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The application of artificial intelligence (AI) in defense made its debut in Iranian discourse in 2005 through a research paper published by the War University, that explored the integration of AI-enabled autonomous weapons in naval operations (Mahmoodi 2005). The power of defense AI, however, became starkly evident in the Iranian media and political discourse almost 15 years later, in the aftermath of the assassination of Mohsen Fakhrizadeh on November 27, 2020, carried out by an autonomous weapon (Kirkpatrick et al. 2020). Shortly after the killing of Fakhrizadeh, the father of Iran's industrial nuclear program, who benefitted from a personal protection regime comparable to that of Iran's President, a senior commander of the Islamic Revolutionary Guard Corps (IRGC) openly acknowledged the use of AI in the assassination (Wintour 2020).

One year later, Iran's Supreme Leader, Ali Khamenei—the singular authority responsible for defining Iran's strategies and serving as the Commander-in-Chief of the Iranian Armed Forces—addressed the topic of AI for the first time in a public speech. Khamenei outlined a vision for Iran to position itself among the top 10 nations in the realm of AI (khamenei.ir 2021). Since then, defense AI has emerged as a central theme in the statements of senior military commanders and government defense authorities in Iran.

AI is primarily viewed as a capability multiplier, injecting fresh blood into the defense doctrine. Iran's doctrine predominantly centers on deterrence, employing cost-effective asymmetric tactics and passive defense to counter both kinetic and non-kinetic threats. The focus is on addressing challenges from Tehran's longstanding major state adversaries, namely the United States (U.S.) and Israel which are perceived as proponents of regime change in Iran.

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Iran takes pride in its past efforts to minimize the risk of ground invasions by adversaries. Despite the persistent territorial challenges posed by insurgent and terrorist groups in its peripheries, Tehran's military leadership is currently wary of potential threats emanating from the sea and air, perceiving these domains as vulnerable to kinetic military operations. In response, the Iranian armed forces have strategically prioritized the development of niche capabilities as deterrent measures. To realize this priority, Tehran has shifted its focus towards harnessing AI to principally sustain the credibility of these measures considering the rapid technological advancements of its major adversaries and regional rivals.

Despite the consistent discourse from Iranian leaders and strategists about the critical need to incorporate AI into Iran's defense strategy and posture, there appears to be limited tangible progress, as indicated by scant publicly available evidence of active projects. This slow development could be attributed to Iran's constraints in financial resources and technological access. Nonetheless, Tehran remains resolute in pursuing this trajectory, opting to sanctify defense AI rather than vilify it.

1 Thinking About Defense AI

The 2019 US assessment of Iran's power noted, "although still technologically inferior to most of its competitors, the Iranian military has progressed substantially over the past few decades" (U.S. Defense Intelligence Agency 2019). Iran is currently in the early stages of developing and operating defense AI, a contrast to other nations elaborated in this edited volume. The purported advancements claimed by Iran since 2021 may encompass a blend of genuine progress and propaganda. However, the Islamic Republic is currently at an advanced stage of thinking about defense AI, prompted by undeniable evidence highlighting the imperative need and urgency to incorporate AI into its defense doctrine.

1.1 The Islamic Republic's Grand Strategy in Defense

The Islamic Republic, a consequential product of the 1979 Revolution, has grappled with a persistent status of loneliness (Tabatabai 2019). Its interests and priorities face constant challenges, often struggling for recognition. The leadership's foremost concern has been the ongoing protection of the nascent Islamic political regime against perceived threats from both state and non-state actors (Bahgat and Ehteshami 2021). Thus, the context within which these perceived threats operate and the corresponding measures to counter them are crafted to fortify the Islamic Republic's triad grand strategy: survival, security, stability (S3).

1.1.1 Threat Perceptions

The ever-changing nature of the Islamic Republic, coupled with the inherent volatility in its surrounding regions, underscores the fluidity of Tehran's threat perceptions. However, the country's threat perception has changed between 2020 and 2024.

Ties with Saudi Arabia are warming up whereas the South Caucasus, traditionally aligned with Iranian interests, has become a new source of instability given resurfacing hostilities between Armenia and Azerbaijan. In addition, the U.S. and, to a lesser extent, Israel are consistently viewed as the Islamic Republic's most enduring state threats (Martini et al. 2023). Both nations also wield formidable capabilities to mobilize non-state threat actors. Tehran believes that Washington and Tel Aviv profoundly seek to disrupt its S3. The U.S. invasions of Iraq and Afghanistan in the early 2000s, coupled with the securitization of Iran's nuclear program, heightened Tehran's fears of an eventual U.S.-led kinetic military intervention. Therefore, recognizing its inability to compete with the U.S. conventionally and aiming to alter Washington's military calculations, Tehran has prioritized the enhancement of defensive capabilities and installations (U.S. Defense Intelligence Agency 2019), emphasizing asymmetric tactics which are "difficult to deter and provide plausible deniability" (Martini et al. 2023: 161).

As Iran has successfully built up its asymmetric capabilities, it has concluded that ground warfare may be given less, if not zero, priority by its major adversaries (MEHR News Agency 2017). This conclusion is rooted in various factors, including Washington's failure to achieve its goals in the invasions of Afghanistan and Iraq, America's Pivot to Asia and its subsequent efforts to right-size military postures in the Middle East (Barnes-Dacey and Lovatt 2022) as well as the absence of a forward-deployed military posture by Israel in Iran's immediate neighborhood. These perceptions have shaped Tehran's overall understanding of the evolving nature of conflict and warfare, especially in situations where its major state adversaries, leveraging advanced technologies, can coordinate kinetic and non-kinetic operations against the country.

