesa.it/SGD-DNA/Staff/DT/TERRARM/Documents/PROCEDURE_NEGOZIATE/2020_04_02_ATTUATORI_JAMMER/DAC_TER_2020_029.pdf.

[105] Italian MoD, *Determinazione a contrarre n. TER 19-037*, 25 June 2019, https://www.difesa.it/SGD-DNA/Staff/DT/TERRARM/AvvisoPN/Documents/2019/25_DAC_TER_19_037.pdf.

[106] Interview, 20 May 2022.

[107] Italian MoD, *Determinazione a contrarre n. TER 20/072*, 17 July 2020, https://www.difesa.it/Amministrazionetrasparente/segredifesa/terrarm/Documents/DAC_2020/DAC_TER20_072.pdf; *Determina a contrarre TER 21/095*, 9 November 2021, https://www.difesa.it/Amministrazionetrasparente/segredifesa/terrarm/Documents/DAC_2021/DAC_TER21_095.pdf.

[108] Interview, 14 July 2022.

[109] Italian MoD, *Aeronautica Militare: il 16° stormo acquista altra capacità C-UAS*, 8 January 2019, https://www.difesa.it/Primo_Piano/Pagine/Aeronautica-Militare-16-stormo-capacita-C-UAS.aspx.

[110] Tom Kington, "Italian Air Force Eyes Microwaves and Lasers to Defeat Drones", in *DefenseNews*, 24 May 2021, https://www.defensenews.com/unmanned/2021/05/24/italian-air-force-eyes-microwaves-and-lasers-to-defeat-drones.

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they cause, which would be particularly important with nearby civilians or in urban environments.[111] Nevertheless, the Armed Forces also expressed a need for hard-kill capabilities, especially to counter AI-guided drones and swarms, which are immune to jammers.[112] This will probably be one of the main pursuits of the European Defence Fund's (EDF) C-UAS project. Additionally, the Army expects the Next Generation Main Battle Tank to include systems to perform mobile SHORAD and V-SHORAD, mitigating the vulnerability of armed columns to drone attacks during manoeuvres. The 2022 DPP draws out the development and acquisition of anti-drone defence systems, both of the conventional and directed-energy types, which should be fulfilled by 2022–24. 16 million euro have been allocated over this period, while further 27.2 million are reserved for the 2025–27 period.[113]

Finally, in the realm of V-SHORAD, there is the need to extend the service life of Stinger missiles beyond 2032. This will be made possible thanks to the Stinger Life Extension Program instituted by the NATO Support and Procurement Agency (NSPA). Nevertheless, the procurement of new systems will soon become unavoidable. The Army, in particular, has stated that the successor of the Stinger will absolutely have to be vehicle-mounted, to ensure mobility of its V-SHORAD systems.[114] The development programme for the new Armoured Infantry Combat System's (AICS), which will be made available for mechanised infantry by 2026,[115] will likely be influenced by such needs.

A project currently being studied envisages the possibility of developing an Italian V-SHORAD system. This would have to be a mobile, fully digital system, which includes a lightweight portable launcher developed to meet the operational requirements of the three branches of the Italian Armed Forces in order to ensure a high level of interoperability. In any case, it is estimated that the replenishment of MANPADS stocks will take at least 5 years.[116]

The Navy, for its part, has announced that the destroyers will be equipped with directed energy weapons, which, with a power above 50 kilowatts (kW), would closely resemble V-SHORAD capabilities.[117]

Moreover, the Army has also lamented the gradual decommissioning of automatic cannons over the past decades. These systems, in their newest and most advanced iterations, are particularly effective in terms of Counter Rockets, Artillery and Mortar

[111] Interview, 20 May 2022.
[112] See Chapter 3.
[113] Italian MoD, *Documento programmatico pluriennale della Difesa per il triennio 2022-2024*, cit., p. 95.
[114] Ibid.
[115] Ibid., p. 48.
[116] Workshop, 14 September 2022.
[117] Aurelio Giansiracusa, "Due nuovi Cacciatorpediniere per la Marina Militare Italiana", in *Ares Osservatorio Difesa*, 19 January 2022, https://aresdifesa.it/?p=27994.

