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Taking Multi-domain Operations from Theory to Practice

EDITED BY ELIO CALCAGNO

Multi-domain operations (MDO) originated in the US amid rising concerns that improving precision strike weapons, combined with increasingly capable anti-access/area-denial (A2/AD) capabilities, would make traditional ground manoeuvre warfare obsolete. Since then, US doctrinal and operational developments with regard to MDO have started to take hold at the NATO level, with the Alliance elaborating its own concept and undertaking a process of MDO-oriented transformation. National nuances remain, however. From an Italian perspective, the MDO effort is at its core an attempt to conceptually expand the battlefield. As such, the term 'multi-domain' is on the surface self-explanatory but fails to capture the full scope of the concept. Technology will be a fundamental enabler of this process, but a truly multi-domain approach to operations depends first and foremost on the military's ability to change the way it plans, trains for, and carries out its activities.

Executive summary

Implementing multi-domain operations: From the US Army's concept to Joint All-Domain C2

The US Army introduced the multi-domain operations (MDO) concept, originally called Multi-Domain Battle, in 2017. After almost two decades of counterinsurgency (COIN) operations, Army leaders were concerned that improving and proliferating precision strike weapons would make traditional ground manoeuvre warfare obsolete.

The Army had reason to be concerned about rising and capable threats. Russia was nearly a decade into its grey-zone cyber and proxy campaign against Ukraine and had already annexed Crimea. Several wargames suggested Russian troops could overrun the Baltic NATO allies within a few days. In these scenarios, using its large inventory of conventional surface-to-surface and air-to-surface precision missiles, Russia could eliminate NATO air defences and command and control (C2) while its long-range air defences could deny US and NATO air superiority.

Under the Multi-Domain Battle concept and its successor, MDO, the Army – and its Training and Doctrine Command (TRADOC), who elaborated the documents – planned to counter the reach of enemy air defences using longer-range surface-to-surface missiles targeted using air-launched effects (ALE) drones delivered by a new family of faster, longer-range and stealthier rotary-wing aircraft. In addition to finding enemy air defences, ALE drones would conduct electronic warfare (EW) jamming or decoy operations against adversary radars to protect crewed aircraft or improve the survivability of US strike weapons.

The other US military services also saw the need for new operational approaches to address the improving anti-access/area-denial (A2/AD) capabilities being fielded by Russia and China. This effort started with the Air-Sea Battle concept

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developed by the US Navy and Air Force in 2011, and culminating in the Joint Staff and Air Force incorporating Joint All-Domain Operations (JADO) into their doctrine in 2021.

Out of the US military services, the Army did the most work to both mature the MDO concept and implement it through programmes and organisation. The centrepiece of this transformation would be the Multi-Domain Task Force (MDTF), which would integrate command, control, intelligence, surveillance, reconnaissance (C2ISR) capabilities, air defences and long-range fires to give ground forces unprecedented reach in relatively contested areas.

To equip MDTFs and relevant portions of the remaining force for MDO, the Army initiated six main modernisation priorities during the late 2010s and early 2020s. These included long-range precision fires (LRPF), future vertical lift (FVL), next-generation combat vehicles (NGCV), assured precision navigation and timing (PNT), soldier lethality and air defence. The Army retains these priorities today, but substantially modified most of them since 2022 in response to lessons from the war in Ukraine.

Multi-domain operations and NATO: Work in progress

According to publicly available sources, NATO defines MDO as "the orchestration of military activities, across all operational domains and environments, synchronised with non-military activities, to enable the Alliance to create converging effects at the speed of relevance". The origin of the concept has its roots in the United States and has gradually spread throughout the alliance, mostly among the larger and more capable militaries, such as the UK, France and Italy. In recent years, through an internal process, NATO has adapted and adopted the MDO concept as the latest evolution of a lineage of approaches to war-fighting that include, among others, Air-Land Battle, network-centric operations (NWC) and joint operations. NATO's open-source working definition of MDO is rather generic, which is at least in part the result of finding a wording acceptable to all Allies, but also helps ensure a degree of flexibility. As such, the definition reaches far beyond purely defence-related aspects, encompassing not only activities in the five operational domains, but also "non-military activities".

The adoption by NATO of the MDO paradigm can be interpreted as a response to the challenge posed by Russia's A2/AD capabilities and hybrid warfare by Moscow and other potential adversaries in recent years, but also as a way to build on the digital revolution that opened new opportunities to reform or even revolutionise how Allies conduct operations.

In a number of cases some European Allies had begun developing their own understanding of MDO before an official internal process could be undertaken by NATO. For instance, Italy's first MDO concept was published in 2022, France's in 2021, and the UK's in 2020. In a way, the US and these countries' experiences and thinking have contributed to NATO's early steps toward the MDO transformation, though each brought slightly different nuances.

The MDO evolution pushes Allied armed forces to widen their approach to conducting operations and change the way an operation is conceived and carried out. In order to ensure that the MDO concept can be operationalised and implemented through the complex and diverse realities of NATO armed forces, the challenges that the Atlantic Alliance faces could be grouped into conceptual, human and organisational aspects.

MDO implementation in NATO seems to be a "work in progress". Some of the concept's prerequisites, including a common understanding and unity of intent are currently being built and will need to be tested in operational theatres. Continuous adaptation will be key to ensure effectiveness, and conceptual, human and organisational challenges will persist in the foreseeable future. This is only the beginning of an overarching process of transformation within the Alliance, and NATO will have to be realistic with regards to the objectives and expectations concerning MDO, accepting a certain level of fragmentation as an intrinsic part of Alliance-wide cultural shifts.

Italy and multi-domain operations: Doctrine, planning and technology

The Italian debate has often focused on whether MDO are an evolution from a 'joint-

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forces' (*interforze*) approach to operations, or a complementary objective. The 2015 White Book for International Security and Defence (*Libro bianco per la sicurezza internazionale e la difesa*), to date the last ever published by the Italian Ministry of Defence (MoD), argued that the country's armed forces should strive to take the concept of joint-force integration, developed in the 1990s, to the higher level of planning and operations command. Out of this context, the MoD instituted the Joint Operations Command (*Comando Operativo di Vertice Interforze*, COVI), with the aim of creating a truly joint top-level chain of command above the chiefs of the single services.

From an Italian perspective the MDO effort is at its core an attempt to conceptually expand the battlefield. As such, the term 'multi-domain' is on the surface self-explanatory but fails to capture the full scope of the concept. In fact, as further conceptualised by the Italian Defence General Staff, MDO take into account the five domains of operations (land, air, sea, cyber and space) but also the physical, virtual and cognitive dimensions, as well as the military and civilian realms. Furthermore, in such a diverse array of contexts, effects can be kinetic and non-kinetic, adding a further layer of complexity to MDO. The space domain in particular offers a fitting example of how the civilian realm can further be divided into the public and private/commercial spheres and effects can be kinetic or non-kinetic.

Although multi-domain operations are conceived by the Italian military as a concept encompassing all the armed forces, it can be useful to analyse how different branches conceptualise and employ it. A common trait to all of Italy's armed forces is the recognition that data, and the ability to process it and distribute it quickly and in large quantities, is a central pillar of the whole MDO transition. A new MDO-oriented C2 approach will therefore require commensurate investment and emphasis on enabling instruments, such as artificial intelligence (AI), high-performance computing (HPC) and cloud technologies from the strategic down to the tactical level. A crucial and challenging but necessary objective will be to harmonise the efforts of each single armed force and direct them towards a common infrastructure capable of enabling truly joint, cross-domain operations. In this endeavour, the MoD and the industry will have to continue working in close cooperation.

While a multi-domain approach to operations depends first and foremost on the military's ability to change the way it plans, trains for, and carries out its activities, technology is undoubtedly a fundamental enabler. At the defence industrial level, a multi-domain-oriented workflow can have a significant effect on how firms conceive, develop and integrate platforms and systems. While many legacy products can be retro-fitted in order to be interoperable with others, those that are interoperable by design are more seamlessly integrated. The Italian defence and technological industrial base (DTIB) in recent years has therefore shifted toward an MDO approach, which revolves around advanced digitalisation and systems integration aiming to enable cross-domain and cross-platform capabilities, from sensing to effects.

This multi-domain approach puts data at the centre, recognising digital superiority as an increasingly decisive advantage in defence and global security. This advantage is achieved through distributed, cyber-secure digital architectures composed of interconnected sensors, platforms and effectors, which are orchestrated and governed by a multi-domain, distributed C2 capability to generate convergent effects at the speed of relevance. The Michelangelo Security Dome will be Italy's first attempt to implement an integrated architecture of this type at such a scale.

Many ongoing initiatives and core capability enhancements across all operational domains are conceived as fitting into a multi-domain framework by design, including the Global Combat Air Programme (GCAP), the Army's AW249 attack helicopter, the future Main Battle Tank (MBT) and the Army Armoured Combat System (A2CS). These assets are intended to cooperate jointly and receive, generate and integrate data from all domains, incorporating key MDO-enabling features like advanced sensing, AI-powered, data-driven decision support, crewed-uncrewed teaming (CUC-T) and enhanced cyber-security and resilience.

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The Italian Army's approach and the multi-domain tactical bubble

The Italian Army (*Esercito italiano*) is currently undergoing a radical and difficult transformation from a force mostly deployed on peacekeeping, stabilisation, COIN and conflict management operations abroad to one more suited to high-intensity, peer-vs-peer confrontations. Indeed, the EI stands out as one of the land forces in Western Europe most widely deployed abroad ever since the end of the Cold War, having operated in Afghanistan, Somalia, Lebanon, Iraq, Kosovo, Niger and more. Cumulatively, these resource-intensive operations, combined with the severe post-Cold War budget cuts that brought Italian defence spending to just over 1 per cent of GDP in the mid-2010s, have led to an outstretched force plagued by capability gaps on the higher end of the spectrum. Indeed, in a document outlining his vision, the Chief of the Army, General Carmine Masiello, argues in no uncertain terms that the EI must find a way to better manage technological innovation first of all to make different army units more cohesive in combat, but also to facilitate joint and multi-domain operations. Gen. Masiello writes that commanders, even at the lower levels of the command chain, should be able to rely on drones, while manoeuvre must integrate the necessary level of cyber and EW tools.

An analysis of the EI's views regarding MDO, based on a reading of the army's official publications, suggests that these are understood in two slightly different if complementary ways. Firstly, MDO are seen as a way to enable army units (from companies to divisions) to make use of capabilities that transcend the land domain, including for instance drones and aircraft, EW, or cyber tools, in order to make manoeuvre more effective. This first, technology-based, interpretation is heavily reliant on new and emerging technologies, which are defined as a fundamental enabler for cooperation among different units, with drones at the forefront. A second interpretation of MDO is tied to doctrine, training and how the aforementioned technologies are used by soldiers and commanders in order to overwhelm the enemy. In essence, therefore, the multi-domain element in the MDO concept as seen by the Italian Army seems to be just one of many characteristics of what is instead more accurately described as a new way of war that better exploits and adapts manoeuvre to new technologies.

The army has managed to maintain a wide spectrum of capabilities that can be considered useful toward MDO, ranging from its rotary wing component to its EW capabilities. Looking ahead, the Italian MBT and A2CS will be particularly significant as they are intended to be natively integrable in a multi-domain system of systems (SoS) and therefore critical additions to the Army's MDO enablers.

Other than weapon systems and platforms, the EI's leading programme relating specifically to MDO is the "Tactical Bubble" (*Bolla Tattica*), which can be seen as a pragmatic approach to this type of operations by focusing on a wholistic approach that cannot be confined only to defensive or offensive activities. The Army defines it as a "series of cyber and electromagnetic protection measures to protect units, systems and connections between them in order to achieve cyber and electromagnetic superiority" in a given area. In fact, the Tactical Bubble can also be described as the practical expression of an evolving effort to achieve a high level of integration of systems and platforms. The goal could be summarised as concurrently improving C2 by enhancing situational awareness across the chain of command; compressing the kill-chain by forming a more efficient and networked link between sensors and effectors; and creating the conditions for army units to carry out cyber and electromagnetic activities (CEMA) and establish a degree of Electromagnetic Spectrum Operations (EMSO) and cyber superiority over the enemy.