1.1.2 Future Conflicts Setting

In the context of kinetic warfare, the Iranian senior military strategists affirm that future military conflicts initiated by state adversaries against Iran are likely to encompass scenarios of sea-based and air-based combat (Mashregh News Agency 2023b). Besides, the outcomes of these scenarios depend significantly on the technological supremacy wielded by either Tehran or its adversaries. According to Iranian military strategists, this superiority empowers either side to swiftly and efficiently gather and analyze vast amounts of data and information within a condensed timeframe (Tasnim News Agency 2023b).

Iran's comprehension of the evolving conflicts orchestrated by its state adversaries extends beyond conventional military operations. Non-kinetic warfare also plays a role in shaping Iran's perceptions of threats and the conflict environment

(U.S. Defense Intelligence Agency 2019). Acknowledging the escalating threats of non-kinetic warfare infiltrating civilian domains, Iran always points to Israel and the U.S. as primary actors or supporters behind cyber-attacks on civilian critical infrastructure (Reuters 2021; France24 2023). The Islamic Republic is deeply apprehensive that, depending on the magnitude of these operations, they may eventually interrupt national administration, undermine domestic stability, and wear off internal order; thus, to the detriment of Iran's S3.

The dual nature of perceived threats faced by the Islamic Republic, encompassing both kinetic and non-kinetic warfare, has led to the formulation of fundamental national security priorities and the corresponding defense doctrine.

1.1.3 National Security Priorities

The Islamic Republic has identified the physical withdrawal of its two principal enemies, the U.S. and Israel, from its vicinity as a paramount national security objective (Martini et al. 2023). Although the Iranian leadership has consistently characterized America as the primary threat to Iran's S3, Supreme Leader Khamenei's assessment of the U.S.'s diminishing influence and isolation in the emerging world order (khamenei.ir 2022a) has intensified Tehran's advocacy for the U.S. retreat from Iran's immediate surroundings. A similar perspective, albeit expressed more assertively, is held regarding Israel. In 2015, Khamenei foresaw the collapse of Israel by 2040 (Brodsky 2023).

The second national security priority underscores the Islamic Republic's aspiration to achieve regional power status. In November 2003, the Supreme Leader outlined the country's strategic vision for 2025, envisioning Iran as a developed nation occupying the foremost position in the economy, science, and technology across Southwest Asia, encompassing Central Asia, the Caucasus, the Middle East, and neighboring countries, as defined in the document. The objective also includes serving as a source of inspiration and a model for the Muslim world (INSF 2003). The Iranian leadership desires the Islamic Republic to be recognized as an influential and responsible power in the Middle East and Asia at large. This ambitious vision may be rooted in the desire to revive a glorified past (Javadi 2021). However, the persistent sense of loneliness, despite having diplomatic relations with the neighboring states, and perceived threats to its S3 since the 1979 Revolution, have compelled the Iranian leadership to seek a regional power status (Raouf 2019).

This pursuit is closely tied to Tehran's comprehension of its strategic depth, defined by the Office of the Supreme Leader as "any factor considered advantageous for a specific nation but recognized as a potential threat by adversaries, capable of serving as a deterrent for the nation in possession" (khamenei.ir 2008). The correlation between the concept of strategic depth and the number of subregions outlined in the country's 2025 strategic vision has motivated the leadership to secure the Islamic Republic's S3 beyond the political borders of the nation. This strategy is apparently rooted in the collective historical memory of the Iranian leadership. "Historically, whenever Iran defined its national security within its political border,

its independence and national sovereignty were violated, and its territorial integrity threatened … Therefore, Iran cannot counter external threats absent a robust regional or even extra-regional presence" (Alfoneh 2020).

1.1.4 Defense Doctrine

The Iranian leadership's comprehension of the nation's threats, the context in which conflicts may arise, and the strategic depth of the Islamic Republic acknowledge the necessity of adopting a comprehensive 360-degree defense approach (Black et al. 2022: 20). It aims to address both external threats posed by Tehran's archenemies and internal threats, which, according to the Iranian leadership, are supported or orchestrated by the same adversaries.

In terms of deterring kinetic operations, Iran acknowledges its conventional military technologies disadvantage compared to the U.S. and Israel (Tasnim News Agency 2023b). Consequently, Iran has formulated a defense strategy centered around cost-effective asymmetric tactics and niche capabilities (U.S. Defense Intelligence Agency 2019). Focusing primarily on countering potential kinetic threats emanating from sea and air, and seeking to bolster its strategic depth, Tehran has prioritized the augmentation of missiles, proxy forces, UAVs, and naval power as the four critical deterrence capabilities:

- *Missiles*

A crucial element of Iran's defense strategy centers on the development of a formidable arsenal, encompassing both cruise and ballistic missiles. These missiles primarily enhance Tehran's asymmetric capabilities. The Islamic Republic openly celebrates the progress in missile technology, considering it a source of prestige (Satam 2023). The Iranian missile arsenal is predominantly deployed from bases in western Iran (NTI n.d.). These bases offer closeness to U.S. military forces in the region, proximity to Israel—in the event of an American or Israeli intervention—, and the insurgent and terrorist entities including the Kurdish armed groups and Islamic State of Iraq and Syria (ISIS).

- *Proxy Forces*

Iran's imperative to deter kinetic operations, assert regional power status and exploit its strategic depth drives Tehran to cultivate proxy forces, predominantly in proximity to Israel (Martini et al. 2023). These proxies provide Iran with plausible deniability. Their demonstrated capabilities and preparedness to confront Iran's adversaries serve as an additional deterrent.

- *Uncrewed Aerial Vehicles (UAVs)*

Iran uses advanced UAVs to address gaps in its aging aircraft and enhance deterrence (U.S. Defense Intelligence Agency 2019). Throughout the 2010s, Tehran developed sophisticated UAVs, mostly through reverse engineering American drones (Iran Press 2020) and leverages UAVs technology to bolster deterrence

against the U.S. and indirectly threaten Israel and, to a lesser extent, Saudi Arabia through proxy networks (Eisenstadt 2021).