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(C-RAM) missions which, unlike simple counter-fire capabilities, are designed to trace and destroy incoming of missiles and projectiles. Calculating the firing trajectory of the incoming projectile and saturating it with hundreds of shots, as it's done by systems like Oto Melara's Draco and Porcupine and Rheinmetall's NBS Mantis, allow to counter smaller shells much more effectively than with missiles and other actuators.[118]

In this context, the Revolver Gun family with Ahead ammunition, both produced by Rheinmetall, proved effective both against UAS and in a C-RAM function. While such a need had already been identified when it comes to the protection of Italian bases abroad, the progressive increase of artillery range has also led to an increased operational depth leading up to the contact line.[119] The extensive use of HIMARS by the Ukrainian Armed Forces, for instance, has demonstrated the enormous progress and dangers posed by MLRSs.

Although the DPP for 2022–2024 identified the modernisation of SHORAD, V-SHORAD and C-RAM as important steps towards improved force protection, it is worth highlighting that this chapter has been relegated to programmes yet to be funded.[120] This decision risks depriving the Defence sector of adequate prioritisation efforts, in turn affecting an industrial sector, in need of a long-term vision to plan and launch the investments.

Implementing new SHORAD and V-SHORAD hardware will also require logistical adjustments by the units that are supposed to operate them, as well as a certain degree of reorganisation of personnel. Part of this adaptation process will also depend on reflections currently underway within the Armed Forces on the best way to incorporate future V-SHORAD capabilities in the ground forces. Beyond the current model, one approach currently being entertained foresees the installation of V-SHORAD and C-UAS systems in a self-defence configuration for heavy-armoured and medium-armoured vehicles, as it has been done in fielding countermeasures against anti-tank systems.[121]

The diversification of air-based threats requires technical and organisational changes in order to allow troops to rapidly pick the SHORAD or V-SHORAD weapon best suited to the specific threat from a broad selection of systems.[122]

Finally, it will be crucial to develop systems which do not resort to overly expensive solutions, such as missiles, to deal with extremely cheap threats like micro-drones or mortar shots. The development of cost-effective V-SHORAD missiles and direct

[118] Interview, 20 May 2022.
[119] Ibid.
[120] Italian MoD, *Documento programmatico pluriennale della Difesa per il triennio 2021-2023*, cit., p. 87.
[121] Interview, 28 July 2022.
[122] See Chapter 3.

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energy systems that with affordable cost-per-intercepts is an effort that goes in this direction.[123]

Table 2 | The current systems for the Italian Armed Forces

	C-UAS		V-SHORAD	SHORAD	SHORAD/MAADS
Effector name	CPM-DJI-120-4B	CPM Watson	FIM-92 Stinger	Aspide and Spada on Skyguard systems (retired)	CAMM-ER
Range	700 m	750 m	8 km, maximum altitude 3,500 m	20 km / 25 km	>45 km
Type	Radio-frequency jammer	Radio-frequency jammer	MANPADS	Surface-to-Air System	Surface-to-Air System

[123] Interview, 20 May 2022.

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4. Cooperation in the EU-NATO framework

by Ottavia Credi and Alessandro Marrone

4.1 PESCO and EDF projects

The European Union (EU) offers interesting cooperation opportunities for member states in the field of SHORAD and V-SHORAD, starting from PESCO and EDF.

When it comes to drones, the Italian-led C-UAS project aims to develop an advanced system of systems, with a state-of-the-art C2 architecture and effector apt to counter mini and micro-drones.[124] This system could be employed both to protect national territories and in operational theatres that see a deployment of European troops. This initiative is closely related to the Joint European System for Countering Unmanned Aerial Systems (JEI-CUAS) project, developed within the 2020 European Defence Industrial Development Programme (EDIDP), forerunner of the EDF.[125] JEI-CUAS, which is coordinated by the Italian company Leonardo, has the objective to develop a next generation C-UAS systems, in particular focusing on mini and micro-drones, which are increasingly present in current and future operational scenarios.