Ultimately, to be truly effective, the Tactical Bubble will require that the Army develop a new "command attitude" that can unleash its potential, especially in the combat phases. At the tactical levels, commanders will have to further develop the ability to act proactively, exploiting the heightened situational awareness awarded by the Tactical Bubble and the compressed kill-chain. Commanders at the operational level will have to focus their attention on "control", meaning assessing the effects that the forces under their command have had against what was laid out during the planning phase – intervening only when

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strictly necessary. In other words, a command attitude that facilitate a decentralisation of command along with a centralisation of control.

Conclusions

Multi-domain, as a term, can seem deceptively self-explanatory. However, while a superficial interpretation of the multi-domain approach to warfare may look no further than its cross-domain quality, MDO are a much more complex and holistic concept. This apparent simplicity inevitably leaves much room to interpretation. Yet, he MDO concept emerged as an attempt to leverage existing advanced technologies in the face of a closing gap with potential adversaries.

While new technologies such as AI, HPC and cloud infrastructures are rightfully considered to be essential components of a multi-domain framework, technology by itself is not enough to take NATO forces from the current paradigm to a multi-domain one. Speed of execution, coordination and synchronisation of effects are therefore just as essential for a true multi-domain approach. Thus, the multi-domain paradigm is not limited to the ability of a system or a military unit to operate in multiple domains, but extends to the integration of different systems, platforms and forces – within or across domains. In fact, platforms and weapon systems cannot be multi-domain in and of themselves, but must instead be integrated with other platforms, sensors and systems. This in turn stresses the enduring importance of doctrinal, organisational and human elements, bearing in mind the relevance of commanders, officers and broadly speaking military personnel in leveraging the options and opportunities provided by technologies thanks to their skills and training. As such, the human factor is central to the MDO transformation, as highlighted by the Italian General Defence Staff approach to MDO.

Against this backdrop, the addition of non-military instruments of power (IoP), as highlighted in the NATO definition of MDO, adds a further layer of complexity to what is essentially a new way of understanding warfare as a holistic effort that aims first of all at the integration of forces and technology. The multi-domain transformation necessarily requires a multi-pronged effort, acting on different but interdependent lines of action, including the following:

1. Integration and interoperability
2. A focus on threats and adversaries
3. Jointness and pragmatism
4. Military-industrial collaborative approach
5. Commanders' access to a recognised picture
6. Empowerment of joint commands
7. Education and training
8. MDO as part of a whole-of-country approach

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1. Implementing multi-domain operations: From the US Army's concept to Joint All-Domain C2

by ***Bryan Clark****

The US Army introduced the multi-domain operations (MDO) concept, originally called Multi-Domain Battle, in 2017.[1] After almost two decades of counterinsurgency (COIN) operations, Army leaders were concerned that improving and proliferating precision strike weapons would make traditional ground manoeuvre warfare obsolete. Although the US military pioneered networked precision strike warfare during the Cold War, the world had entered what Dr. Andrew Krepinevich calls a "Mature Precision Strike Regime" by the 2010s in which most armed forces used guided munitions that exploited US innovations in satellite navigation and mobile communications.[2]

The Army had reason to be concerned about rising and capable threats. Russia was nearly a decade into its grey-zone cyber and proxy campaign against Ukraine and had already annexed Crimea. Several wargames suggested Russian troops could overrun the Baltic NATO allies within a few days.[3] In these scenarios, using its large inventory of conventional surface-to-surface and air-to-surface precision missiles, Russia could eliminate NATO air defences and command and control (C2) while its long-range air defences could deny US and NATO air superiority.

Under the Multi-Domain Battle concept and its successor, MDO, the Army – and its Training and Doctrine Command (TRADOC), who elaborated the documents – planned to counter the reach of enemy air defences using longer-range surface-to-surface missiles targeted using air-launched effects (ALE) drones delivered by a new family of faster, longer-range and stealthier rotary-wing aircraft.[4] In addition to finding enemy air defences, ALE drones would conduct electronic warfare (EW) jamming or decoy operations against adversary radars to protect crewed aircraft or improve the survivability of US strike weapons.

As ALEs and missiles suppressed or destroyed enemy air defences, new rotary-wing aircraft would scout and land assault teams close to the enemy's neutralised rocket and air defence artillery. Army forces would then destroy enemy fires capabilities and allow friendly troops to move forward at scale. In addition to stopping an enemy advance, the MDO approach would allow US forces to retake ground in a contested, precision-strike environment.

The other US military services also saw the need for new operational approaches to address the improving anti-access/area-denial (A2/AD) capabilities being fielded by Russia and China. This effort started with the Air-Sea Battle concept developed by the US Navy and Air Force in 2011, and culminating in the Joint Staff and Air Force incorporating Joint All-Domain Operations (JADO) into their doctrine in 2021.[5]

Like the Army, other services viewed MDO as orchestrating actions across domains to overcome adversary long-range precision weapons. For the Navy and Air Force, this consisted of using actions in the electromagnetic spectrum and space to degrade enemy targeting so air and maritime weapons platforms could approach closely enough to attack.

However, unlike the Army, the other services did not translate the broad outlines of JADO or MDO into more detailed service-centric concepts or force structure. The Navy pursued Distributed Maritime Operations to increase the targeting problem for opponents like China while retaining the ability to mass fires against enemy forces, such as in an invasion of Taiwan.[6] The Air Force

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1 US Defense Department, *Multi-Domain Battle: Evolution of Combined Arms for the 21st Century, 2025-2040*, December 2017, https://www.govinfo.gov/app/details/GOVPUB-D101-PURL-gpo129084.

2 Krepinevich, Andrew F., "Maritime Competition in a Mature Precision-Strike Regime", in *CSBA Reports*, 2014, https://csbaonline.org/research/publications/maritime-competition-in-a-mature-precision-strike-regime.

3 Shlapak, David A. and Michael W. Johnson, *Reinforcing Deterrence on NATO's Eastern Flank: Wargaming the Defense of the Baltics*, Santa Monica, RAND, 2016, http://www.rand.org/t/rr1253.

4 US Army Training and Doctrine Command, "The U.S. Army in Multi-Domain Operations 2028", in *TRADOC Pamphlets*, No. 525-3-1 (6 December 2018), https://www.army.mil/article/243754.

5 Air-Sea Battle Office HQ Marine Corps, *The Air-Sea Battle Concept Summary*, 10 November 2011, https://www.hqmc.marines.mil/News/Article/Article/553062.

6 O'Rourke, Ronald, "Defense Primer: Navy Distributed Maritime Operations (DMO) Concept", in *CRS In Focus*, No.

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published doctrine for how it would support JADO but did not advance an independent cross-domain concept.[7]

1.1 Implementing MDO

Out of the US military services, the Army did the most work to both mature the MDO concept and implement it through programmes and organisation. The then-Army chief of staff, General James McConville, described in a series of concept papers starting in 2021 how the service would transform to implement MDO. The centrepiece of this transformation would be the Multi-Domain Task Force (MDTF), which would integrate C2, intelligence, surveillance, reconnaissance (C2ISR) capabilities, air defences and long-range fires to give ground forces unprecedented reach in relatively contested areas.[8]

Army leaders recognised that the entire service could not be reorganised and equipped to conduct MDO against a high-end adversary like Russia. Instead, MDTFs would act as the vanguard force in two ways: in operations by gaining access for the rest of the ground force; and in development by pioneering new tactics and experimenting with new systems.

Although MDO was initially oriented toward the European theatre against Russia, Army leaders hoped that MDTFs would make MDO and ground forces relevant in the Indo-Pacific, which was the stated priority of several presidential administrations. By emphasising long-range fires, Army leaders envisioned that MDTFs deployed in Japan's southwest islands and in the Philippines could impact a largely maritime fight against China in the South and East China Seas.

During the past five years, the Army established two fully-functional MDTFs. The 1st MDTF is stationed in Joint Base Lewis-McChord, Washington and focused on the Indo-Pacific. The 2nd MDTF is stationed in Germany and concentrates on the European theatre. The Army plans to field three more MDTFs during the next three years, with two focused on the Indo-Pacific and one oriented toward Europe. The Army rotationally deploys MDTF elements to their theatres to conduct training and exercises.[9]

1.2 Equipping for MDO

To equip MDTFs and relevant portions of the remaining force for MDO, the Army initiated six main modernisation priorities during the late 2010s and early 2020s. These included long-range precision fires (LRPF), future vertical lift (FVL), next-generation combat vehicles (NGCV), assured precision navigation and timing (PNT), soldier lethality and air defence.[10] The Army retains these priorities today, but substantially modified most of them since 2022 in response to lessons from the war in Ukraine.

Under LRPF, the Army planned to replace its 1990s-era Army Tactical Missile System (ATACMS) with the longer-range Precision Strike Missile (PrSM). By exploiting lighter materials, new propulsion designs and miniaturised electronics, the PrSM can reach 50 nm farther than ATACMS in half the space, allowing a launcher to carry two PrSMs instead of one ATACMS.[11] By most measures, PrSM has been a success, and is already being fielded through low-rate initial production.[12]

To provide MDTFs longer reach, the Army established two other programmes as part of LPRF modernisation. The Mid-Range Capability (MRC) programme developed launchers and fire control systems to operate Navy SM-6 and Tomahawk missiles. The MRC programme's Mk-70 Typhon launcher is a ground version of the US

IF12599 (4 December 2025), https://www.congress.gov/crs-product/IF12599.

7 US Department of the Air Force, *Air Force Doctrine Publication 3-99: The Department of the Air Force Role in Joint All-Domain Operations*, 19 November 2021, https://www.doctrine.af.mil/Portals/61/documents/AFDP_3-99/AFDP%203-99%20DAF%20role%20in%20JADO.pdf.

8 US Department of the Army, "Army Multi-Domain Transformation. Ready to Win in Competition and Conflict", in *Chief of Staff Papers*, No. 1 (16 March 2021), https://apps.dtic.mil/sti/citations/AD1143195.

9 Feickert, Andrew, "The Significance of the Multi-Domain Task Force (MDTF)", in *CRS In Focus*, No. 11797 (17 December 2025), https://www.congress.gov/crs-product/IF11797.

10 US Congress Committee on Armed Services, *Fiscal Year 2024 Army Modernization Programs*, 26 April 2023, https://www.congress.gov/event/118th-congress/house-event/LC72791/text.

11 Marino, Cheryl, "Then & Now ATACMS to PrSM: Out with the Old, in with the New", in *Army AT&L Magazine*, Summer 2024, p. 139-143, https://asc.army.mil/armyalt/Summer2024/html/print/AL&TMagazine_Summer2024_DL.pdf.

12 Ames, Darrell, "Precision Strike Missile Increment 1 Achieves Milestone C Approval", in *US Army Articles*, 6 July 2025, https://www.army.mil/article/286878.

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Navy's Mk-41 vertical launch system, and may be replaced by a smaller launcher emerging from the Army's Common Autonomous Missile Launcher (CAML) programme.[13] At the longest ranges, the Army is developing a long-range hypersonic weapon (LRHW), called Dark Eagle, which uses a boost-glide hypersonic missile able to hit targets more than 2,000 nm away.[14]

The FVL modernisation effort included two programmes. To enable scouting in contested air environments, the Army pursued the Future Armed Reconnaissance Aircraft (FARA), which would replace Kiowa and other small helicopters.[15] To complement FARA and enable delivery of troops and material the Army started the Future Long-Range Assault Aircraft (FLRAA) programme.

The Army substantially revised both FVL programmes based on the low survivability of rotary wing aircraft during the war in Ukraine. Army leaders cancelled the FARA programme in 2024 after spending nearly two billion dollars on research and development (R&D), deciding to instead use small uncrewed air systems (UAS) for the armed reconnaissance mission.[16] Emulating the model demonstrated in Ukraine and Russia, Army troops would use a variety of small UAS to find, fix and even engage enemy forces.

The Army continued the FLRAA programme and awarded Bell a contract in 2022 for a long-range tilt-rotor assault aircraft called the V-280, which is now entering production. To address the vulnerability of helicopters demonstrated in Ukraine, the Army developed a new tactic for MDO in 2024 called large-scale, long-range air assault (L2A2). Under L2A2, after long-range fires and EW suppress enemy air defences, V-280s would deliver a brigade-sized group of several thousand soldiers up to 500 miles away during one period of darkness. This approach would, in theory, circumvent enemy efforts to stop the manoeuvre using small drones.[17]

The MDO concept depends on soldiers 'survivably' moving at speed to take ground after long-range missiles and UAS have degraded enemy fires capabilities. To transform its approach to manoeuvre the Army planned to develop, as part of Next Generation Combat Vehicle (NGCV) modernisation, a mobile protected firepower (MPF) light tank, a robotic combat vehicle (RCV) and an optionally-unmanned troop transport to replace the Cold War-era Bradley Fighting Vehicle.

