DAIO Defense AI Observatory

Enabling Technology of Future Warfare

Defense AI in Turkey

Çağlar Kurç

DAIO Study 23|08

Ein Projekt im Rahmen von
dtec.bw
Zentrum für Digitalisierungs- und Technologieforschung der Bundeswehr

About the Defense AI Observatory

The Defense AI Observatory (DAIO) at the Helmut Schmidt University in Hamburg monitors and analyzes the use of artificial intelligence by armed forces. DAIO comprises three interrelated work streams:

- Culture, concept development, and organizational transformation in the context of military innovation
- Current and future conflict pictures, conflict dynamics, and operational experience, especially related to the use of emerging technologies
- Defense industrial dynamics with a particular focus on the impact of emerging technologies on the nature and character of techno-industrial ecosystems

DAIO is an integral element of GhostPlay, a capability and technology development project for concept-driven and AI-enhanced defense decision-making in support of fast-paced defense operations. GhostPlay is funded by the Center for Digital and Technology Research of the German Bundeswehr (dtec.bw).

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His research on the arms industries investigates the causes that underlie states' decisions to embark upon defense industrialization and its implications on the global arms market. In addition to projects, he co-organized E-Workshop series that aimed to shed empirical light on the defense industrial decision-making process in emerging countries and the political, economic, and military factors that have shaped it. His Twitter account is @ckurc.

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Content

1 Summary

Autonomous systems will shape the future of warfare. Therefore, defense Artificial Intelligence (AI) development in Turkey focuses primarily on improving the capabilities of autonomous systems, sensors, and decision support systems. Increasing autonomous systems' capability in intelligence gathering and fighting, as well as enabling swarm operations, is prioritized in developing defense AI. While Turkey enhances the capabilities of autonomous systems, humans will continue to be critical for decision-making in the foreseeable future.

Human involvement in the decision-making process poses an important question: how to effectively ensure human-machine interactions? Currently, the fast pace of development and deployment of autonomous systems worsen the problem of human-machine interaction. As Turkish defense industry representatives contend, it is easier to make machines talk to each other but very difficult to add humans into the mix, because existing structures are not suitable for effective human-machine interaction. Moreover, it is believed that AI enhancements to decision-making systems would help humans to make faster decisions and ease human-machine interactions.

Turkey's intentions and plans for the development of AI can be traced in official strategy documents, as well as R&D focus group reports. Prominent documents include the following:

- The 11th Development Program, which sets out Turkey's economic development goals and critical technology investments;
- The National Artificial Intelligence Strategy 2021–2025, which sets the framework for AI development in Turkey;
- Focus Technology Network (Odak Teknoloji Ağı, OTAĞ) Reports, which lay out technology roadmaps for specific defense technologies. These documents provide insight into how Turkey approaches AI, defense AI, and related technologies.

Turkey specifically focuses on AI-related technologies like machine learning, computer vision and natural language processing with an application focus on autonomous vehicles and robotics. Autonomous systems, mainly uncrewed aerial vehicles (UAVs), remain a priority in Turkish AI development since 2011. This has since expanded to include all types of uncrewed vehicles. In parallel, enhancing these vehicles with AI is gaining traction. The intertwined development of AI and related technologies form the core of Turkey's AI ecosystem.

Turkey's AI ecosystem is nascent but growing. As of October 2022, there are 254 AI startups listed in the Turkish AI Initiative (TRAI) database. Turkey aims to create syn-

ergies between its defense and civilian industries, academic institutions, and government through various ecosystem initiatives. Since many organizations are involved, these initiatives lead to repetition and redundancy. Redundancy also arises from the nature of AI technology itself. Since AI is a general-purpose technology that could be applied to different settings, various companies have products for both civilian and defense sectors; hence the same companies participate in different ecosystem initiatives. Furthermore, it is commonplace to see civilian companies cooperating with defense companies, partnering in defense AI research, and offering products.

Turkey encourages international AI collaboration in the civilian space but not in defense. However, since skills are transferrable, defense AI benefits indirectly from such cooperation.

Turkey pays a great amount of attention to the issue of interoperability in the development of autonomous systems, especially those with swarm capabilities. Beyond swarms, the interoperability of NATO allies is also an important issue. Turkey, therefore, views NATO standards as vital in developing autonomous systems and underlying technologies.