Italy is also leading the PESCO project European Global RPAS Insertion Architecture System (GLORIA), aiming at developing a "modelling & simulation" architecture for the analysis, elaboration and evaluation of innovative procedures for Remotely Piloted Aircraft Systems (RPAS). Overall, the project also seeks to develop concept, doctrines and operational standards for drones and relative countermeasures.[126]

On the EDF front, in 2021 the Fund published calls, among others, for the development of infrared detectors, new radar-based technologies and endo-atmospheric interceptors.[127] Two new projects are planned to be launched by the Fund in 2023 in order to develop new laser-based directed-energy and RF systems.[128]

[124] PESCO website: *Counter Unmanned Aerial System (C-UAS)*, https://www.pesco.europa.eu/project/counter-unmanned-aerial-system-c-uas.

[125] European Commission, *Factsheet JEY-CUAS*, 30 June 2021, https://europa.eu/!jxPXbr.

[126] PESCO website: *European Global Rpas Insertion Architecture System (GLORIA)*, https://www.pesco.europa.eu/project/european-global-rpas-insertion-architecture-system; *Rotorcraft Docking Station for Drones*, https://www.pesco.europa.eu/project/rotorcraft-docking-station-for-drones.

[127] Funding & Tender Opportunities Portal of the European Commission: *Infrared Detectors*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-sens-r-ird; *Advanced Radar Technologies*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-sens-r-radar; *Endo-Atmospheric Interceptor – Concept Phase*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-airdef-d-eatmi.

[128] Interview, 27 May 2022.

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European collaborations in research, development and technology represent a great opportunity for Italy. Such synergies allow to combine diverse European industrial and technological capabilities, achieving better results and economies of scale. This, in turn, ensures both a better fulfilment of the needs of the Italian Armed Forces and of their partners, as well as an increased competitiveness of European and national businesses on global markets.

4.2 NATO and international initiatives

Air-based threats have traditionally been a priority for NATO, which plays a key role in the IAMD system of its members, especially on the European continent.[129] The evolution of the threat in light of the Russian invasion of Ukraine heightened the awareness of the Atlantic Alliance to this topic on several levels.

For one, the Alliance is developing, through the NATO Industrial Advisory Group (NIAG), Key User Requirements (KUR) for SHORAD, V-SHORAD, C-RAM systems and Counter small Unmanned Aerial Systems (C-small UAS).[130] The draft version of the KURs will be functional to spur a wider reflection on allied procurement needs, which will likely focus on the update of older generation systems. The signing of the Memorandum of Understanding (MoU) for the Concept Phase, to which Italy decided to participate, is expected in mid-October 2022.

Within the NIAG framework, the Alliance is pursuing several projects with the support of industrial representatives from its member states. An example of this is the NIAG study for the evaluation of allied capabilities and effectiveness in the field of surface-based air and missile defence.[131]

In October 2020, the defence ministers of four NATO members (Germany, Greece, Hungary and the United Kingdom) launched a multilateral initiative called Rapidly Deployable Mobile C-RAM Capability. This initiative sees a strong presence of both Rheinmetall and MBDA.[132] C-RAM capabilities represent a crucial element of allied defence and, with this project, NATO aims to increase interoperability thanks to the development of cost-effective solutions and directed-energy systems. Such systems can enhance the capabilities of conventional kinetic systems, increasing

[129] Alessandro Marrone, "Europe's Missile Defence: NATO Role and EU Contribution", in Alessandro Marrone and Karolina Muti, "Europe's Missile Defence and Italy: Capabilities and Cooperation", in *Documenti IAI*, No. 21|05 (April 2021), p. 35-40, https://www.iai.it/en/node/13072; Interview, 20 May 2022.

[130] Interview, 27 May 2022.