In less than a decade since it established the NGCV programmes, the Army has substantially revised or cancelled all of them. The Army cancelled the M10 Booker MPF light tank after concluding it was not survivable in a fight like that happening in Ukraine, where a 500 US dollars drone can disable a tank and kill most of the occupants.[18] The RCV programme was renamed Unmanned Ground Commercial Robotic Vehicles (UGCRV), and is pursuing low-cost commercial autonomous vehicles that will provide mobility and fires to support MDO tactics being developed through the service's Transformation in Contact (TIC) initiative.[19]

The Army has made steady progress on its efforts to field assured command, control and communications (C3) through the Next-Generation C3 programme, which is using TIC to co-evolve tactics and new equipment like the TITAN command, control, communications, computers, intelligence (C4I) system. To control the electromagnetic spectrum these systems depend on, the Army radically shifted its approach

13 Arthur, Gordon, "Army Bullseyes Maritime Target with SM-6 Fired From Portable Launcher", in *USNI News*, 17 July 2025, https://news.usni.org/?p=116982.

14 Feickert, Andrew, "The U.S. Army's Long-Range Hypersonic Weapon (LRHW): Dark Eagle", in *CRS In Focus*, No. 11991 (12 June 2025), https://www.congress.gov/crs-product/IF11991.

15 Magnuson, Stew and Sean Carberry, "Army's Latest Attempt to Replace Scout Helicopter Abruptly Ends; Billions More Wasted", in *National Defense Magazine*, 8 February 2024, https://www.nationaldefensemagazine.org/articles/2024/2/8/armys-latest-attempt-to-replace-scout-helicopter-abruptly-ends-billions-more-wasted.

16 Skove, Sam, "In Shakeup, Army Cancels Planned Scout Helo, Will Retire Two Drones", in *Defense One*, 8 February 2024, https://www.defenseone.com/defense-systems/2024/02/shakeup-army-cancels-planned-fara-helo-will-retire-two-drones/394061.

17 Decker, Audrey, "Bell Presses on with FLRAA as Army Cools on Large Programs", in *Defense One*, 16 October 2024, https://www.defenseone.com/business/2024/10/bell-presses-flraa-army-cools-large-programs/400328.

18 Judson, Jen, "Dead on Arrival: Army Pulls Plug on M10 Booker Light Tank", in *Defense News*, 12 June 2025, https://www.defensenews.com/land/2025/06/12/dead-on-arrival-army-pulls-plug-on-m10-booker-light-tank.

19 Roque, Ashley, "Army Moving out with Cheaper Robotic Combat Vehicle Competition, but with a New Name", in *Breaking Defense*, 18 August 2025, https://breakingdefense.com/?p=47904.

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to EW from vehicle-borne to man-portable systems in 2025 drawing upon lessons from Ukraine.

Air defence is the modernisation priority with the most unknowns at this point. The Army is fielding a comprehensive integrated air and missile defence (IAMD) C2 system called the Integrated Battle Management C2 System (IBCS), along with a new Lower Tier Air and Missile Defence Sensor (LTAMDS) for the Patriot system. Both of these programmes are in production.[20] Poland was the first international customer for IBCS and conducted a live fire exercise in 2025 combining IBCS with a domestic surface-to-air missile system.[21]

Patriot and IBCS are designed for strategic or national air defence rather than protecting troops on the move. The Army is addressing those needs with the Indirect Fire Protection Capability (IFPC), a vehicle-mounted system which carries 18 AIM-9X Sidewinder or AGM-114 Hellfire missiles to engage threats up to 10 km away.[22] Closer in, the Army's vehicle-mounted short-range air defence (SHORAD) systems like the SGT STOUT and Avenger use Stinger missiles and guns to shoot down aircraft within a few kilometres.[23]

1.3 Joint All-Domain C2

The most significant investment in MDO at the joint level is the US Department of Defence's (DoD) Joint All-Domain Command and Control (JADC2) initiative. While the other services diverged from MDO in their own doctrine and programmes, joint and DoD-wide leaders focused on developing new capabilities to connect sensors, shooters and commanders across domains and services under JADC2.

DoD leaders originally envisioned JADC2's goal as creating a dramatically more interoperable military. But the difficulty of upgrading multiple generations of C2 systems and networks to be compatible became too difficult and the DoD has since downscaled its ambitions to focus JADC2 on specific kill chains needed to address combatant commanders' key operational problems.

The DoD mounted a series of Global Information Dominance Experiments (GIDE) that connected forces and commanders across theatres and domains.[24] To complement this overall joint effort, the Navy began Project Overmatch and the Army started Project Convergence to assemble priority kill chains across domains and services. These service experimentation campaigns have yielded substantial interoperability improvements in a bottom-up manner.[25]

1.4 Transforming for the future

Army leaders recognised in 2024 that the MDO concept and its enabling capabilities were not adapting quickly enough to the operational environment reflected by the war in Ukraine. They initiated TIC to experiment with uncrewed vehicles, counter-UAS capabilities and new systems and tactics for sensing and C3 in contested environments.

Instead of a traditional approach, which would push new systems out to units and train them on their use, TIC provides Army units new systems just before or during their time at the Army's major training centres and asks units to both assess the systems' utility and develop tactics that best exploit them. With TIC, the Army has again reformed its priorities for MDO to be C3, long-range fires from rocket artillery or drones, and air defences in the form of counter-UAS systems.[26]

20 Roque, Ashley, "Army Moves LTAMDS into Low-Rate Initial Production", in *Breaking Defense*, 21 April 2025, https://breakingdefense.com/2025/04/army-moves-ltamds-into-low-rate-initial-production.

21 Ames, Darrell, "Republic of Poland's NAREW Program Successfully Conducts Live-Fire Test", in *US Army Articles*, 22 September 2025, https://www.army.mil/article/288660.

22 Feickert, Andrew and Ebrima M'Bai, "The U.S. Army's Indirect Fire Protection Capability (IFPC) System", in *CRS In Focus*, No. 12421 (14 January 2026), https://www.congress.gov/crs-product/IF12421.

23 Wiggins, Vincent R., "The Evolution of Air Defense. Adapting to Emerging Threats", in *Military Review*, Vol. 105, No. 5 (September-October 2025), p. 136-153, https://www.armyupress.army.mil/Journals/Military-Review/English-Edition-Archives/September-October-2025/Air-Defense.

24 US Department of War, *DoD Chief Digital and Artificial Intelligence Office Hosts Global Information Dominance Experiments*, 30 January 2023, https://www.war.gov/News/Releases/Release/Article/3282376/dod-chief-digital-and-artificial-intelligence-office-hosts-global-information-d.

25 Enoch, Joseph and David Miller, "Project Convergence Capstone 5 Experiments at NTC", in *US Army Articles*, 3 April 2025, https://www.army.mil/article/284397; Chen, Lily, "Commercial Tech Partnerships Drive Unprecedented Progress for Project Overmatch and Navy Capability", in *DVIDS News*, 18 June 2025, https://www.dvidshub.net/news/501030.

26 Anderson, Bradley and Kathryn Bailey, "Transforming

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MDO has undergone many changes in the decade since its emergence. Instead of quickly gaining ground after adversary air defences and long-range fires are suppressed, infantry and armour units now must contend with a highly contested electromagnetic environment dominated by small drones. Through TIC, Army leaders hope to ensure the Army remains relevant to a rapidly changing operational environment.

in Contact", in Army AT&L Magazine, Summer 2024, p. 37-43, https://asc.army.mil/armyalt/Summer2024/html/print/AL&TMagazine_Summer2024_DL.pdf.

2. Multi-domain operations and NATO: Work in progress

by ***Karolina Muti****

According to publicly available sources, NATO defines MDO as "the orchestration of military activities, across all domains and environments, synchronized with non-military activities, to enable the Alliance to deliver converging effects at the speed of relevance".[1] The origin of the concept has its roots in the United States[2] and gradually spread throughout the alliance, mostly among the larger and more capable militaries, such as the UK, France and Italy. In recent years, through an internal process, NATO has adapted and adopted the MDO concept as the latest evolution of a lineage of approaches to war-fighting that include, among others, Air-Land Battle, network-centric operations (NWC) and joint operations.[3] NATO's open-source working definition of MDO is rather generic, which is at least in part the result of finding a wording acceptable to all Allies, but also helps ensure a degree of flexibility. As such, the definition reaches far beyond purely defence-related aspects, encompassing not only activities in the five operational domains, but also "non-military activities".

Such understanding of multi-domain operations, while conceptually in line with many allies' approaches and reflecting the increasingly blurred lines between the military and civilian dimensions of conflict and the vital role of a variety of institutional, industrial, societal and technological actors/stakeholders, pushes Allies beyond the "joint" paradigm. It must be clarified that the inclusion of a non-military dimension into the definition of MDO does not entail NATO's responsibility on such non-military activities, as they are separate and autonomous. It rather serves the purpose to remind that MDO must

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1 NATO Allied Command Transformation (ACT), *Multi-Domain Operations: Enabling NATO to Out-pace and Out-think Its Adversaries*, 29 July 2022, https://www.act.nato.int/?p=1327.

2 For a more detailed analysis of the origins of the MDO concept as elaborated by the US Army, see chapter 1 of this study.

3 IAI interview, 8 October 2025.

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be seen as a component in a broader framework which includes national Instruments of Power (IoP), composed by both military and non-military elements,[4] with the latter out of NATO's control.[5] On one hand, such factual restriction limits the complexity. On the other hand, NATO acknowledges the existence of state activities, but also increasingly non-state activities relevant to achieve MDO objectives.[6] In this sense, the Alliance bears the responsibility for the military component among the national IoPs, but aims to benefit from and synchronise with other IoPs and services or assets belonging to external stakeholders when needed.

The adoption by NATO of the MDO paradigm can be interpreted as a response to the challenge posed by Russia's A2/AD capabilities[7] and hybrid warfare by Moscow and other potential adversaries in recent years, but also as a way to build on the digital revolution that opened new opportunities to reform or even revolutionise how Allies conduct operations.[8]

NATO's public definition of MDO does not provide, on its own, clues to understand how MDO could work from an operational or tactical standpoint. The Alliance has tried to promote a shared understanding of MDO among its member states in light of the challenge of operationalising the concept. The "Multi-domain Multinational Understanding" (MMU) project led by the UK and NATO Allied Command Transformation (ACT) tried to provide a common, "agreeable" terminology and foundational principles, based on the work of a community of interest in the framework of a Multinational Capability Development Campaign (MCDC) programme.[9] 15 Allies participated in the programme, including the United States, the UK, Italy, France, Germany, Poland, Spain, Sweden, whereas the EU, Japan, Norway and Romania were observers to the activity.[10] The principles identified by the project relevant for MDO are: a shared understanding; unity of effort; dynamic posture; agility; and innovation.[11]

These principles "should encompass the design, planning and execution of multi-domain activity across the strategic, operational and tactical levels and within a CJIIM context".[12] The MMU Report published in November 2022 provided recommendations to NATO, suggesting to translate the five principles into operational requirements; to review current joint functions to identify gaps in C2, doctrine, organisation, training, from a multi-domain perspective; to use wargaming and experimentation to validate the multi-domain principles; and to establish a mechanism to share these principles "across multinational instruments of power, agencies, entities and organizations".[13]

In a number of cases some European Allies had begun developing their own understanding of MDO before an official internal process could be undertaken by NATO. For instance, Italy's first MDO concept was published in 2022,[14] France's in 2021,[15] and the UK's in 2020.[16] In a way, the

4 NATO ACT, *Multi-Domain Operations in NATO – Explained*, 5 October 2023, https://www.act.nato.int/?p=8383.

5 Bundeswehr Office for Defence Planning, *Multi-Domain Operations for the Bundeswehr. A Short Introduction*, March 2024, https://www.bundeswehr.de/resource/blob/5753418/11123cfdc6a7117559625ae08cec7b31/brochuere-engl-data.pdf.

6 Dailey, Ann Marie, "NATO Needs a Plan for Military and Nonmilitary Instruments of Power to Work Together", in *New Atlanticist*, 2 November 2023, https://www.atlanticcouncil.org/?p=698312.