- *Naval Power*

The Islamic Republic strengthens its deterrence and power status through robust naval capabilities in the Persian Gulf and the Sea of Oman. The nation's maritime defenses incorporate a diverse range of platforms and weapons strategically designed to counter the U.S. Navy, primarily based in the Arab Gulf states, and regularly patrolled in the Persian Gulf and the Sea of Oman (Black et al. 2022). Iran places a significant emphasis on asymmetric tactics, notably the deployment of uncrewed surface vessels (USVs) and UAVs, as a crucial element of its naval strategy (U.S. Defense Intelligence Agency 2019). This approach aims to overwhelm the defenses of opposing warships. Additionally, in its quest for regional power status and the bolstering of strategic depth, Iran has showcased its naval capabilities by conducting out-of-area operations aimed at patrolling Iranian commercial vessels, reaching increasingly greater distances from Iranian shores (Bailey 2022). A notable achievement was the first-ever circumnavigation of the globe by the 86th flotilla of the Iranian Navy, spanning from September 2022 to May 2023 (Akbari 2023). This accomplishment was lauded by the Supreme Leader as a significant milestone and a source of national pride (khamenei.ir 2023).

While these four niche capabilities embody the Islamic Republic's asymmetric tactics to deter kinetic operations, the Iranian military has also predominantly developed electronic warfare (EW) mostly for defensive purposes (Tabatabai et al. 2021). EW is crafted and employed to optimize the functionality of defense assets and infrastructure, such as radar systems, and enhance their stealth connectivity with command and control (C2) (Battlespace 2023). The integration of AI into defense systems would further bolster Iran's EW, aligning it with the four key deterrence capabilities. Moreover, Iran's EW endeavors to identify and thwart state adversaries' intrusions into Iranian territories. The primary objective of Iran's EW military exercise in August 2023, for instance, was to counter intruding UAVs and micro air vehicles (MAVs) (Tehran Times 2023a). This exercise held particular significance as one of the key defense facilities in southern Iran had been targeted by MAVs in January 2023, allegedly conducted by Israel (Chulov 2023).

In response to non-kinetic threats, the Islamic Republic also employs asymmetric tactics, emphasizing a blend of deterrence, defense, and retaliation. In addressing perceived threats to its military and strategic assets, Iran actively engages in deterrence strategies while adhering to a passive defense doctrine (Nadimi 2018). As a comprehensive nationwide program, passive defense encompasses a range of tactics aimed at hindering foreign intelligence gathering and ensuring the resilience and protection of critical infrastructure, such as military equipment and nuclear facilities. Key measures include the use of camouflage, concealment, force dispersal, underground facilities, and the strategic deployment of highly mobile units (U.S. Defense Intelligence Agency 2019). Notably, grounded in the central tenets of Iran's passive defense doctrine, underground facilities have been constructed to

bolster diverse facets of Iran's defense industries, crucial nuclear infrastructure, and military forces (Gambrell 2023). This includes support for naval sites, missile bases, and equipment storage.

Iran's passive defense doctrine extends to cyber defense strategies focused on safeguarding civilian critical infrastructure and networks from cyberattack, misuse and compromise (Nazarinejad and Pourshasb 2020). The National Passive Defense Organization (NPDO), operating under the General Staff of the Armed Forces, whose constitution was ratified by Parliament in 2023, has evolved into an agency with the authority to issue legally binding decisions, marking a significant transformation two decades after its foundation.

One of the primary responsibilities of the NPDO is to leverage both national cyber and non-cyber resources to deter, prevent, identify, and effectively counter any cyberattacks on Iran's national infrastructure (Tehran Times 2023b). The NPDO plays a role in safeguarding the integrity and security of Iran's critical assets, ensuring resilience and survivability against cyber threats.

In addition to deterrence and defense, Iran has openly acknowledged its cyber offensive capabilities with the sole intention of retaliating against those responsible for cyberattacks aimed at its critical infrastructure (Anderson and Sadjadpour 2018). Cyber capabilities also play a key role for domestic stability as the Islamic Republic is convinced that major state adversaries want to exploit the cyber domain, including social media and satellite TV, to conduct "cognitive warfare" (Mirzaei 2023) and stir domestic upheaval. This expands the role of AI into the cyber domain, as well be discussed below.

1.2 Defense AI

As argued, Iran's threat assessment prompts the country to follow a 360-degree defense strategy focused on deterrence and asymmetric responses to strategic challenges (Martini et al. 2023; McInnis 2017a). In this context, Commander-in-Chief Khamenei consistently underscores the imperative of integrating cutting-edge science and advanced technologies into the armed forces' arsenals and installations (khamenei.ir 2022b). The ongoing modernization of Iran's defense assets and infrastructure equips the country with enhanced capabilities to safeguard its national security. However, the Islamic Republic has grappled with enduring challenges, notably long-standing restrictions on accessing the military technology market due to U.S. embargoes (Ben Taleblu 2023). Consequently, the Iranian armed forces have been compelled to maintain technological momentum through strategies such as indigenous procurement, technology appropriation, illicit acquisition, and reverse engineering (Boffey 2023).

Given these contexts and challenges, Iranian leadership and strategists have arguably recognized AI as a groundbreaking technology, applicable not only in defense but also in various facets of life. Supreme Leader Khamenei emphasizes the significance of AI as a crucial factor in shaping future global governance

(khamenei.ir 2021). A consensus among Iranian thinkers and strategists regarding AI is articulated by a philosopher who is loyal to the Islamic Republic:

> Artificial intelligence revolutionizes the production and distribution of goods, leading to substantial cost reduction and significantly expanding accessibility. In the contemporary landscape, a society's inability to master this technology poses a threat to economic viability and political competitiveness (Mashregh News Agency 2023d).