[131] See: NATO, *Proposed NIAG Study on Surface Based Air and Missile Defence (SBAMD) Survivability and Effectiveness in Joint and Combined Operations when faced by a Peer State Threat*, 28 April 2021, https://content.ndia.org/-/media/sites/ndia/divisions/international/niag/cnad-niagproposed-study.ashx.

[132] NATO, *Four Allies Launch Multinational Initiative on Rapidly Deployable Mobile Counter Rockets, Artillery and Mortar Capability*, 23 October 2020, https://www.nato.int/cps/en/natohq/news_178951.htm.

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available options and thus improving the chances of operational success.[133] This activity has then flowed into the Modular Solution for Very Short Range, Short Range, and Medium Range Ground Based Air Defence (Modular GBAD) High Visibility Project, led by MBDA Italia.[134] The project has the objective to create a multinational framework for the development and acquisition of a medium-, short- and very short-range air defence systems. The main goal of the project is to simplify and optimise the entire spectrum of medium- and short-range defence options available to allies. This will also bring an overall improvement of allied capabilities in terms of operational flexibility, scalability and interoperability.

Allied ministers of Defence also decided to establish the C-UAS Practical Framework, led by the Emerging Security Challenges Division. Within this framework, the Countering Unmanned Aircraft System Working Group (C-UAS WG)[135] was subsequently set up. Throughout the establishment of this cooperation framework, the Alliance aims to adopt a shared method among its members in the field of UAS countermeasures.

The Alliance's most recent initiatives on countering drones also includes the Counter Unmanned Aircraft System (C-UAS) Technical Interoperability Exercise 2021 (TIE21). This exercise, organised by the NATO Communications and Information Agency (NCIA), aims to enhance counter-drones technology, also through the development of stricter interoperability standards for commercial systems used for these purposes.[136]

The Joint Air Power Competence Centre and the NATO Science and Technology Organisation are also jointly working with this perspective, formulating recommendations for an integrated system to counter UAS.[137] The Alliance indeed argues that there is a need for greater integration of existing C-UAS solutions, from the technical to the operational level.[138] Such integrated approach shall include both reaction capacities to imminent threats, as well as preventive measures, and not only focus on in-flight systems but include all elements pertaining to the use of UAS.

[133] NATO Science & Technology Organization, "Directed Energy Weapons Concepts and Employment", in *STO News*, 26 June 2018, https://www.sto.nato.int/SitePages/newsitem.aspx?ID=3587.

[134] NATO, *Factsheet: Modular Ground Based Air Defence (Modular GBAD)*, February 2022, https://www.nato.int/nato_static_fl2014/assets/pdf/2021/10/pdf/2110-factsheet-m-gbad.pdf.

[135] See: André Haider, "A Comprehensive Approach to Countering Unmanned Aircraft Systems and Why Current Initiatives Fall Short", in *JAPCC Flyers*, August 2019, https://www.japcc.org/?p=1262.

[136] NCIA, *NATO Agency Holds Exercise to Improve Counter-Drone Technology*, 11 November 2021, https://www.ncia.nato.int/about-us/newsroom/nato-agency-holds-exercise-to-improve-counterdrone-technology.html.

[137] Ester Sabatino and Francesco Pettinari (eds), "La minaccia dei droni duali e le sfide per l'Italia", cit., p. 65.

[138] Osman Aksu et al., *A Comprehensive Approach to Countering Unmanned Aircraft Systems*, Kalkar, Joint Air Power Competence Centre (JAPCC), January 2021, https://www.japcc.org/?p=10501.

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Despite ongoing discussions on this topic. NATO has not yet defined a Standardisation Agreement (STANAG) on countering UAS. Any effort in this direction will likely still take some time, mainly due to lacking convergence between member states as well as overall clarity on the C-UAS issue.[139]

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[139] Interview, 28 July 2022.