7 Schmidt, Andreas, "Countering Anti-Access / Area Denial: Future Capability Requirements in NATO", in *The Journal of the JAPCC*, No. 23 (Autumn/ Winter 2016), p. 69-77, https://www.japcc.org/?p=11835.

8 Gilli, Andrea et al., "NATO, Multi-Domain Operations and the Future of the Atlantic Alliance", in *Comparative Strategy*, Vol. 44, No. 1 (2025), p. 73-91, https://www.doi.org/10.1080/01495933.2024.2445491.

9 NATO C2COE, *Multi-Domain Multinational Understanding (MCDC)*, 14 February 2023, https://c2coe.org/multi-domain-multinational-understanding-mcdc.

10 Multinational Capability Development Campaign (MCDC), *Multi-Domain Multinational Understanding*, November 2022, p. ii, https://assets.publishing.service.gov.uk/media/63c1666ae90e074ede1f356c/MCDC_MDI.pdf.

11 Ibid., p. iii.

12 Ibid., p. 14. CJIIM: combined, joint, inter-agency, intergovernmental and multinational. See Ibid., p. 1.

13 Ibid., p. 26.

14 For an analysis of Italy's approach to MDO, see chapter 3 of this study.

15 French Armed Forces-Centre interarmées de concepts, de doctrines et d'expérimentations (CIDCE), *Multimilieux et multichamps (M2MC), la vision française interarmées* (62/ARM/CICDE/NP), 6 September 2021, https://www.defense.gouv.fr/sites/default/files/cicde/20210906-NP-CIA-0.1.1_M2MC-2021_VF2.pdf.

16 UK Ministry of Defence, *Multi-Domain Integration* (Joint Concept Note 1/20), November 2020, https://assets.publishing.service.gov.uk/media/6579c11a254aaa000d050c6e/20201112-ARCHIVE_JCN_1_20_MDI_Official.pdf.

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US and these countries' experiences and thinking have contributed to NATO's early steps toward the MDO transformation, though each brought slightly different nuances.[17]

For instance, the "Multi-domain operations for the Bundeswehr" document by the Office for Defence Planning in Germany recognises that German Armed Forces' adaptation to a full MDO ability will take a generation, comparing the complex process of adaptation to a "marathon", rather than a "sprint".[18] The Bundeswehr lists a number of elements to be developed in order to achieve MDO, including a reference architecture and framework scenarios for MDO, cloud/edge/artificial intelligence (AI) capabilities as technical foundations, and an assessment of how technical evolution impacts mission control and C2. Meanwhile, the French version of MDO, "*multimilieux* and *multichamps*", refers to the electromagnetic spectrum and to the information domain as additional elements of the equation. The UK's "Multi-Domain Integration" joint concept note, while still looking at the importance of integrating effects in different domains and new technologies, focuses on creating synergies with non-military elements in an inter-agency, inter-ministerial approach, looking at the international realm through global and regional lenses, and can be seen as the one that has more clearly influenced the NATO Concept.[19] Italy's MoD concept for MDO largely matches its Allies' and can be described as an effort to leverage technology in order to expand the battlefield and integrate effects across domains (land, sea, air, cyber, space), dimensions (physical, virtual and cognitive), and realms (military and civilian).[20]

Those Allies who had not had the chance or means to develop full-fledged MDO concepts are now in the process of assimilating NATO's own concept, or integrating their capabilities into the Alliance's developing MDO framework. Both groups, however, will now be called upon to adapt the concept to the national realities of their Armed Forces.

After almost three years from the adoption of the MDO concept by the Alliance,[21] implementation and operationalisation across 32 Allies are still in an embryonic phase. Common understanding of MDO remains a key challenge for Allies, given that there are different national understandings, but also significant nuances inevitable between different armed forces. The NATO Multi-domain Conference held in Ankara in May 2025 identified ensuring a common understanding of MDO across the Alliance as one of the three main aspects that NATO should focus on.[22] The other priorities included promoting a Cross-Domain Command approach "in mindset and culture", and coordination in MDO capability development.[23]

Levels of common understanding vary across NATO with regard to different aspects of MDO. There seems to be a more advanced shared understanding, agreement and clarity on the higher level strategic objectives, and on technological and capability aspects, compared with the operational and tactical levels including more granular issues such as doctrine, processes and organisation.[24] From a technological and capability standpoint, this refers to what technologies and capabilities are needed to operationalise the concept, and what are the general technological and capability gaps and challenges related to MDO. From a higher level, strategic standpoint, there is substantial agreement among Allies over MDO consisting in achieving information and decision superiority based on: implementing network-centric operations; achieving speed of action and decision making; planning, operating and gaining advantages seamlessly across domains by synchronising effects and compressing the kill-chain. Elements like information and data superiority over adversaries, faster decision making and situational awareness are all well consolidated strategic goals at the NATO level and

17 IAI interview, 8 October 2025.
18 Bundeswehr Office for Defence Planning, *Multi-Domain Operations for the Bundeswehr*, cit.
19 Blythe, Wilson Jr., "Divergent Paths. Multi-Domain Operations in NATO", in *Academia.edu*, 2025, https://www.academia.edu/129638574; UK Ministry of Defence, Multi-Domain Integration, cit.
20 For an analysis of the Italian approach to MDO, see chapter 3 of this study.
21 Kramer, Franklin et al., "NATO Multidomain Operations: Near- and Medium-Term Priority Initiatives", in *Atlantic Council Issue Briefs*, 21 February 2024, https://www.atlanticcouncil.org/?p=695148.
22 NATO ACT, *2025 Multi-Domain Operations Conference: Driving Success Across All Domains*, 27 May 2025, https://www.act.nato.int/article/2025-mdo-conference.
23 Ibid.
24 IAI interview, 30 July 2025.

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have been part of Allied thinking and warfighting concept since well before MDO emerged as a new paradigm, as exemplified by the 2021 Warfighting Capstone Concept (NWCC). While until recently these goals were part of an effort toward "Joint Operations", NATO has now expanded its scope to include non-military assets and capabilities more substantially.

A number of key technologies and capabilities have been central to NATO efforts and seen as enablers, such as improved C2, offensive and defensive Cyber and Electromagnetic Activities (CEMA), coupling cybersecurity with interoperability, fusion/integration of data from different sources. In March 2025, after an exceptionally fast procurement process, NATO acquired an AI-enabled warfighting platform to be employed within NATO's Allied Command Operations (ACO) at SHAPE, in line with the need to digitalise the entire force structure and obtaining advanced capabilities in all domains.[25] The system, Palantir's Maven Smart System NATO (MSS NATO), shares some features with the US military's own Project Maven and is meant to enable MDO by integrating and processing data from multiple sources into a common platform, making use of AI applications such as large language models, machine learning and generative AI.[26] MSS NATO was incorporated during Allied exercises Steadfast Deterrence 2025 and Steadfast Duel 2025.[27] The latter was particularly significant in that it aimed to validate NATO's approach to MDO and its C2 capabilities in large scale MDO.[28] Ultimately, the software should facilitate intelligence fusion, battlespace management, operational planning and faster decision-making within the alliance.

Such enablers are generally a focal point shared by most Allies, yet there may be significant debate in coming years over specific applications, standards and common infrastructure when it comes to integrating them into command structures and kill-chains.

Meanwhile, coming to a shared understanding in areas heavily depending on the human factor, such as doctrine, planning, operations or training seems more cumbersome.[29] A number of Allies acknowledge that MDO requires a shift in mindset and culture inside the Armed Forces.[30] However, NATO needs to be realistic in terms of the time required for such a cultural change to happen, which could take to Allied armed forces and NATO itself more than a generation. Even then, some national nuances will likely endure, due to different national cultures and military traditions. Nevertheless, Joint Allied Training will be key in achieving operationally sound results, as MDO are multinational by definition, considering that no Ally alone has the capabilities to reach autonomous MDO, with the notable exception of the United States. The MMU Report called for the establishment of a "continuous program of education and training across domains and disciplines",[31] taking into account how emerging and disruptive technologies (EDT) are changing modern warfare and the role of the human factor within it.

The MDO evolution pushes Allied armed forces to widen their approach to conducting operations and change the way an operation is conceived and carried out. In order to ensure that the MDO concept can be operationalised and implemented through the complex and diverse realities of NATO armed forces, the challenges that the Atlantic Alliance faces could be grouped into conceptual, human and organisational aspects.

Conceptually, the challenge refers to the Allied MDO definition itself, and a certain level of ambiguity that it generates. In recent years, Allies used a number of terms to address MDO, from the US "Joint All-Domain Operations", to UK "Multi-Domain Integration",[32] to the French

25 Gilli, Andrea et al., "NATO, Multi-Domain Operations and the Future of the Atlantic Alliance", cit.

26 Eshel, Tamir, "NATO AI Modernization: Palantir's Maven Smart System Acquisition", in *Defense Update*, 18 April 2025, https://defense-update.com/?p=159788.

27 NATO Joint Warfare Centre (JWC), *The Joint Warfare Centre Trains to Integrate Maven Smart System*, 25 August 2025, https://www.jwc.nato.int/?p=12165.

28 NATO ACT, *Integration in Motion: NATO's Collective Readiness Tested at STEADFAST DUEL 2025*, 4 November 2025, https://www.act.nato.int/?p=12682.

29 IAI interview, 31 July 2025.

30 Aerospace Power Conference 2025, "Doctrine and Leadership" Panel, 8-9 May 2025, https://www.aeronautica.difesa.it/?p=181461.

31 MCDC, *Multi-Domain Multinational Understanding*, cit., p. 17.

32 Dinsdale, Ranald, "Multi-Domain Integration: Demystified", in *Cyber & Specialist Operations Command Blog*, 11 October 2021, https://cyberandspecialistoperationscommand.blog.

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version of *Multimilieux et Multichamps*,[33] or, more specifically, Multinational Multi-Domain Command and Control.[34] These terms are similar in their nature and characteristics, but they are not synonyms,[35] and they show an array of different interpretations and nuances to the concept spanning throughout the Alliance. The breadth of NATO's MDO definition encompasses elements that are external to the military dimension and to the NATO mandate, opening the Pandora box of national IoP outside pure defence, and of "external stakeholders", which go beyond the "whole of government" approach. Conceptually speaking, therefore, breaking silos and recognising the elevated level of interconnection between these areas is the first step to matching the current threat landscape and international context.

Nevertheless, "synchronising" what instruments NATO can control with what it cannot, such as some national IoPs and external stakeholders across 32 different national political, economic and social systems entails a level of complexity difficult to manage. Furthermore, a shared understanding of MDO may be achievable across Allied armed forces, but not necessarily across governments and societies. Although it is important for NATO to make an active effort to reach out and coordinate with the non-military dimensions and prepare the ground for MDO, this should not come at the price of overall clarity, pragmatism, and of a homogenous direction for NATO Armed Forces. In fact, in light of the cognitive warfare led by adversaries against Allied societies and the turnover typical of democratic processes, NATO needs to navigate this complex environment assuming that, in the framework of a "whole of government" approach, a truly shared understanding by national institutions and agencies within the Alliance may stay fragmented, influencing the overall unity of intent. In this sense, the bar, which was set ambitiously high for the Allied military instruments, should be posed somewhat lower for what concerns the objective of "synchronising" with national IoPs and external stakeholders, due to the panoply of diverging interests, incentives and agendas.

The Human aspect is probably the most challenging and multifaceted. It can relate to elements so varying as to encompass the functioning of NATO as an international organisation and institution with its processes, hierarchies and bureaucracy; doctrine and learning, education and training throughout military ranks; strategic culture, trust and delicate political balances. Information sharing among Allies is a good example of an area where solid technological solutions exist to support MDO, but lack of trust among Allies and their services – due to political tensions and/or competition – may be an obstacle to the levels of integration needed to take MDO to the next level. Adversity to change in complex organisations may also play a role, even if NATO has proven to be particularly adaptable throughout its history. Yet at the operational level, differences in how Allies organise and manage capabilities and forces in the cyber and space domains,[36] which are both key to successful MDO, add a layer of complexity.

To sum up, MDO implementation in NATO seems to be a "work in progress". Some of the concept's prerequisites, including a common understanding and unity of intent are currently being built and will need to be tested in operational theatres. Continuous adaptation will be key to ensure effectiveness, and conceptual, human and organisational challenges will persist in the foreseeable future. This is only the beginning of an overarching process of transformation within the Alliance, and NATO will have to be realistic with regards to the objectives and expectations concerning MDO, accepting a certain level of fragmentation as an intrinsic part of Alliance-wide cultural shifts.

gov.uk/2021/10/11/multi-domain-integration-demystified.