This understanding aligns with the dominant view on AI discussed in other chapters of this volume. Thus, the Iranian defense and military leadership acknowledges the transformative potential of AI, considering it a key force multiplier that elevates the effectiveness of the Islamic Republic's defense doctrine and strengthens the resilience of defense capabilities (Mashregh News Agency 2023a). This is of paramount importance for Iran, given that strategic considerations, influenced partly by the nation's isolation and constrained access to the global market imposed by Tehran's major adversary, have consistently prioritized the goal of achieving self-sufficiency in developing indigenous defense capabilities (Tabatabai 2020) with a focus on technological comparative advantages. In 2012, the Supreme Leader issued a comprehensive decree that forbade the procurement of foreign goods and services for defense purposes. The objective was to mitigate reliance on external entities during actual conflicts, thereby ensuring a self-sufficient and secure defense supply (khamenei.ir 2012).

Iran is driven to invest in defense AI by a compelling factor: the continuous integration of advanced technology into the defense and military capabilities of its major adversaries, notably the U.S. and Israel, along with key regional rivals such as Turkey and Saudi Arabia. The technological advancements of these nations pose a potential threat to Iran's asymmetric defense doctrine if it neglects the adoption of technological upgrades. Ideally, Tehran aspires to secure a leading position in the high-stakes military technology race, recognizing the potential for enhanced power and prestige for the Islamic regime in Tehran (khamenei.ir 2019). However, numerous challenges such as insufficient financial and skilled human resources as well as limited access to the global high technology market have impeded the realization of this vision. Therefore, Tehran strategically emphasizes the crucial role of cutting-edge military technology, including AI, as a means to sustain the credibility of its deterrence stance.

Since the entry of defense AI into Iran's mainstream discourse, military leaders have consistently emphasized the pivotal role of AI in streamlining data collection and analysis processes (Mashregh News Agency 2023c). However, there is skepticism regarding whether Iranian leaders possess a thorough understanding of the appropriate level of AI involvement in decision-making during actual conflict scenarios. Despite this uncertainty, incidents stemming from human errors, exemplified by the downing of Ukraine International Airlines Flight 752 over Tehran by Russian-made anti-aircraft missiles in January 2020 (The New York Times 2020) may propel Iran towards the adoption of AI-enabled autonomy in defense capabilities and installations. This strategic shift is aimed at mitigating the impact of human errors and enhancing overall operational efficiency.

Despite the potential benefits and incentives for autonomy in defense AI, the Islamic Republic is likely to maintain a cautious stance. The defensive posture of Iran's armed forces requires a strategy to avoid inadvertently targeting adversary's assets and forces when humans are not fully in the loop of decision-making. Iran consistently demonstrates a reluctance to provoke escalation, maintaining this stance even when supporting its partners and proxies across the region or undertaking retaliatory actions. For example, reports from both Iraqi and American sources indicate that Tehran communicated its specific retaliatory measures to Washington following the killing of IRGC Major General Qasem Soleimani, key architect of Iran's defense doctrine, by American forces in January 2020 (Ayash and Davison 2020). With the integration of AI into its defense capabilities, the Islamic Republic faces the critical challenge of striking a calibrated balance between autonomy and strategic restraint.

2 Developing Defense AI

Iran's development of defense AI remains in its nascent phase, shrouded in strategic ambiguity yet occasionally characterized as loud weapons. Nevertheless, the incorporation of AI into defense capabilities is in line with Iran's defense doctrine, which revolves around three key objectives: deterring threats posed by state adversaries, ensuring the survivability and resilience of critical infrastructure and ensuring domestic stability.

2.1 State Deterrence

Based on its strategic assessment discussed above, Iran has dedicated time and resources to bolstering its asymmetric sea and air capabilities, concurrently expanding its proxy network to enhance its strategic depth. AI emerges as a new enabling factor in Tehran's enhanced deterrence strategy.

As of January 2024, Major General Safavi, the senior military aide to Khamenei and head of the Defense-Security Commission within Iran's Strategic Council on Foreign Relations—an advisory body to the Supreme Leader—stands as the sole senior strategist elucidating Iran's three-fold rationale for integrating AI into naval and air force operations: (1) enhancing agility, (2) accelerating decision-making processes, and (3) reducing reliance on human forces (Mashregh News Agency 2023b).

In November 2023, the IRGC organized its first-ever national conference on emerging opportunities and threats in the maritime domain. Rear Admiral (RADM) Alireza Tangsiri, the commander of the IRGC Navy, identified four areas in which Iran has incorporated AI into its military capabilities: USV, UAV, missile, and submersible. According to Tangsiri (Gerdab 2023a):

- Iranian USVs are autonomous speed boats with extended coverage capabilities, excelling in mission execution through AI-guided missiles for precise and effective target engagement, combining autonomy and strategic firepower.
- Iranian UAVs have advanced with improved AI-driven capabilities, extended range, heightened precision, and stealth technology. Increased flight time, enlarged warheads, and the ability to confront EW tactics enhance offensive capabilities, allowing engagement of moving and maritime targets in diverse military scenarios.
- Iranian missiles feature extended range, adaptive navigation, and multi-system launch capability, with dynamic evasion options. They provide strategic advantages with reduced preparation time, rotational shooting, and counteraction measures against adversaries' EW. AI-based sea-based missiles demonstrate remarkable precision, targeting objectives up to 2000 kilometers away.
- Iranian submersibles showcase versatility in AI-enabled autonomous navigation, executing missions, and contributing to Intelligence, Surveillance & Reconnaissance (ISR) operations. Whether for military or scientific purposes, they navigate challenging underwater environments, playing a pivotal role in advancing technological capabilities beneath the ocean's surface.