5. Conclusions

by Alessandro Marrone and Michele Nones

In light of this analysis, adopting a whole-of-country perspective as well as considering Italy's next steps in this context, the following key elements stand out:
1. SHORAD and V-SHORAD as a priority for the Italian Armed Forces;
2. saturation risk, complexity and cost-per-intercept;
3. SHORAD and V-SHORAD as a system of systems;
4. multi-layered and integrated approach to Air Defence;
5. supply chain security and European technological sovereignty;
6. industrial implications;
7. cooperation within NATO and EU frameworks.

5.1 SHORAD and V-SHORAD as a priority for the Italian Armed Forces

First, it is necessary to underline the importance and urgency of the issue at hand. The Ukrainian war represents a watershed moment that compels NATO's armed forces, including Italy's, to better prepare for high-intensity scenarios in which short and very-short-range air defence could face a symmetric threat. The extensive use of UAS, which are provided by various countries, in the Russian-Ukrainian war, as well as the subsequential doctrinal development in terms of tactics, techniques and procedures, marks a change of pace from the pre-existing trends of using drones within more or less sophisticated attacks.

This is a change of pace that Italy needs to address, even more so given the ongoing conflict is closely watched by other potential adversaries who will draw their own lessons in terms of capacity-building in this field. This is also important when it comes to current and future use of UAS by state and non-state actors in operational theatres where Italian military personnel is deployed, among which Mali, Niger, Iraq and Libya stand out in terms of risk. The latent risk of an attack against critical infrastructures on the national territory also persists, which is also an area in which air defence is a key responsibility of the Armed Forces. Given the rampant spread and availability of UAS, the need for Italy to equip itself with C-UAS systems is increasingly urgent in an operational perspective.

5.2 Saturation risk, complexity and cost-per-intercept

A key element that emerges from operational experience, particularly in Ukraine, is that of saturation of SHORAD and V-SHORAD systems by a threat made up of numerous assets acting in unison, i.e., relying also (but not exclusively) on swarms of relatively affordable UAS. The quantity and quality of long, medium and short-range attacks that could potentially be carried out by even medium-sized adversaries is such that it exceeds, at least in part, the current defensive capabilities of modern armed forces. This was repeatedly emphasised by Ukraine in its resistance to the Russian invasion. Looking ahead, it is likely that increasingly

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high-perfomance UAS, even larger ones, will be integrated by the armed forces of several countries at both a tactical and operational level, with consequences on doctrinal and capacitive developments.

This, in turn, makes mission definition for defensive systems particularly complex. It also poses a crucial problem in terms of cost-per-intercept, and therefore of adequate quantities of ammunition. A sustainable amount must be available to the Italian Armed Forces in order to put them in a condition to counter potentially very high numbers of simultaneous targets. In order to withstand a sophisticated, large-scale and/or sustained attack, the cost of effectors should, to some extent, be comparable to that of the incoming threat. New directed energy weapons are among the most affordable interception options. More generally, it is necessary to keep in mind that SHORAD and V-SHORAD are only a single element within a country's defensive posture. When facing massive threats from state and non-state actors, other elements such as intelligence, multi-domain approach and deterrence should help avoid a scenario in which defensive systems are overwhelmed.

5.3 SHORAD and V-SHORAD as a system of systems

Considering the saturation risk, it is even more important to set up SHORAD and V-SHORAD as a system of systems, integrating a wide range of sensors and effectors into a single C2 chain, i.e., a single decision-making process. This integrated vision involves active and passive sensors, including state-of-the-art active radar systems and smart sensors, as well as hard-kill (including innovative direct energy laser weapons) – and soft-kill (RF-based directed energy weapons) effectors. These systems should be considered complementary to each other, not alternative. Neutralisation techniques depend on target type and operational scenario, and the best defence consists in a wide range of integrated options available to the Armed Forces in terms of effects management. The SHORAD and V-SHORAD of an advanced country like Italy must succeed in bringing all available assets into one system, especially since each is characterised by a different level of destruction.