33 CIDCE, *Multimilieux et multichamps (M2MC)*, cit.

34 MCDC, *Multi-Domain Multinational Understanding*, cit.

35 Bundeswehr Office for Defence Planning, *Multi-Domain Operations for the Bundeswehr*, cit.

36 For an analysis of NATO's role in space matters, see Calcagno, Elio, "NATO and its members: A space Alliance?", in Alessandro Marrone and Michele Nones (eds), "The Expanding Nexus between Space and Defence", in *Documenti IAI*, No. 22|01 (February 2022), p. 44-49, https://www.iai.it/en/node/14669.

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3. Italy and multi-domain operations: Doctrine, planning and technology

by ***Nicolò Murgia*** and ***Elio Calcagno****

The concept of MDO generally relates to the ability to generate effects across domains and dimensions, relying also on cyber, electromagnetic and – according to some – cognitive warfare. The increasing reliance on the electromagnetic spectrum and cyber domain to enable operations, but also to defend from enemy attack, together with the need for optimal synchronisation across domains and forces, has put into serious question the idea of supremacy, or even dominance, in a single domain. Domains are therefore increasingly interconnected, and generating effects in one can rarely be extricated from concurrent effects in another. In addition, elements such as cognitive warfare are inherently cross-domain and extend beyond purely military targets. Conceptualising MDO therefore requires going beyond an interpretation that envisages a mere sum of effects originating from different domains. Instead, at the core of the multi-domain operations concept is the mutual amplification of these effects through a multiplier effect that is based on a unified and integrated framework that includes all components leading to physical, virtual and cognitive impacts.[1]

The Italian debate has often focused on whether MDO are an evolution from a 'joint-forces' (*interforze*) approach to operations, or a complementary objective. The 2015 White Book for International Security and Defence (*Libro bianco per la sicurezza internazionale e la difesa*), to date the last ever published by the Italian Ministry of Defence (MoD), argued that the country's armed forces should strive to take the concept of joint-force integration, developed in the 1990s, to the higher level of planning and operations command.[2] Out of this context, the MoD instituted the Joint Operations Command (*Comando Operativo di Vertice Interforze*, COVI), with the aim of creating a truly joint top-level chain of command above the chiefs of the single services.

From an Italian perspective the MDO effort is at its core an attempt to conceptually expand the battlefield. At a Defence General Staff level, multi-domain operations are described as:

> Military activities conducted across multiple domains to perceive, understand and act on converging effects aimed at generating multiple dilemmas at such a speed as to overcome the adversary's decision-making capacity. Activities are conducted by synchronising military actions with other instruments of national power and/or with allies and partners, under a synchronised command and control structure (so-called Multi-Domain Command & Control, MDC2).[3]

As such, the term 'multi-domain' is on the surface self-explanatory but fails to capture the full scope of the concept. In fact, as further conceptualised by the Italian Defence General Staff, MDO take into account the five domains of operations (land, air, sea, cyber and space) but also the physical, virtual and cognitive dimensions, as well as the military and civilian realms. Furthermore, in such a diverse array of contexts, effects can be kinetic and non-kinetic, adding a further layer of complexity to MDO. The space domain in particular offers a fitting example of how the civilian realm can further be divided into the public and private/commercial spheres and effects can be kinetic or non-kinetic.[4]

Among the other official Italian documents which emphasise the relevance of MDO is the 2022 Strategic Concept of the Defence Chief of Staff (*Concetto Strategico del Capo di Stato Maggiore della Difesa*). In the document, a boost in the enhanced joint-forces integration is seen as a prerequisite for the necessary upgrade of the

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1 IAI interview, 31 July 2025.

2 Italian Ministry of Defence, *Libro Bianco per la sicurezza internazionale e la difesa*, 2015, https://flpdifesa.org/wp-content/uploads/2015/05/Libro-Bianco-30.04.2015-5a-versione-def-sul-sito-MD.pdf.

3 Italian Defence General Staff, *The Italian Defence Approach to Multi-Domain Operations*, 2022, p. 24-25, https://www.difesa.it/assets/allegati/31787/2.1defence_approach_to_mdos.pdf.

4 Calcagno, Elio et al., "Le minacce cyber ed elettromagnetiche alle infrastrutture spaziali", in *Documenti IAI*, No. 24|07 (July 2024), https://www.iai.it/en/node/18696.

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synchronisation of the effects stemming from the five domains, thus making a formal link between MDO and cross-service integration.[5] This is specifically represented by the strengthening of the C2 capabilities of the COVI through the development by Leonardo of a Joint Operations Centre (JOC), a unified info-structure from which to manage operations at a joint-forces level, including the establishment of a Joint Common Operational Picture (JCOP) guaranteeing a complete multi-domain situational awareness[6] enriched with information from non-military domains (such as political, social, economic, information), and the construction of a cultural and operational *modus operandi* that goes beyond the traditional understanding of conflict as being tied and confined to individual domains. In addition, the Strategic Concept calls for enhanced strategic anticipation and situational awareness vis-à-vis potential adversaries, which then need to be coupled with the harmonisation and synchronisation of effects in order to maximise their potential. Indeed, the 2023 Defence Minister's policy guidelines emphasise that the military must become intrinsically multi-domain, as it can no longer be limited to the ability to operate in multi-domain scenarios and contexts on a contingent basis.[7] The synergy of the components relating to the various domains must therefore be seen as a structural feature, rather than an adaptation to specific operational requirements linked to certain contexts.

Although multi-domain operations are conceived by the Italian military as a concept encompassing all the armed forces, it can be useful to analyse how different branches conceptualise and employ it. The Italian Army (*Esercito Italiano*, EI), in the wake of the US Army's early efforts, was unsurprisingly the first to tackle the MDO concept.[8] The EI therefore regards the integration of MDO as being part of its transformation process toward a more agile, adaptable, integrated and networked force. The conceptualisation regarding MDO has been attributed to the 3rd Detachment, General and Financial Planning (*III Reparto Pianificazione Generale e Finanziaria*), which is responsible for doctrinal development and conceptual experimentation.[9] The EI's Conceptual Approach (*Approccio Concettuale*) 2020 on MDO and the Operational Concept of the Italian Army (*Concetto Operativo dell'Esercito Italiano*) 2020-2035, highlighted how commanders must conceive effects as not limited to the physical sphere, but must include in the land manoeuvre the information sphere, and integrate space- and cyber-related effects. At the organisational level, formations need to operate as nodes in a joint sensor-to-shooter network, in order to integrate their specific task in an agile and adjustable framework rather than acting as isolated brigades. Aspects like EW, ISR and cyber, need to be integrated in the early stages of mission planning by default. In terms of execution, the EI considers it necessary to ensure a high degree of flexibility and decentralisation in exploiting cross-domain effects while pursuing centralised aims. The Tactical Bubble (*Bolla Tattica*) is the Army's leading effort toward a truly multi-domain approach to operations, and aims to develop wide-ranging integration among crewed and uncrewed systems and platforms, in a system of systems (SoS) framework, with a view to improving C2, compressing kill-chains, networking sensors and effectors, and allowing relevant units to carry out CEMA. In view of this, exercises and training clearly play a crucial role in the full integration of such an approach, and must put emphasis on multi-echelon wargaming, cyber-red teaming, and joint activities to test C2 flows and information sharing across services.

The Italian Air Force (*Aeronautica Militare*, AM) is organically an enabler of MDO through its manned and unmanned platforms, providing

5 Italian Defence General Staff, *Il concetto strategico del Capo di Stato Maggiore della Difesa*, September 2022, https://www.difesa.it/assets/allegati/28000/concetto_strategico_del_casmd_2022.pdf.

6 Leonardo, *JOC-COVI, a Multi-Domain Oriented Information Ecosystem*, 7 October 2024, https://www.leonardo.com/en/focus-detail/-/detail/joc-covi-ecosistema-informativo-multi-dominio.

7 Italian Ministry of Defence, *Documento programmatico pluriennale della difesa per il triennio 2023-2025. Edizione 2023*, 25 January 2023, https://www.difesa.it/assets/allegati/30714/dpp_2023-2025.pdf.

8 For a detailed analysis of the Italian Army's approach to MDO, see chapter 4 of this study.

9 Italian Ministry of Defence, *La componente terrestre nelle Operazioni Multi-Dominio*, 28 January 2021, https://www.difesa.it/primopiano/la-componente-terrestre-nelle-operazioni-multi-dominio/52082.html.

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sensors for enhanced situational awareness as well as airborne ISR capabilities and satellite communications (SATCOM) that generate effects that allow them to interact with all domains as needed. Despite no specific doctrine documents having been published in the public domain so far, planning and practice activities highlight a focus on interoperability and on the fusion of aerospace with the information and cyber domains. Systems like the F-35 are designed to operate fully integrated in a cross-domain network in conjunction with land and naval assets. In a joint exercise with the Italian Navy (*Marina Militare*, MM) in 2022, F-35Bs of the AM and MM were deployed to Pantelleria to test air expeditionary capabilities and to perform COMposite Air Operations (COMAO), including Close Air Support (CAS) and air interdiction.[10] The objectives of the exercise were to increase the degree of cooperation between the two armed forces and to identify synergies in the use of the F-35B among them, even though the two branches operate the system differently. The exercise was also a clear example of how the AM sees its role as a cross-domain enabler, ranging from situational awareness to C2 and ensuring enhanced connectivity among assets in all domains.

Finally, the Italian Navy has developed its approach to MDO adapting the concepts of sea control/denial to the increasing importance of integrating and coordinating effects in all domains, including cyber and space. For the Navy, however, the rapid technological advancements making the underwater environment ever more accessible have added a further challenge to creating a true SoS for carrying out naval warfare.[11] The Future Combat Naval System (FCNS) 2035 document therefore establishes an MDO concept based on a SoS comprised of crewed and uncrewed systems, networked sensors, and space- and cyber-based enablers. For a platform-dependent force already used to operations integrating an array of assets dispersed across domains, MDO are almost a given, with FCNS 2035 focusing mostly on the importance of achieving a higher level of technological integration.[12] In view of this and the rising complexity of naval technologies, cyber resilience, the ability to protect the use of the electro-magnetic spectrum, and the capacity to quickly and reliably process high quantities of digital data, remain the key enablers for a more effective navy. Exercises are inevitably becoming a key element to test MDO capabilities and integrate this concept into the planning and operational processes of the MM, validating aspects like maritime-space synergies and the underwater-cyber nexus. Similarly to the AM experience, the integration of the MDO concept into MM operations is technology-driven, meaning that advanced systems and high-end platforms as part of a resilient network are the backbone of further development of MDO doctrines.

A common trait to all of Italy's armed forces is the recognition that data, and the ability to process it and distribute it quickly and in large quantities, is a central pillar of the whole MDO transition. A new MDO-oriented C2 approach will therefore require commensurate investment and emphasis on enabling instruments, such as AI, high-performance computing (HPC) and cloud technologies from the strategic down to the tactical level. A crucial and challenging but necessary objective will be to harmonise the efforts of each single armed force and direct them towards a common infrastructure capable of enabling truly joint, cross-domain operations. In this endeavour, the MoD and the industry will have to continue working in close cooperation.

The Michelangelo Security Dome, an advanced multi-domain integrated defence system announced by Leonardo in November 2025, is an example of such need for cooperation. Indeed, the Chief of Defence Staff, Gen. Portolano, has stated that there has been close cooperation with Leonardo in order to define the operational requirements.[13] Inevitably with a strong focus on

10 Italian Air Force, *F35B a Pantelleria: integrazione interforze e multidominio dell'Aeronautica militare e della Marina militare*, 27 January 2022, https://www.aeronautica.difesa.it/?p=7865.

11 Calcagno, Elio and Alessandro Marrone (eds), "The Underwater Environment and Europe's Defence and Security", in *Documenti IAI*, No. 23|13 (June 2023), https://www.iai.it/en/node/17225.

12 Italian Navy, *Il Future Combat Naval System 2035 nelle operazioni multi-dominio*, 2021, https://www.marina.difesa.it/media-cultura/Notiziario-online/Documents/Il%20Future%20Combat%20Naval%20System%202035.pdf.