On a different front, Iran has incorporated AI into its border control operations. Brigadier General Alireza Sheikh, Deputy of Training and Education of the Army, reveals that AI-enabled portals are now responsible for analyzing and transmitting real-time images and data pertaining to border movements directly to the Army's headquarters in Tehran (Tasnim News Agency 2022). This marks a notable departure from the past, where data collection, up until at least 2020, predominantly relied on human resources (ICAO 2021).

In the realm of C2, senior military commanders underscore the significance of AI in both air and sea domains. The Commander of the IRGC Aerospace Force's Passive Air Defense, for instance, emphasized that "the integration of AI-driven C2 offers crucial decision support to effectively counter extensive and intricate threats. It plays a key role in guiding air defense personnel, enabling them to respond to threats swiftly and appropriately" (Tasnim News Agency 2021a).

In addition to defensive capabilities, Iran's network of proxies serves as a formidable asymmetric asset, not only countering potential kinetic operations but also functioning as a crucial enabler for Tehran to maintain its strategic depth. Publicly available data does not confirm Iran providing AI-driven capabilities to its proxies. Nonetheless, Iranian authorities have openly admitted Tehran's support to both state and non-state actors within the Axis of Resistance (Fars News Agency 2015a). This assistance primarily entails technology transfer more than direct procurement of military equipment (Tabatabai and Clarke 2019), particularly in situations where ongoing resupply poses significant challenges (U.S. Defense Intelligence Agency 2019).

In this context, proxies, especially those in proximity to Israel, may acquire knowledge and technology from Tehran to enhance their AI capabilities. This holds particular significance given Tel Aviv's utilization of AI for ISR and carrying out

strikes against Hamas in Gaza during the military conflict that began in October 2023 (Davies et al. 2023). The IRGC may consider supplying AI-based technologies primarily aimed at countering Israel's ISR capabilities, despite Tehran's own defense AI development being in its early stages.

2.2 Critical Infrastructure Protection

Critical infrastructure remains a prime target in non-kinetic operations. Iran's significant challenges with the Stuxnet virus in its nuclear facilities during the late 2000s (Modderkolk 2024) have prompted a reassessment and refinement of strategies aimed at securing military and civilian critical infrastructure.

Denial and deception (D&D) techniques are instrumental in reducing vulnerability and bolstering the resilience of Iran's strategic assets and installations (U.S. Defense Intelligence Agency 2019). Simultaneously, Iran employs a multilayered passive defense strategy to safeguard civilian critical infrastructure from cyberattacks and external intrusions (Lamrani 2020). This defensive approach has gained prominence, particularly in the face of the evolving landscape where AI has become a potent tool for offensive cyber operations. The integration of AI introduces heightened complexity and diminished traceability to cyberattacks.

With 35% of cyberattacks targeting Iranian civilian critical infrastructure in 2022 leveraging AI (Tasnim News Agency 2023a), the NPDO has strategically prioritized the infusion of AI across all indigenous systems entrusted with national cyber defense responsibilities from 2023 to 2024 (Tasnim News Agency 2023d). Due to Iran's limited access to the global technology market and apprehensions regarding the security of advanced firewall technologies originating from the West, amid concerns of potential exploitation by adversaries, the NPDO has embarked on collaborative efforts with Iranian academic institutions and technology start-ups. This collaboration aims to seamlessly integrate AI into Iran's cyber defense strategy, ensuring a robust and indigenous approach to safeguarding national security.

Adopting a proactive stance towards AI, the NPDO focuses on enhancing all defense capabilities, encompassing infrastructure, through the seamless integration of AI. The Organization has ambitiously outlined mid-2024 as the timeline to realize this goal. This strategic endeavor, complemented by a fusion of D&D techniques and deliberate ambiguity regarding Iran's military advancement, positions the nation to safeguard critical infrastructure in both civilian and military sectors against non-kinetic cyber threats instigated or supported by Tehran's major state adversaries (Martini et al. 2023). Notwithstanding these concerted efforts, the Islamic Republic's technological lag may persist, rendering critical infrastructure vulnerable to cyberattacks as AI and other emerging technologies continue to advance.

NPDO asserts that Iran's cyber defense capabilities encompass an offensive component specifically crafted for retaliatory purposes. The focal points of Iran's cyber offensive endeavors primarily involve the infrastructure of the U.S. and Israel (Maloney 2023). Nevertheless, states perceived as threats to the regime's S3, such

as Albania, due to harboring the Islamic Republic's most formidable dissident group, are not exempt from Tehran's cyber offensive actions (Oghanna 2023). According to the 2024 U.S. Annual Threat Assessment, "Iran's growing expertise and willingness to conduct aggressive cyber operations make it a major threat to the security of U.S. and allied and partner networks and data" (Office of the Director of National Intelligence 2024). The expanding expertise of Iran may involve the incorporation of AI in its cyber offense capabilities.

2.3 Domestic Stability

Post-revolutionary Iran has been marked by persistent protests and social upheaval. Since September 2022, the Iranian regime has grappled with one of the most extensive and prolonged series of protests since the 1979 Revolution, further eroding the key components of the regime S3. In response, Iran has consistently strengthened its law enforcement, military, and security apparatuses. This persistent pattern aims to suppress dissent at home and abroad and includes censorship to advance ideological control over the nation and impose a coercive order within Iranian society (Daragahi 2023; Fitzpatrick 2023). In this context, solutions combining AI with biometric technologies like facial recognition, developed by Iranian startups or imported from China (Alimardani 2023), are growing in importance to target dissenting citizens. In view of ensuring domestic control, Iran and Russia seem willing to formalize a bilateral Grand Interstate Treaty to advance military-technological cooperation (Institute for the Study of War 2023), which could include cooperation on AI.