This implies a strong investment in adequate C2 capacities, including high computational capabilities, as this is a key element to enable a system of systems to combine effectiveness, collateral damage reduction and cost-per-intercept sustainability. The capacity to model engagement effects and collateral damage, first developed in the field of missile defence, also represents a valuable element for SHORAD and V-SHORAD. As anticipated in the previous chapters, artificial intelligence could support the OODA loop, even though the decision-making capabilities of operators will remain essential. With regard to the action phase, integrating effectors presents additional challenges compared to that of sensors.

5.4 Multi-layered and integrated approach to Air Defence

The system of systems perspective is only a part of a broader multi-layered approach to Air Defence, which must include a wide spectrum of integrated systems, in order to intercept the threat as far as possible from the target and retain the ability to

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choose the best effector each time. In fact, no effector alone can guarantee results that meet the standards for effective defence. The Ukrainian war demonstrated how, in a high-intensity symmetric conflict, the full operational implementation of recent technological developments can extend the range of missiles and UAS. The same also applies to artillery and rockets which, reaching in some cases a range of about 70 km, can hit in-depth beyond the frontline. In other words, SHORAD and V-SHORAD must face a somewhat "shortened" space for offensive operations, imposing increasingly compressed reaction times on the defender.

In this multi-layered and integrated approach, SHORAD systems have to operate as a complement to more sophisticated missile defence systems such as SAMP-T, with the former prioritising cost-per-intercept while the latter prioritise the countering of more challenging threats. In this complementary approach, it is possible to achieve that level of overall cost-effectiveness that must remain a fundamental criterium in the choice of effector, starting from MANPADS to cannons and upwards. At the same time, a wider spectrum of effectors places a greater burden on logistics, maintenance and modernisations, which can only be mitigated by a high degree of standardisation. There is also a need to integrate SHORAD and V-SHORAD assets into a more complex C2 system, and to address the problem of portable assets which are not designed to be integrable in a system of systems, but were rather conceived as a stand-alone capability. In addition, there is a problem regarding mobility of SHORAD and V-SHORAD systems, which in high-intensity conflict scenarios will increasingly have to protect not only fixed targets, but also military formations on the move. This will be pivotal to avoid losses such as the ones suffered by the Russian forces in Ukraine. Particularly important in this regard is the ongoing reflection within the Italian Army regarding the possible integration of SHORAD and V-SHORAD systems in heavy-duty vehicles and that of systems such as MANPADS in Command Posts. Finally, a growing problem pertains the interconnection of multiple air defence assets, both national and of allied countries, which increases vulnerability to cyberattacks.[140]

5.5 Supply chain security and European technological sovereignty

The Russian invasion of Ukraine, with the resulting donations of Western weapons systems to Kyiv and the growth of Defence budgets in many European countries, represents a watershed moment in terms of supply chains security. Currently, the timeframe for supplying the Italian Armed Forces with new shipments of systems such as Stinger is estimated to be around 4–5 years. This time span is comparable to that needed for the development of a new state-of-the-art system, with higher performance and lower upgrading needs in the short term, through cooperative programmes between top European industries. It's therefore necessary, when

[140] On the risk of cyber attacks in connection with the networking of ground equipment, see: Alessandro Marrone and Karolina Muti, "Next Generation Soldier. Executive Summary", in *Documenti IAI*, No. 21|16 (November 2021), https://www.iai.it/en/node/14376.

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investing in both national and European Defence budgets,[141] to give a fresh look to supply chain security, as well as increasing operational and technological sovereignty by filling these capacitive gaps with European solutions. It's safe to say that these include C-UAS and C-RAM capabilities, both in Italy and Europe. Filling those gaps also implies a better definition of which threats should be included in C-UAS, given the variety of drones and recent operational and technological developments, as well as the contributions given by SHORAD and V-SHORAD systems. In the future, it will therefore be important to balance the strengthening of operational and technological sovereignty at a national level and, on the other hand, a renewed effort towards European integration.[142]

5.6 Industrial implications

Conceptualising SHORAD and V-SHORAD as a system of systems, adopting a multi-layered and integrated approach, and renewing supply chain security through European cooperation has a number of important implications for the industrial sector.