13 Italian Chamber of Deputies, *Audizione del Capo di Stato Maggiore della Difesa, Generale Luciano Portolano, nell'ambito dell'esame del Documento Programmatico Pluriennale per la Difesa per il triennio 2025-2027*, 9 December 2025,

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air and missile defence given current threats,[14] the Dome will eventually consist in a multi-domain defence architecture that integrates sensors deployed in all physical domains with cyber-defence platforms, C2 systems, AI capabilities and coordinated effectors.[15] According to Gen. Portolano, the system's architecture will have to be modular and scalable, and the Dome itself will be crucial in defending critical infrastructures and any area exposed to multidomain threats, in complementarity with NATO's IAMD.[16]

3.1 The industrial level

While a multi-domain approach to operations depends first and foremost on the military's ability to change the way it plans, trains for, and carries out their activities, technology is undoubtedly a fundamental enabler. At the defence industrial level, a multi-domain-oriented workflow can have a significant effect on how firms conceive, develop and integrate platforms and systems.[17] While many legacy products can be retrofitted to be interoperable with others, those that are interoperable by design are more seamlessly integrated. The Italian defence and technological industrial base (DTIB) in recent years has therefore shifted toward an MDO approach, which revolves around advanced digitalisation and systems integration aiming to enable cross-domain and cross-platform capabilities, from sensing to effects. In this regard, the main example as the largest prime contractor and system integrator in the country is represented by Leonardo with its industrial strategy, which is structured around the concept of moving from working across domains to working across multi-domains, within a digital continuum, as expressed by its CEO and General Manager Roberto Cingolani.[18]

This multi-domain approach puts data at the centre, recognising digital superiority as an increasingly decisive advantage in defence and global security. This advantage is achieved through distributed, cyber-secure digital architectures composed of interconnected sensors, platforms and effectors, which are orchestrated and governed by a multi-domain, distributed C2 capability to generate convergent effects at the speed of relevance. The Michelangelo Security Dome will be Italy's first attempt to implement an integrated architecture of this type at such a scale. From a technological point of view, a necessary set of key digital enablers include HPC, AI, cloud technologies and digital twins. In the Italian context, the development of these enablers is supported by Leonardo's Davinci-1[19] supercomputer, one of the most powerful HPCs in the aerospace, defence and security sector.[20]

Many innovative initiatives and core capability enhancements across all operational domains are ongoing at the national level. GCAP marks a significant leap forward, as it is designed for Multi-Domain synergy and functioning as a System of Systems.[21] Its planned capabilities rely on a fully digital infrastructure, including an AI/supercomputing-based C2 system, a combat cloud architecture and cyber-resilient datalinks, allowing synchronisation and effectiveness of operations across all domains. The Army's

https://documenti.camera.it/leg19/resoconti/commissioni/stenografici/html/04c03/audiz2/audizione/2025/12/09/indice_stenografico.0007.html.

14 Leonardo sees the Michelangelo Dome's enabling technologies as featuring a mix of existing systems like the SAMP/T New Generation (NG) – equipped with Leonardo's KRONOS Grand Mobile High Power radar, and future systems such as first batch of four Italian next-generation radars for long-range ballistic defence. See in this regard: Leonardo, *Michelangelo Security Dome Development Marks First Achievement with Successful Air Defence Test in Italy*, 9 December 2025, https://www.leonardo.com/en/press-release-detail/-/detail/09-12-2025-michelangelo-security-dome-development-marks-first-achievement-with-successful-air-defence-test-in-italy; Leonardo, Michelangelo, *Leonardo's New Multi-Domain Integrated Defence System*, 27 November 2025, https://www.leonardo.com/en/focus-detail/-/detail/michelangelo-sistema-multidominio-difesa-aerea-leonardo.

15 Leonardo, *Michelangelo, Leonardo's New Multi-Domain Integrated Defence System*, cit.

16 Italian Chamber of Deputies, *Audizione del Capo di Stato Maggiore della Difesa*, cit.

17 IAI interview, 30 July 2025.

18 Leonardo, *Multi-Domain Technologies to Address Future Operational Scenarios*, 19 July 2024, https://www.leonardo.com/en/focus-detail/-/detail/tecnologie-multi-dominio_focus.

19 Leonardo website: *Supercomputer davinci-1*, https://www.leonardo.com/en/innovation-technology/davinci-1.

20 Dominelli, Celestina, "Leonardo Aims for Leadership in Supercomputing and Innovation", in *Il Sole 24 Ore*, 17 April 2025, https://en.ilsole24ore.com/art/leonardo-points-to-supercomputing-leadership-and-innovation-AHFpvnM.

21 Marrone, Alessandro (ed.), "The New Partnership among Italy, Japan and the UK on the Global Combat Air Programme (GCAP)", in *Documenti IAI*, No. 25|03 (March 2025), https://www.iai.it/en/node/19737.

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flagship projects, such as the Army's AW249 helicopter,[22] future Main Battle Tank (MBT) and the Army Armoured Combat System (A2CS),[23] are conceived as fitting into a multi-domain framework by design. These assets are intended to cooperate jointly and receive, generate and integrate data from all domains, incorporating key MDO-enabling features like advanced sensing, AI-powered, data-driven decision support, crewed-uncrewed teaming (CUC-T), and enhanced cyber-security and resilience. The Italian Navy achieved a significant milestone during the Formidable Shield 25 exercise. The first Multi-Purpose Combat Ship (*Pattugliatore Polivalente d'Altura*, PPA), the *Giovanni delle Bande Nere*, successfully validated its IAMD capabilities, utilising advanced tools, such as Leonardo's SADOC 4 C2 system, designed to coordinate defence quickly and effectively against even the most advanced air and missile threats, along with the Dual Band Radar (DBR), an advanced radar suite designed to detect and track ballistic, airborne (including drones and supersonic missiles) and surface threats. The success of this operation, coupled with the SADOC 4's ability to operate, and exchange data cohesively, with allied NATO naval forces,[24] led to the Italian Navy being recognised as having one of the highest levels of IAMD capability in the world. SADOC 4 is therefore a key MDO enabler for the Navy, as it can integrate information coming from an array of uncrewed systems (aerial, surface and underwater), including data and video, as well as plan missions and assign tasks as needed, as demonstrated during NATO's Robotic Experimentation and Prototyping with Maritime Unmanned Systems (REPMUS) exercises.[25]

In the space domain, new LEO Earth observation constellations will integrate advanced sensing, AI algorithms and data processing capabilities powered by HPC directly in orbit. Meanwhile, multi-mission and multi-sensor ground segment assets will play a key role to achieve enhanced situational awareness and operational effectiveness across all domains. Furthermore, the Military Space Cloud Architecture (MILSCA)[26] project, an Italian MoD initiative, is laying the foundation for a space backbone cloud architecture, which will be essential for supporting multi-domain interoperability and accelerating data sharing, processing and access anywhere and anytime.

In the cyber domain, the 'secure-by-design' principle, along with a 'zero trust' approach are crucial to protect critical assets from the systemic threat resulting from the convergence of the physical and cyber dimensions. In this context, Leonardo plays a key role in numerous EU projects, such as FREIA,[27] ECYSAP,[28] and EDOCC,[29] aimed at guaranteeing the secure transfer of data, interoperability and operational resilience in multinational multi-domain contexts.

22 Leonardo, *Discovering the AW249, the New Helicopter to Operate in Future Multi-Domain Scenarios*, 18 June 2024, https://www.leonardo.com/en/focus-detail/-/detail/nuovo-elicottero-aw249.

23 Rossi, Chiara, "A Leonardo e Rheinmetall il primo contratto congiunto per i nuovi corazzati dell'Esercito Italiano", in *Start Magazine*, 5 November 2025, https://www.startmag.it/?p=339288.

24 Leonardo, *NATO Integrated Defence: Leonardo's Capabilities at Formidable Shield 2025*, 21 July 2025, https://www.leonardo.com/en/news-and-stories-detail/-/detail/formidable-shield-2025-capacita-leonardo.

25 Spinosa, Francesco, "L'esercitazione REPMUS si propone l'obiettivo di sperimentare e sviluppare soluzioni tecniche di integrazione ed interoperabilità", in *Notiziario della Marina*, 2 October 2024, https://www.marina.difesa.it/media-cultura/Notiziario-online/Pagine/20241002_Maricenprog_Repmus24.aspx.

26 Leonardo, *Leonardo: Kick Off for the Project of the First Space Cloud System for Defense*, 19 February 2024, https://www.leonardo.com/en/press-release-detail/-/detail/19-02-2024-leonardo-kick-off-for-the-project-of-the-first-space-cloud-system-for-defense.

27 Leonardo, *Leonardo's Cyber Capabilities to Protect the European Union*, 30 September 2025, https://www.leonardo.com/en/news-and-stories-detail/-/detail/leonardo-s-cyber-capabilities-to-protect-the-european-union.

28 Leonardo, "Multi-Domain Technologies to Address Future Operational Scenarios", cit.

29 Leonardo website: *Collaborative Research Projects*, https://www.leonardo.com/en/innovation-technology/funded-research-projects.

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4. The Italian Army's approach and the multi-domain tactical bubble

by ***Elio Calcagno*** and ***Pietro Serino****

The Italian Army (*Esercito italiano*) is currently undergoing a radical and difficult transformation from a force mostly deployed on peacekeeping, stabilisation, COIN and conflict management operations abroad to one more suited to high-intensity, peer-vs-peer confrontations. Indeed, the EI stands out as one of the land forces in Western Europe most widely deployed abroad ever since the end of the Cold War, having operated in Afghanistan, Somalia, Lebanon, Iraq, Kosovo, Niger and more.[1] Cumulatively, these resource-intensive operations, combined with the severe post-Cold War budget cuts that brought Italian defence spending to just over 1 per cent of GDP in the mid-2010s, have led to an outstretched force plagued by capability gaps on the higher end of the spectrum. Indeed, in a document outlining his vision, the Chief of the Army, General Carmine Masiello, argues in no uncertain terms that the EI must find a way to better manage technological innovation first of all to make different army units more cohesive in combat, but also to facilitate joint and multi-domain operations.[2] Gen. Masiello writes that commanders, even at the lower levels of the command chain, should be able to rely on drones, while manoeuvre must integrate the necessary level of cyber and EW tools.[3]

4.1 Relevant documents

The EI has published a number of documents directly and indirectly elaborating its understanding of the concept of MDOs. Published in 2020, "Multi-domain operations: A conceptual approach" (*Approccio Concettuale*), does not offer a specific definition, but it implies that MDO require that the EI be capable of conducting operations that will engage it constantly and simultaneously from all five domains (land, sea, air, cyber and space).[4] Indeed, there is an awareness within the Army that it, more than other services, needs a paradigm shift in order to prepare to coming challenges, regardless of the domain they come from. The document explains, however, how MDO are a challenge that goes "well beyond the acquisition of cutting-edge platforms and software" but instead relates to adapting to a new way of waging war. While the war in Ukraine has contributed to so much change in most NATO countries in terms of MoD as well as individual armed forces planning and operational doctrine, the 2020 document takes a general approach that is still largely up to date. The Army's "Operational Concept 2020-2035" (*Concetto Operativo dell'Esercito Italiano*) sees as one of its main goals a better "multi-domain efficacy", which is attained by adopting "an approach strongly oriented toward a combined and synergic use of multiple lethal and non-lethal capabilities, and a decentralisation of operations down to the lowest levels".[5] Even though this particular document was published in 2020, its predictions on decentralised operations being a key aspect of future operations has been amply validated by the Ukraine conflict.

While not specifically focused on MDO, another document from 2022, titled "Army 4.0" (*Esercito 4.0*), approaches the EI's necessary evolution with regard to manoeuvre and the capabilities necessary to face peer- or near-peer-conflict scenarios.[6] Army 4.0 provides a blueprint for an EI more capable of carrying out operations in increasingly complex scenarios and takes into account capabilities transcending the land domain itself, such as aerial drones and attack helicopters, but also EW and countermeasures originating from space and cyber space.[7]

An analysis of the EI's views regarding MDO, based on a reading of the army's official publications, therefore suggests that these are understood in two slightly different if

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1 Calcagno, Elio and Alessandro Marrone (eds), "Artillery in Present and Future High-Intensity Operations", in *Documenti IAI*, No. 24|10 (September 2024), https://www.iai.it/en/node/18861.