3 Organizing Defense AI

The Islamic Republic's General Staff of the Armed Forces (GSAF) serves as the highest defense and military authority in the country, responsible for coordinating and overseeing the activities of the Iranian Armed Forces including the IRGC, the Army and the Ministry of Defense (MoD). Led by the Chief of General Staff, appointed by the Supreme Leader, the GSAF is instrumental in formulating defense policies, operational planning, and ensuring the overall readiness of Iran's armed forces and defense agencies.

The Army and the IRGC have distinct roles outlined by the GSAF under the Supreme Leader's guidance. Specifically, the IRGC operates in the Persian Gulf, while the Army manages operations in the Caspian Sea and the Sea of Oman. Domestically, the Revolutionary Guard oversees internal security, while the Army exclusively handles air defense (Tabnak News Agency 2022). However, unlike the Army, the IRGC faces no constraints on involvement in domestic politics and financial activities. In addition, the IRGC consists of two additional forces: the Quds Force, responsible for unconventional warfare, intelligence, and special operations

beyond Iran's borders, and the Basij, a paramilitary volunteer force deployed for internal security and crowd control during public protests. The Quds Force and, to a lesser extent, Basij, have played a crucial role in advancing Iran's strategic depth and revolutionary ideologies globally (Bahgat and Ehteshami 2021). Thus, through its engagement in domestic affairs and external actions, the IRGC has steadily increased its influence over time, becoming a decisive force in safeguarding Tehran's S3.

The GSAF is dedicated to acquiring advanced conventional and specialized defense capabilities for both the Army and the IRGC. With a focus on achieving self-sufficiency and developing indigenous defense capabilities, three departments within the GSAF—namely, "Logistics, Support, and Industrial Research," "Research and Training," and "Science, Research, and Technology"—are directly involved in steering defense research and development (R&D). However, the IRGC, the Army and the MoD have their own R&D departments, dedicated to advancing military technologies.

The Research and Self-Sufficiency Jihad Organization (RSSJO) is an entity closely associated with the air, navy, and ground forces of both the IRGC and the Army in Iran. The primary roles of these six organizations revolve around overseeing and conducting specialized R&D activities tailored to the unique needs of each respective military force. These entities also collaborate with civilian universities and military research institutes. Notable examples include Imam Hossein University (IHU), Malek Ashtar University of Technology (MUT), and Imam Khamenei University of Marine University and Technology (IKUMUT), which are three IRGC-affiliated research universities. Additionally, the Army operates the War University and the Imam Khomeini Naval University of Noshahr. These academic institutions engage in direct collaboration with various RSSJOs for R&D in defense. With a specific focus on defense AI, the RSSJOs are believed to be involved in independent R&D efforts and joint initiatives with academic institutions.

The MoD is also involved in defense R&D, overseeing multiple entities dedicated to advancing military technology and providing military capabilities to both the IRGC and the Army. The MoD comprises 13 companies and two organizations, with each entity being allocated a specific budget from the country's annual public budget. The Aerospace Industries Organization (AIO) stands out as a pivotal entity within the MoD, overseeing the development and production of aerospace technologies for both civilian and military applications. Established in the early 1980s, the AIO plays a central role in advancing Iran's capabilities across various domains, including reconnaissance planes, UAVs, cruise and ballistic missiles, satellite launch programs, avionics, propulsion systems, and aerospace manufacturing (IFMAT n.d.). Subsidiaries, subordinates, and front companies affiliated with the AIO have been implicated in procuring equipment worth millions of euros for the development of Iran's missile program (U.S. Department of the Treasury 2006). AIO developed and unveiled the first AI cruise missile, Abu Mahdi, in July 2023 (Iran International 2023).

As the MoD and its affiliated entities are engaged in the development of advanced military technology, a senior authority within the MoD announced in December

2022 that the Ministry has signed partnership agreements with 80 universities and the majority of the 800 industrial towns nationwide (IRNA 2022). The connectivity between universities, industrial towns, and MoD entities is facilitated primarily through two research institutions: the Defensive Innovation and Research Organization (DIRO) and the Defense Industries Training and Research Institute (DITRI).

Formerly led by Mohsen Fakhrizadeh until 2020, DIRO functions as Iran's equivalent to the U.S.'s Defense Advanced Research Projects Agency (DARPA), focusing on the development of cutting-edge technologies for defense and military applications. Besides, DITRI serves as a crucial component of the MoD's support structure, providing high-level scientific and technological assistance for educational and research processes. It plays a principal role in fostering technology and innovation within the defense industries. DITRI functions as a hub for missile design and the manufacturing of crucial components essential to produce solid rocket fuel (Iran Watch 2019).

No publicly available data or evidence exists regarding the involvement of these institutions in defense AI. However, considering the MoD's tangible strides in developing AI-driven capabilities, as demonstrated by the Abu Mhadi missile, the prospect of the MoD's departments and agencies playing a role in defense AI is not merely speculative.

This assumption is reinforced by the actions of the Supreme Council of the Cultural Revolution (SCCR), which established a dedicated Commission for Defense AI within its Secretariat in September 2022 (SCCR 2022). The Commission comprises representatives from all branches of the armed forces, the SGAF, the Office of the Supreme Leader, the Ministry of Intelligence, and the Ministry of Higher Education. This composition underscores the paramount importance placed on cultivating synergy and collaboration among diverse stakeholders in the realm of defense AI.

In the domain of critical infrastructure protection, the primary duty of securing military critical infrastructure rests with the armed forces and the MoD. Furthermore, the NPDO is assigned the responsibility of ensuring the safety and resilience of civilian critical infrastructure. As per the NPDO's director, this undertaking is accomplished with the collaboration of Iranian start-ups. The NPDO has also entered into partnership agreements with several civilian technology universities to garner assistance and intellectual support for its missions (SSN 2022). A noteworthy aspect of these agreements is the commitment of the universities to establish academic programs dedicated to the NPDO's focal areas. The NPDO has pledged to incorporate AI into safeguarding critical infrastructure. In pursuit of this goal, collaboration with start-ups and universities is anticipated to encompass elements of defense AI.