First, there is a need for more and better cooperation between industries operating in Italy. This includes pooling technologies and systems to fill the highlighted capacity gaps and minimising fragmentation and unnecessary duplications. The MoU signed by MDBA Italia and Rheinmetall in 2021 is an important step forward in this direction.

Second, there is an urgent need for clarity, certainty and stability regarding adequate investments by the Ministry of Defence, in this as well as in other areas of the military policy. This is paramount to enable the effective and efficient programming of research, development and production activities by the private sector, and to enable the Italian industry to compete or cooperate on an equal footing with European partners. In particular, the lack of certain funding for C-RAM, V-SHORAD, SHORAD and CAMM-ER in the 2022 Multiannual Planning Document should be fixed. This absence represents a step backwards compared to the 2021 document. As technological innovation accelerates, the procurement process will have to accelerate as well, also through improvements in the Ministry of Defence's procedures with regard to contracting. Moreover, the involvement of institutions such as the *Organisation Conjointe de Coopération en matière d'Armement* (OCCAR) has significantly facilitated some Italian procurement processes in the recent past.[143]

Thirdly, cooperation between the Defence Ministry and industry should be encouraged in activities preceding and accompanying the definition of technology

[141] See: Vincenzo Camporini et al., "Per affrontare la minaccia russa gli europei devono investire insieme", in *AffarInternazionali*, 21 April 2022, https://www.affarinternazionali.it/?p=97388.

[142] Workshop, 14 September 2022.

[143] Ibid.

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roadmaps, the synergic alignment of national and European funding and the development of prototypes, including testing and validation. Technological innovation must be pursued, but without postponing production in order to wait for the optimal solution: acquiring close-to-top solutions, built following an open architecture to be regularly updated and modernised over time and in line with operational needs, is often a more effective approach.

Last but not least, Italian industrial actors should demonstrate to be more prone to innovation and business risk, keeping up with major changes. This is crucial to seize the opportunities that are likely to arise among NATO countries in the following years, for examples in terms of C-UAS capabilities that will need to be much more numerous and spread among military formations. The same goes for greater stocks of different types of ammunition, including SHORAD and V-SHORAD, needed to meet higher needs for deterrence and collective defence within NATO.

5.7 Cooperation within NATO and EU frameworks

As highlighted in the previous chapters, NATO represents an important framework for the definition of Key User Requirements and multilateral initiatives in the field of GBAD, C-UAS and C-RAM, in line with the Alliance's crucial role for IAMD on the European continent.[144] The war in Ukraine and the subsequent emphasis put by the new Strategic Concept on deterrence and defence against near-to-peer competitors[145] is likely to further reinforce the importance of the NATO framework for SHORAD and V-SHORAD in high-intensity conflict scenarios. The situation among allied countries is highly fluid, as they're currently in a phase that will define those concepts that will influence future standards, and there is not yet full clarity or strong convergence between them. Italy must therefore equip itself to play a proactive, constructive and timely role at various roundtables and ongoing initiatives, starting with the NATO working group on C-UAS, C-RAM and GBAD and keeping whole-of-country perspective and with an eye to employment concepts.

The EU framework has its own importance and characteristics, complementary to those of NATO. Given the military and industrial fragmentation among countries of the Old Continent, which also has negative implications for the Atlantic Alliance, intra-European collaborations in research, development and technology are a win-win projects for both NATO and the EU. As mentioned in previous chapters, these collaborations make it possible to bring together different European technological and industrial capabilities, achieving better results even through the development of interoperable and integrable systems. Italy already plays a significant role by leading the Gloria PESCO project, as well as JEY-CUAS (EDIDP) coordinated by Leonardo. On this basis, Italy can and must go further, also with an eye on the

[144] See: Alessandro Marrone and Karolina Muti, "Europe's Missile Defence and Italy", cit.