2 Italian Army, *L'Esercito nei prossimi 3 anni: La visione del Capo di SM dell'Esercito*, November 2024, https://www.esercito.difesa.it/assets/allegati/a4_vision_rgb.2025.10.15.07.57.17.387.pdf.

3 Ibid.

4 Italian Army, *Operazioni Multi-Dominio: Approccio Concettuale*, 2020.

5 Ibid.

6 Italian Army General Staff, *ITA Army 4.0. Projected into the Future*, 2022.

7 Ibid.

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complementary ways. Firstly, MDO are seen as a way to enable army units (from companies to divisions) to make use of capabilities that transcend the land domain, including for instance drones and aircraft, EW, or cyber tools, in order to make manoeuvre more effective. This first, technology-based, interpretation is heavily reliant on new and emerging technologies, which are defined as a fundamental enabler for cooperation among different units, with drones at the forefront.[8] A second interpretation of MDO is tied to doctrine, training and how the aforementioned technologies are used by soldiers and commanders in order to overwhelm the enemy. In essence, therefore, the multi-domain element in the MDO concept as seen by the Italian Army seems to be just one of many characteristics of what is instead more accurately described as a new way of war that better exploits and adapts manoeuvre to new technologies.

4.2 Capabilities across domains

Despite the aforementioned gaps and budget difficulties, the army has managed to maintain a wide spectrum of capabilities that can be considered as useful toward MDO. Firstly, the EI's crewed rotary wing component has been cultivated for decades, including in terms of attack helicopters, which remain a priority even while other European partners have hesitated to replace their current fleets. In fact, Italy is on course to replacing the aging AH-129D Mangusta with the AW249 Fenice[9] a next-generation combat helicopter specifically designed for complex MDO and high-threat environment. Some of the main requirements for this new platform were specifically tied to CUC-T, connectivity, interoperability and multi-domain integration.[10] Developed through close cooperation between the Italian MoD and Leonardo, this platform is meant to significantly enhance the multi-role capabilities of its predecessor and is designed with an open architecture that integrates an advanced, AI-powered battlefield management system to acquire, fuse and present large volumes of data, extending its operational reach, accelerating decision-making and enhancing effectiveness and survivability across all domains.[11]

Along the same vein, both the Italian MBT programme and A2CS programme for a family of armoured vehicles are intended to be natively integrable in a multi-domain SoS and therefore critical additions to the Army's MDO enablers.[12]

As in all of Europe, small- and medium-sized drones remain a critical gap for the Italian army as lessons from the war in Ukraine are observed closely but are not easily applied to a peace time planning and procurement cycle, especially at the time the EI is trying to fill critical gaps in conventional capabilities such as MBTs, air defence systems, artillery and infantry fighting vehicles (IFV). While in 2024 the army has constituted a new unit dedicated to the use of drones for artillery targeting purposes, the 3rd regiment "Bondone", these are meant to direct artillery fire and hence not directly deliver effects to or from the air domain.[13] Nevertheless, given that the 2024 concept for deep battle manoeuvre (*La manovra non a contatto e le capacità abilitanti*) points to a significant strengthening of the army's long range precision strike capabilities, both through guided rockets and guided artillery shells, drones will become a central enabler as tools for intelligence, surveillance, target acquisition and reconnaissance (ISTAR), as well as battle damage assessment (BDA).[14] More generally, questions

8 Italian Army, *L'Esercito nei prossimi 3 anni*, cit.

9 Valpolini, Paolo, "Eurosatory 2024 – Leonardo Unveils the AW249 Fenice, the New Italian Army Combat Helicopter", in *European Defence Review*, 17 June 2024, https://www.edrmagazine.eu/?p=37215.

10 "Leonardo presenta a Eurosatory l'elicottero da combattimento AW249", in *Analisi Difesa*, 18 June 2024, https://www.analisidifesa.it/?p=176272.

11 Marrone, Alessandro and Giancarlo La Rocca (eds), "Future Military Helicopters: Technological Innovation and Lessons Learned from Ukraine", in *Documenti IAI*, No. 23|19 (September 2023), https://www.iai.it/en/node/17434; Leonardo, *Discovering the AW249, the New Helicopter to Operate in Future Multi-Domain Scenarios*, 18 June 2024, https://www.leonardo.com/en/focus-detail/-/detail/nuovo-elicottero-aw249.

12 "Primo contratto per 21 veicoli A2CS Combat assegnato dall'Esercito Italiano", in *Ares Difesa*, 5 November 2025, https://aresdifesa.it/?p=62251; Leonardo, *Annual Shareholder Meeting 2025*, 6 May 2025, https://www.leonardo.com/documents/15646808/29956900/AGM+2025_Leonardo_ENG_+nuovo_FINAL.pdf.

13 Carrer, Gabriele, "Droni, Cimic e cyber. L'Esercito 4.0 prende forma", in *Formiche*, 25 January 2024, https://formiche.net/?p=1604439.

14 For an analysis of the Italian Army's artillery capabilities, see Calcagno, Elio and Alessandro Marrone (eds), "Artillery in

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remain over which kinds and what number of drones the army will need to face current and future threats, but perhaps more importantly how drones will be integrated into the army's force structure and infantry units.

Cyber, and more broadly operations in the cyber domain and the electromagnetic spectrum (a.k.a. CEMA), are the core tasks assigned to the newly-constituted 9th Regiment for Cyber Security "Rombo". The regiment evolved from a previous, smaller unit founded in 2019 and currently deals with planning and conducting CEMA, gathering information on CEMA-based threats, managing networks on the army's IT systems in-theatre, and carrying out cyber-defence tasks in support of the Army's C4 Command and its Computer Incident Response Teams (CIRT).[15]

Meanwhile, the 33rd Regiment for Electronic Warfare has been in charge with the EI's EW operations, as a battalion since 1976 and in its current form since 2022, and is in charge of delivering EW capabilities to operations.[16]

Given the proven centrality of advanced air defences in a modern, peer-vs-peer level conflict like the one unravelling in Ukraine, the Italian army's SAMP/T long range air defence system can be seen not only as a crucial component in a layered air defence complex, but also as a high-value instrument to deliver effects in the form of defensive and offensive fires in the air domain.[17] The SAMP/T New Generation (NG) marks a significant upgrade from the original version.[18] With the added capability to deal with hypersonic missiles, the NG system allows the Army to gain another significant capability in the air domain, also through integration with medium and short range air defence systems.

4.3 A Tactical Bubble for the Army

Other than weapon systems and platforms, the EI's leading programme relating specifically to MDO is the "Tactical Bubble" (*Bolla Tattica*), which can be seen as a pragmatic approach to this type of operations by focusing on a wholistic approach that cannot be confined only to defensive or offensive activities. The Army defines it as a "series of cyber and electromagnetic protection measures to protect units, systems and connections between them in order to achieve cyber and electromagnetic superiority" in a given area.[19] In fact, the Tactical Bubble can also be described as the practical expression of an evolving effort to achieve a high level of integration of systems and platforms. The goal could be summarised as concurrently improving C2 by enhancing situational awareness across the chain of command; compressing the kill-chain by forming a more efficient and networked link between sensors and effectors; and creating the conditions for army units to carry out CEMA and establish a degree of Electromagnetic Spectrum Operations (EMSO) and cyber superiority over the enemy.[20] The Army has recently carried out a targeted testing and experimentation campaign in Qatar with a view to implementing the tactical bubble, involving the 9th Regiment, the Artillery Command, the Army's Special Operations Forces Command (*Comando delle Forze Speciali dell'Esercito*, COMFOSE) and the 'Julia' Alpine Brigade. The experimentation activities consisted in testing counter-UAS systems, cross-domain capabilities, sensor-to-shooter coordination, and their integration within the Tactical Bubble. The aim was to test the speed and efficacy of information sharing and integration with an array of C2 systems covering different needs and layers, including IMPERIO, C2DN/EVO,

Present and Future High-Intensity Operations", cit.

15 Italian Army website: *9° Reggimento Sicurezza Cibernetica "Rombo"*, https://www.esercito.difesa.it/organizzazione/capo-di-sme/comfoter/comfoter-supporto/brigata-informazioni-tattiche/9-rep-sic-rombo/9-reggimento-sicurezza-cibernetica-rombo/122604.html.

16 Italian Army website: *33° Reggimento EW*, https://www.esercito.difesa.it/organizzazione/capo-di-sme/comfoter/comfoter-supporto/brigata-informazioni-tattiche/33-reggimento-ew/33-reggimento-ew/122535.html.

17 Gibson, Brian W. and Seth Gilleland, "How Army Air Defense Underpins the Military Component of Integrated Deterrence", in *Military Review*, Special ed. March 2024, p. 18-21, https://www.armyupress.army.mil/Journals/Military-Review/English-Edition-Archives/March-2024/Air-Defense.

18 Ruitenberg, Rudy and Tom Kington, "France and Italy Order Upgraded SAMP/T Air-Defence Systems", in *Defense News*, 18 September 2024, https://www.defensenews.com/global/europe/2024/09/18/france-and-italy-order-upgraded-sampt-air-defense-systems; Giansiracusa, Aurelio, "Sistemi SAMP-T NG per Francia ed Italia", in *Ares Osservatorio Difesa*, 19 September 2024, https://aresdifesa.it/?p=51880.

19 Italian Army, *Stella Alpina 2024: l'Esercito si addestra per gli scenari operativi odierni e futuri impiegando le più moderne tecnologie militari emergenti*, 18 September 2024.

20 IAI interview, 17 October 2025.

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ARGO, SIF and JDIFSS.[21] The systems tested in Qatar had been improved following the Army's feedback on the back of a previous field exercise that took place in Sardinia, where 9th Regiment was tasked with the creation of a bubble, together with a combat network. These efforts are part of an ongoing exchange between Army and industry geared toward an incremental approach to elevating EI operations to a multi-domain framework. The official partnership between the EI and Leonardo, announced in November 2024, is another example of this strategic approach and aims at jointly developing new sensor and platform integration solutions – a drive that is directly related to the Tactical Bubble concept.[22] The partnership's goal is to enable the A2CS, MBT and AW249 flagship programmes as well as uncrewed systems to operate cooperatively to produce convergent effects across all operational domains and dimensions, in line with the concept of cooperative combat.

The existence of a large number of legacy assets, as in any army, poses a significant challenge given the need to integrate as many existing systems into higher-level C4I and combat management systems. Compromises will inevitably have to be found given that not all technologies currently in use by the Army will be integrable to the same degree into these systems.[23]

With regard to the Italian Army, the Tactical Bubble can therefore be seen as an effort to integrate and distribute complex data from the battlefield horizontally, enhancing access to mission-critical information at the tactical and operational levels. Such an endeavour would ideally help to cut the distance from sensor to shooter, enabling commanders to more easily access the shooter best suited to the desired effect.[24] While this approach is undoubtedly applicable to army structures as an excellent starting point, its integration with Italy's other armed forces, as well as those of NATO allies, will be crucial in order to attain the best possible multi-domain results.

Ultimately, to be truly effective, the Tactical Bubble will require that the Army develop a new "command attitude" that can unleash its potential, especially in the combat phases. At the tactical levels, commanders will have to further develop the ability to act proactively, exploiting the heightened situational awareness awarded by the Tactical Bubble and the compressed kill-chain. Commanders at the operational level will have to focus their attention on "control", meaning assessing the effects that the forces under their command have had against what was laid out during the planning phase – intervening only when strictly necessary. In other words, a command attitude that facilitate a decentralisation of command along with a centralisation of control.

21 Massa, Tommaso, "Sperimentazione in Qatar per l'Esercito Italiano", in *Portale Difesa*, 12 November 2025, https://www.rid.it/shownews/7667/sperimentazione-in-qatar-per-la-bolla-tattica-dell-rsquo-ei.

22 Italian Army, *Una partnership che mira a sviluppare soluzioni tecnologiche per l'integrazione di tutte le piattaforme da combattimento*, 21 November 2024.