4 Funding Defense AI

In 2022 and 2023, Iran allocated €6.2bn and @6.3bn, respectively, to its defense budget (Emirates Policy Center 2023). Aligned with Iran's 7th Five-Year Development Plan, which shapes the country's annual budgets and development strategies until 2028, a provision exists mandating the dedication of at least 5% of the public budget to enhance defense capabilities (Government of Iran 2023). However, obtaining precise figures for defense AI R&D proves challenging due to the complex network of stakeholders in this domain, characterized by opaque budgets and the partial allocation of efforts, if any, to defense AI within each entity (McInnis 2017b).

In accordance with the latest annual budget for the fiscal year 2023, commencing on March 21, 2023, the AIO has been allocated the highest research budget among all entities under the MoD. The designated budget for AIO's research is €59,000; however, it does not provide a clear breakdown indicating the specific amount earmarked for investment in defense AI. The total research budget for the 15 entities within the MoD is approximately €265,000 (Shenasname 2023).

In relation to passive defense, the annual budget for the fiscal year 2023 designates €6.6M exclusively for the NPDO (Shenasname 2023). Furthermore, each agency and ministry is mandated to allocate a one-percent budget commitment to support passive defense initiatives facilitated by the NPDO, resulting in a combined contribution of €1.6bn throughout the fiscal year 2022 (SNN 2023). Although the specific allocation of these funds for defense AI remains unclear, the NPDO's emphasis on the comprehensive integration of AI into the critical infrastructure protection implies that a substantial portion of the budgets is likely directed towards advancing defense AI capabilities.

5 Fielding and Operating Defense AI

Despite a growing recognition of the pivotal role played by AI in Iran's defense doctrine, the current state of deployment, as per publicly available data, does not definitively illustrate complete integration into the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR). Financial constraints emerge as a crucial impediment to Iran's progress, given that the R&D and implementation of advanced AI technologies demand substantial resources. Moreover, the challenges are exacerbated by the clear technological advantage maintained by adversaries compared to Tehran's utilization of less sophisticated, if not outdated, gear.

The strategic choices made by Iran in this context indicate a nuanced approach aimed at navigating financial limitations, addressing technological disparities, and progressively constructing a more resilient defense infrastructure capable of tackling contemporary challenges (Martini et al. 2023). Within this framework, the

deployment of AI remains selective, primarily confined to a few niche defense capabilities, representing a pragmatic response to the existing hurdles.

As of January 2024, the Abu Mahdi precision-guided cruise missile, formally disclosed in July 2023, signifies Iran's first foray into modern defense capabilities, wherein AI integration has been engineered into its core architecture since inception. Positioned as the premier long-range anti-ship cruise missile, it boasts a range exceeding 1000 kilometers, advanced AI-enabled C2 systems, radar evasion, and real-time course adjustments. Designed for engaging warships, frigates, and destroyers, it features dual-band radar seekers for enhanced precision. The launch system enables swift preparation and deployment, with multi-missile launch capability for synchronized convergence onto a target. Developed by the Ministry of Defense, it's a cutting-edge addition to Iran's military capabilities, deployed to both the IRGC and the Army. The missile's inauguration was characterized by the Iranian Minister of Defense as "strategic" and "unprecedented" in sophistication and impact (Tasnim News Agency 2023c).

Two additional missiles have been unveiled by Iranian military officials, featuring AI capabilities. In contrast to the Abu Mahdi missile, both the ballistic missile Fath-360 and the Ghadir cruise missile represent military capabilities that have been augmented through the integration of AI. The Fath-360 missile is a short-range tactical ballistic missile guided by satellites. It has a range of 30 to 120 km and can carry a warhead weighing up to 150 kg. Developed by the MoD, it was initially deployed to the IRGC in 2020 and later to the Army in 2021. The Ghadir cruise missile, introduced in 2014, is an anti-ship cruise missile featuring a range of 330 km. This missile can be deployed from both coastal installations and naval vessels (Gerdab 2023b). These AI-augmented missiles made their debut during the IRGC war game in August 2023, reportedly as a response to Russia's move against Iran's territorial integrity. This followed Moscow's support for the United Arab Emirates' stance on disputed islands with Iran, expressed in the July 2023 joint statement of the sixth Russia-Gulf Cooperation Council Joint Ministerial Meeting for Strategic Dialogue (Reuters 2023).

Iran's UAVs have garnered significant attention, particularly for their use by Russian forces in Ukraine. According to the U.S. official assessment, Iran supply Russia with UAVs to bolster Moscow's capacity to target Ukraine, given the depletion of Russia's own precision-guided munitions (U.S. Defense Intelligence Agency 2023). Subsequently, Iran has delivered numerous one-way attack UAVs, the Shahed-131 and Shahed-136, to support Russia's military operations in Ukraine. The Shahed-181, which can be used for ISR and combat missions and can be equipped with two precision-guided missiles (D'Urso 2020), is the sole UAV reportedly equipped with AI technologies within its class. Reports covering the IRGC Aerospace Force's annual military exercise in 2021 speculated that AI might have been used to coordinate navigation and flight paths to enable a group of several UAVs to fly in synchronized formation (Tasnim News Agency 2021b).