[145] Alessandro Marrone, "NATO's New Strategic Concept: Novelties and Priorities", in *IAI Commentaries*, No. 22|30 (July 2022), https://www.iai.it/en/node/15667.

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2023 EDF calls, in order to ensure both a better fulfilment of the needs of the Italian Armed Forces and their partners, as well as the competitiveness of European and national companies involved in global markets. The defence of a country such as Italy from air-based threats, both in terms of SHORAD/V-SHORAD and not, cannot ignore cooperation with allied and partner countries.

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Acronyms

ABT	Air Breathing Threats
ACUS	AMI Counter Uas System
AICS	Armoured Infantry Combat System
AMMR	AESA Multi-Mission Radar
CAMM-ER	Common Anti-air Modular Missile Extended Range
C-RAM	Counter Rockets, Artillery And Mortar
C-UAS	Counter Unmanned Aircraft Systems
C-UAS WG	Countering Unmanned Aircraft System Working Group
C2	Command and control
CNPM	National Sea-Projection Capabilities (*Capacità nazionale di proiezione dal mare*)
COMACA	Anti-Air Artillery Command (*Comando Artiglieria Controaerei*)
SHORAD	Short Range Air Defence
DPP	Multiannual Planning Document (*Documento programmatico pluriennale*)
EDF	European Defence Fund
EDIDP	European Defence Industrial Development Programme
EU	European Union
EUTM	European Union Training Mission
EW	Electronic Warfare
FOC	Full Operational Capability
FORZA NEC	Forza Network Enabled Capabilities
GBAD	Ground Based Air Defence
GLORIA	Global RPAS Insertion Architecture System
GNA	Government of National Accord
HIMARS	High Mobility Artillery Rocket System
IAMD	Integrated Air and Missile Defence
ISIS	Islamic State
ISTAR	Intelligence, Surveillance, Target Acquisition and Reconnaissance
JEY-CUAS	Joint European sYstem for Countering Unmanned Aerial Systems
KFOR	Kosovo Force
kg	kilogrammes
km	kilometres
KUR	Key User Requirements
kW	kilowatt
LNA	Libyan National Army
m	metres

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m/s	metres per second
MAADS	Medium Advanced Air Defence System
MANPADS	Man-Portable Air-Defence System
MIASIT	Bilateral Mission for Support and Assistance in Libya (*Missione bilaterale di assistenza e supporto in Libia*)
MIBIL	Italian Bilateral Military Mission in Lebanon (*Missione militare bilaterale italiana in Libano*)
MINUSMA	Multidimensional Integrated Stabilization Mission in Mali
MISIN	Bilateral Support Mission in the Niger Republic (*Missione bilaterale di supporto nella Repubblica del Niger*)
MLRS	Multiple Launch Rocket System
MOU	Memorandum of Understanding
NBCR	Nuclear, biological, chemical, radiological
NCIA	NATO Communications and Information Agency
NIAG	NATO Industrial Advisory Group
NLAW	Next generation Light Anti-tank Weapons
NSPA	NATO Support and Procurement Agency
OODA	Observe-Orient-Decide-Act
PCMI	Module Engagement Command Post (*Posto Comando Modulo di Ingaggio*)
PESCO	Permanent Structured Cooperation
RF	Radio frequency
RF-DEW	Radio Frequency Directed Energy Weapon
RPAS	Remotely Piloted Aircraft Systems
SAMP/T	*Sol-Air Moyenne Portée/Terrestrial*
SGD	Italian General Secretariat of Defence (*Segretariato Generale della Difesa*)
SHORAD	Short Range Air Defence
SRBM	Short Range Ballistic Missiles
STANAG	Standardization Agreement
STO/FP	Survive To Operate/Force Protection
TIE21	Technical Interoperability Exercise 2021
UAS	Unmanned Aerial Systems
UNIFIL	United Nations Interim Force In Lebanon
V-SHORAD	Very Short Range Air-Defence
WSN	Wireless Sensor Network

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