23 IAI interview, 17 October 2025.

24 Ibid.

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Conclusions

by ***Elio Calcagno*** and ***Alessandro Marrone***[1]

Multi-domain, as a term, can seem deceptively self-explanatory. However, while a superficial interpretation of the multi-domain approach to warfare may look no further than its cross-domain quality, MDO are a much more complex and holistic concept. This apparent simplicity inevitably leaves much room to interpretation. When the US Army's TRADOC first elaborated the Multi-Domain Battle concept, it was intended as a set of guiding principles for the army's capabilities in the face of improving Russian and Chinese A2/AD bubbles and precise strike capabilities, as well as their proliferation around the world. When the MDO concept followed in 2018, the emphasis was put on overwhelming the enemy and forcing it to face operational and tactical dilemmas by employing forces in a coordinated and combined manner, in order to reach a higher level of convergence of effects across space and time. In the US context, and particularly as envisioned by the US Army, MDO are first and foremost a means to continue leveraging US technological superiority and enabling manoeuvre, even as adversaries have invested in the means to disrupt information and communication systems. The US version of MDO therefore takes into account adversary capabilities and how they can hinder manoeuvre by employing precision strike and contesting the electromagnetic spectrum. For instance, the US Army is also working on ensuring that the command chain is resilient to enemy activities in the cyber domain and electromagnetic spectrum. Among other aspects, from a US Army perspective this effort requires ensuring commanders on the field can exercise flexible command and multi-domain control in order to maintain a certain level of mission command even when communications are severed or highly degraded.

In Europe, where even the largest and most well-equipped armed forces are much smaller than their US counterparts, armies, navies and air forces have historically tended to divide the traditional domains (land, air and sea) more markedly into separate 'jurisdictions'. For instance, few Western European armies are equipped with attack helicopters, and land-attack fixed wing aircraft have been the prerogative of air forces, like in the US, meaning that generating effects across domains has often – but not always – required a joint-forces approach. In these contexts, MDO are at least partly a way to conceptualise and exploit advantageously the already-blurring lines between domains by pushing for a high level of integration between armed forces. Seen this way, MDO are an incremental evolution of the joint warfare doctrine. Indeed, the pressing need to equip army units with the means to defend themselves from small tactical drones and drone swarms is not in itself a multi-domain-oriented endeavour, but rather an attempt to enhance force protection (FP). Therefore, taken in isolation, the provision of countermeasures for threats coming from different domains is neither a novelty in modern warfare nor does it necessarily amount to making forces multi-domain.

As succinctly put in the Italian Defence General Staff definition, multi-domain operations are first and foremost "military activities conducted across multiple domains [...] aimed at generating multiple dilemmas at such a speed as to overcome the adversary's decision-making capacity".[2] To an extent, the ability to generate meaningful effects across all physical domains has been a common feature of modern armed forces, yet the rise of cyber warfare – combined with armed forces' dependence on digital infrastructures – is an example of a set of new capabilities that must be integrated into all armed forces at different levels.

The MDO concept emerged as an attempt to leverage existing advanced technologies in the face of a closing gap with potential adversaries. While new technologies such as AI, HPC and cloud infrastructures are rightfully considered to be essential components of a multi-domain framework, technology by itself is not enough to take NATO forces from the current paradigm to a multi-domain one. Speed of execution, coordination and synchronisation of effects are therefore just as essential for a true multi-domain approach. Thus, the multi-domain paradigm is

1 Alessandro Marrone is Head of IAI's "Defence, security and space" programme.

2 Italian Defence General Staff, *The Italian Defence Approach to Multi-Domain Operations*, cit., p. 24.

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not limited to the ability of a system or a military unit to operate in multiple domains, but extends to the integration of different systems, platforms and forces – within or across domains. In fact, platforms and weapon systems cannot be multi-domain in and of themselves, but must instead be integrated with other platforms, sensors and systems. This in turn stresses the enduring importance of doctrinal, organisational and human elements, bearing in mind the relevance of commanders, officers and broadly speaking military personnel in leveraging the options and opportunities provided by technologies thanks to their skills and training. As such, the human factor is central to the MDO transformation, as highlighted by the Italian General Defence Staff approach to MDO.

Against this backdrop, the addition of non-military IoP, as highlighted in the NATO definition of MDO, adds a further layer of complexity to what is essentially a new way of understanding warfare as a holistic effort that aims first of all at the integration of forces and technology. The multi-domain transformation necessarily requires a multi-pronged effort, acting on different but interdependent lines of action, including the following.

Integration and interoperability – Firstly, MDO are at their core an effort to achieve complex integration of the human and technological elements of a country's military potential. From a technological point of view, platforms, sensors and weapon systems are already undergoing this process throughout the NATO alliance – mostly at the national level. It will be of the outmost importance that Allies do not diverge in their capabilities as they transform their militaries into MDO-capable forces and build instead a high level of interoperability. The increasing centrality of technology to NATO and Western operations means that, in fact, the level of necessary interoperability will be higher than ever before. At the same time, there is a real risk that the increasingly complexity of relevant technologies might generate systems that are too impractical to operate or too vulnerable to disruption in contested environments.

A focus on threats and adversaries – MDO were conceived as a response to a specific context and will need to evolve further as threats and near-peer adversaries like Russia and China evolve themselves. As such, the multi-domain transformation should be seen as a means to an end – the efficacy and lethality of European and NATO militaries – and not as a fixed target that might distract from shifting circumstances.

Jointness and pragmatism – All relevant systems must be designed with a strong emphasis on multi-domain and joint-forces integration, by ensuring connectivity and interoperability across domains and forces. This is not only a challenge from an international point of view, where requirements and industrial interests may vary, but also from a joint-forces perspective in a single country. In this regard, only a top-down approach, where MDO are conceived and implemented at a joint defence staff level and then integrated into the individual armed forces, can ensure a coherent and wide-ranging transformation that truly benefits from the multi-domain paradigm. Metaphorically, the MDO concept stresses that the military IoP is not anymore merely the sum of its parts, but the result of their multiplication: if one of the factors leans toward zero, the overall result decreases as well in terms of effects. Furthermore, the integration of platforms, sensors and weapon systems within individual armed forces and between different armed forces (as in the NATO context) will not happen overnight and may not extend to all legacy systems. European militaries, including in Italy, should be pragmatic in how they adapt older systems to a new multi-domain C5ISR infrastructure and move gradually where resources are limited. This is especially relevant for the armies, which have historically been less platform-centric than their navy and air force counterparts.

Military-industrial collaborative approach – The enabling technologies that compose such an infrastructure, such as HPC, AI and cloud computing, as well as their interactions, are highly complex and subject to a fast pace of innovation. Militaries may find it more challenging to set new MDO-oriented requirements as the state-of-the-art shifts quickly and technologies become increasingly complex. A collaborative approach involving militaries and the industry can help foster a common understanding of

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what is achievable from a technological point of view and therefore help end users more easily set requirements that strike the right balance between ambition and technical feasibility.

Commanders' access to a recognised picture – At the tactical and operational level, MDO entail a much higher level of coordination and synchronisation of effects, but also enhanced tactical C2, with a view to decision superiority, in order to allow commanders to operate flexibly, quickly and effectively as part of a larger, net-centric whole. This will require a sort of 'recognised multi-domain picture', where field commanders have access to relevant data, also from other domains, from a wider range of sources than ever before. While technology today already allows for such a shift, much attention will have to be given to deconfliction and how to make such data manageable – and not overwhelming – for tactical- and operational-level commanders. Ultimately, the MDO transformation should facilitate the linkage between tactical commanders and data from other domains, units and armed forces by shortening the kill-chain from sensor to effect as well as from commander to effect.

Empowerment of joint commands – From an operational and strategic point of view, joint operation centres such as the Italian JOC-COVI will become ever more crucial hubs for orchestrating the type of coordinated and synchronised effects that characterise MDO. The, yet the physical spaces and related technologies and infrastructure needed to populate such centres are only one part of the equation. The joint commands these centres are built to serve must concurrently be empowered to act at the top of a true joint-level, apical chain of command in order to achieve real MDO that can benefit from sensors and effectors from all domains and armed forces.

Education and training – As stated by the Italian MoD, the multi-domain transformation is a holistic endeavour that must extend to the education and training of individuals and units at all levels. Armed forces should therefore continue to adapt their training practises to this new paradigm both as single services and together as part of a joint force. Such adaptation concerns not only the use of current and upcoming technologies, but also the doctrinal and organisational aspects of MDO, the NATO context, and broadly speaking the gradual, wide-ranging change of mindset needed to orchestrate such a complex integration across different domains. Education and training efforts should focus on a broad range of officers, also considering the aforementioned importance of tactical C2, and have to cultivate the decision-making skills that are even more crucial within multi-domain operations.

MDO as part of a whole-of-country approach – While a narrower understanding of MDO may not on the surface represent such a significant departure from the joint-operations approach, it is its broader definition – which accounts those non-military threats and IoP – that constitutes the most challenging leap forward. Coordinated and synchronised kinetic or non-kinetic effects, in the physical, virtual and cognitive dimensions, across the five domains of operations are already part and parcel of modern warfare. Yet the increasing relevance of civilian actors, both commercial and public, adds a layer of complexity in terms of planning and carrying out true MDO, but also of protecting critical infrastructures – and to some extent Western societies – by making them more resilient to hybrid warfare. In this regard, only a whole-of-country approach can ensure that military and non-military IoP can add up to a sum greater than their constituent parts.

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Acronyms

A2/AD	Anti-Access/Area-Denial
A2CS	Army Armoured Combat System
ACT	Allied Command Transformation
AI	Artificial intelligence
ALE	Air-Launched Effect
AM	Aeronautica Militare
ATACMS	Army Tactical Missile System
BDA	Battle Damage Assessment
C2	Command and Control
C2ISR	Command, Control, Intelligence, Surveillance, Reconnaissance
C3	Command, Control, Communications
C4I	Command, Control, Communications, Computers, Intelligence
CAML	Common Autonomous Missile Launcher
CAS	Close Air Support
CEMA	Cyber and Electromagnetic Activities
CIRT	Cyber Incident Response Team
CJIIM	Combined, Joint, Intra-Government, Inter-Agency, Multinational
COIN	Counterinsurgency
COMAO	Composite Air Operations
COMFOSE	Comando delle Forze Speciali dell'Esercito
COVI	Comando Operativo di Vertice Interforze
CUC-T	Crewed-Uncrewed Teaming
DBR	Dual Band Radar
DoD	Department of Defence
DTIB	Defence and Technological Industrial Database
EDT	Emerging and Disruptive Technologies
EI	Italian Army
EMSO	Electromagnetic Spectrum Operations
EW	Electronic Warfare
FARA	Future Armed Reconnaissance Aircraft
FCNS	Future Combat Naval System
FLRAA	Future Long-Range Assault Aircraft
FVL	Future Vertical Lift
GCAP	Global Combat Air Programme
GIDE	Global Information Dominance Experiments
HPC	High-Performance Computing
IAMD	Integrated Air and Missile Defence
IBCS	Integrated Battle Management C2 System
IFPC	Indirect Fire Protection Capability
IFV	Infantry Fighting Vehicle
IoP	Instruments of Power
ISTAR	Intelligence, Surveillance, Target Acquisition and Reconnaissance
IT	Information technology
JADC2	Joint All-Domain Command and Control
JADO	Joint All-Domain Operations
JCOP	Joint Common Operational Picture
JOC	Joint Operations Centre
L2A2	Large-scale Long-range Air Assault
LEO	Low Earth Orbit
LRHW	Long-Range Hypersonic Weapon
LRPF	Long-Range Precision Fires
LTAMDS	Lower Tier Air and Missile Defence Sensor
M2MC	Multimilieux et multichamps
MBT	Main Battle Tank
MCDC	Multinational Capability Development Campaign
MDC2	Multi-Domain Command and Control
MDO	Multi-Domain Operations
MDTF	Multi-Domain Task Force
MILSCA	Military Space Cloud Architecture
MM	Marina Militare
MMU	Multidomain Multinational Understanding
MoD	Ministry of Defence
MPF	Mobile Protected Firepower
MRC	Mid-Range Capability
NG	New Generation
NGCV	Next Generation Combat Vehicle
NWC	Network-Centric
NWCC	Nato Warfighting Capstone Concept
PNT	Precision Navigation and Timing
PPA	Pattugliatore Polivalente d'Altura
PrSM	Precision Strike Missile
R&D	Research and Development
RCV	Robotic Combat Vehicle
REPMUS	Robotic Experimentation and Prototyping with Maritime Unmanned Systems
SATCOM	Satellite Communications
SHORAD	Short-Range Air Defence
SoS	System of Systems

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TIC	Transformation in Contact
TRADOC	Training and Doctrine Command
UAS	Uncrewed Air System
UGCRV	Unmanned Ground Commercial Robotic Vehicle

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