In the realm of securing critical infrastructure, each Iranian province has unique passive defense strategies sanctioned by the NPDO. These strategies are specifically designed to align with the varied networks and capabilities inherent to each

province (PANA 2023). This decentralized approach ensures a targeted and flexible nationwide passive defense strategy. Moreover, the NPDO has established offices within public agencies and national industries, providing guidance and regulations to fortify the resilience of the infrastructure (Tasnim News Agency 2023a). Additionally, it conducts real-time monitoring to guarantee the continual safety and security of vital assets, safeguarding against cyberattacks and external intrusions. With the NPDO's renewed focus and commitment to AI, it becomes evident that a significant portion of these passive defense efforts is updated through the application of AI technologies.

In sum, RADM Tangsiri's remarks on the defense AI development discussed above recognize Iran's multiple endeavors in this field. Nevertheless, upon closer examination of instances and use cases, it becomes evident that the envisioned advancement of defense AI in the Islamic Republic is not materializing to the extent initially articulated.

6 Training for Defense AI

The IHU and MUT are public post-graduate universities specifically designed to cater to the research and operational needs of the Armed Forces and/or the MoD. For the academic year 2023-2024, both universities had a capacity to admit 29 students for the Master of Science in AI. Additionally, these institutions admitted 26 students for the Master of Science in EW and 56 students for the Master of Science in passive defense. Upon graduation, admitted students are obligated to work either at the Armed Forces or the MoD (Sanjesh Organization 2023a). Regarding the PhD programs, the MUT has accepted four researchers for AI, while the IHU has admitted four researchers for EW for the academic year 2023-2024. Upon completion of their studies, the researchers are required to contribute their expertise to the Armed Forces (Sanjesh Organization 2023b).

The War University welcomes post-graduate officers from "friendly and allied" foreign countries. As of 2021, the institution has provided training to officers from North Korea, India, Oman, Pakistan, and Iraq. The training encompasses both theoretical and operational courses (ISNA 2021). While specific details about the incorporation of defense AI into the curriculum are not publicly available, given the program's emphasis on information and intelligence planning, it is plausible that the utilization of military technology, including AI for ISR, forms an integral component of the program.

Considering the ever-evolving landscape of AI, continuous in-service education and training programs are imperative for research and military personnel engaged in defense AI within the Armed Forces and the MoD. As the Army, the IRGC, and the MoD each maintain their dedicated research institutes, these institutes serve the crucial function of collecting best practices and state-of-the-art capabilities from both leading nations and potential adversaries (Fars News Agency 2015b), with the goal of bolstering local efforts in the field of defense AI. In this regard, Iran has also

benefited from training with countries like North Korea. Furthermore, unverified reports have occasionally surfaced indicating Tehran's collaboration with authoritarian states such as Russia, China, and Belarus for technology transfer and military personnel training (Ben Taleblu 2023). Despite the Supreme Leader's ban on acquiring foreign goods and services for defense, with certain exceptions, including technology transfer, it is difficult to gauge to what extent these training and technology transfer initiatives also cover defense AI.

Iran's approach to support proxies encompasses the transfer of technology. This requires equipping proxies with knowledge and technology on the assembly and use of the military capabilities (Al-Alam 2024). There is currently no evidence suggesting that Iran's proxies employ defensive AI capabilities. Nevertheless, it is reasonable to conjecture that Iranian military scientists and commanders may have shared advanced aspects of EW with Tehran's proxies. As defense AI advances, there is a potential for these proxies to exploit the positive externalities of defense AI capabilities provided by the Islamic Republic. This is particularly significant given that Iran's adversaries, such as Israel, have been using defense AI to counter Hamas in the Gaza Strip since October 2023.

In the realm of passive defense, the NPDO adopts a strategic approach that prioritizes public awareness. Harnessing the power of mass media and platforms such as Friday Prayers, the Organization is committed to educating and enlightening the public on passive defense measures (U.S. Defense Intelligence Agency 2019). Moreover, with a dedicated presence in industries and public agencies the NPDO strives to provide training and information to employees and workers, emphasizing best practices crucial for civilian infrastructure protection and staff safety in digital spheres. On an annual basis, a dedicated week is devoted to showcasing the accomplishments in passive defense and highlighting the NPDO's initiatives, drawing nationwide attention and admiration (Cyberno 2023). This weeklong event serves as a catalyst for amplifying the Organization's outreach through mass media channels, thereby fostering heightened public awareness.

7 Conclusion

Defense technological innovations play a pivotal role in conferring a strategic advantage upon the Islamic Republic—an ideology deeply embedded in the leadership's convictions in Tehran. Iran perceives defense AI as the latest innovation that can be leveraged to safeguard the core tenets of its overarching strategy: the preservation of regime survival, security, and stability against significant state adversaries.

Strongly opposed to the existing world order and its centers of power, the Islamic Republic is unreserved in thinking about and developing defense AI as a means to rekindle its founding vision: a resilient model for the Muslim world and a precursor for all oppressed communities and nations globally. The genuine architects of the Islamic Republic view Iran not merely as a state but as an ideology, and they believe

that AI in defense and other domains holds the potential to actualize the visionary aspiration.

If this is indeed Iran's perception of defense AI as a once-in-a-lifetime opportunity to challenge its major adversaries and transform into an unassailable and inspired power, then the leadership is likely to leave no room for hesitation in capitalizing on defense AI. However, Iran acknowledges its technological inferiority, a consequence of its restricted access to the global technology market. Thus, Iran may seek to expand cooperation with authoritarian regimes to co-develop or import defense AI solutions. But—as happened in the past when Iran stepped up its industrial nuclear programs and worked with Moscow and Beijing behind the scenes (Katz 2021)—any move to advance its defense AI capabilities could pose a direct threat to Russia, indirectly endanger China's interests in the Middle East, and further sour relations with regional powers. Although the Iranian leadership is fully cognizant of these dangers, the deeply ingrained sense of strategic loneliness, that is ingrained in the country's strategic culture, may compel Tehran to prioritize the development of defense AI, leaving little room for alternative options.

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