Turkey currently has a distributed organizational approach to AI. Each government agency sets up its own AI organization with overlapping responsibilities. Currently, although the Defence Industry Agency (Savunma Sanayi Başkanlığı, SSB) has not yet established an AI-specific organization, the SSB Department of R&D manages some AI projects, while the SSB Department of Unmanned and Smart Systems manages the platform-level projects. At the moment, it is not clear how these organizational structures enable defense innovation or organizational reforms based on the available information.

Turkey seeks to increase its R&D spending on AI, aiming to increase employment and grow the ecosystem. The SSB would grant more AI-based projects in the future and be willing to buy more autonomous systems, encouraging an upward trend in R&D spending. However, although Turkey would like to increase spending, the financial crisis may likely hinder current efforts.

Training and managing a skilled workforce are essential to building the indigenous AI development capacity that Turkey is looking for. This includes two components. First is the fostering of human resources that can develop and produce defense AI. Turkey is therefore investing in new university programs, researcher training, open-source platforms, and employment while supporting technology competitions. Second is the training of military personnel that would use defense AI. Defense AI is also slowly becoming part of the Turkish Armed Forces' (Türk Silahlı Kuvvetleri, TSK) training activities. Currently, there is very little open information on how Turkey intends to train military personnel in using defense AI.

2 Thinking About Defense AI

Turkey's approach to Artificial Intelligence (AI) revolves around other emerging technologies. In other words, AI is an enabling technology that would improve the capabilities of emerging systems, such as autonomous systems, and aid decision-making systems through improving human-machine interfaces and enhancing training. This can be seen in how AI is defined in the National Artificial Intelligence Strategy 2021–2025. According to the document, AI is "in a very general sense, the ability of a computer or computer-controlled robot to perform various activities in a similar way to intelligent living things."[1] AI-supported systems use advanced algorithms that learn from patterns contained in the data and make predictions.[2] The main thrust of the defense AI development in Turkey focuses on improving the capabilities of various autonomous systems such as sensors and decision support systems. Turkey believes the future of warfare will be defined by using autonomous systems that would increase the operational tempo.

AI will usher in a new era of fighting in which swarms of systems gather intelligence and fight. As the information gathered from the battlefield increases, it goes beyond the capabilities of human cognition. Thus, AI emerges as the facilitator for information fusion and data evaluation. Information from different locations about a single target needs to be fused and delivered to decision-makers. Likewise, swarm operations require various systems to operate in seamless coordination with each other, which requires a high level of autonomy. The required autonomy is believed to be realized by incorporating AI into these systems. However, future warfare would continue to include human-controlled systems as well, at least in the foreseeable future. As a result, autonomous systems need to communicate with human decision-makers.

Turkish scholars expect two main consequences of AI on future warfighting.[3] The first is the increased speed of the Observe, Orient, Decide, Act (OODA) loop. AI-supported systems will increase the rate of intelligence gathering, surveillance, target acquisition, and reconnaissance. Consequently, the military's decision-making processes will accelerate as the commanders' access to information increases. Combined with AI-enhanced decision-making systems, commanders would make faster decisions. Second, related to the increased capability of gathering information, militaries and intelligence agencies could advance predictive analysis.

We can observe the reflection of these expectations in the capstone documents of Turkey. OTAĞ reports provide insight into Turkey's approach to defense AI and related technologies, while the 11th Development Program and the National

1 Cumhurbaşkanlığı Dijital Dönüşüm Ofisi, "Ulusal Yapay Zeka Stratejisi 2021–2025," p. 12.
2 Cumhurbaşkanlığı Dijital Dönüşüm Ofisi, "Ulusal Yapay Zeka Stratejisi 2021–2025," p. 12.
3 Kasapoğlu and Kırdemir, The Rising Drone Power: Turkey on the Eve of Its Military Breakthrough, p. 16.

Artificial Intelligence Strategy 2021–2025 inform about Turkey's approach to AI in general and related fields of activity.

The 11th Development Program is the foundational document that determines the overall framework for area-specific strategy documents. It focuses on Turkey's overall economic development and sets out respective goals. The document also sets out the technologies that are deemed critical for Turkey's continued development.[4]

The National Artificial Intelligence Strategy 2021–2025, meanwhile, sets out the goals for developing AI in parallel with the overall economic development strategy. It lays out the current state of Turkey's AI capabilities, which various government organizations and the private sector are pursuing to enhance Turkey's AI proficiency, and discusses the necessary steps to be taken to improve Turkey's capabilities.[5]

In parallel with the overall AI strategy, various government organizations are expected to produce their own area-specific AI strategies. Although SSB recently organized a focus meeting for a national defense AI strategy,[6] we do not know whether the document will be made public. Furthermore, SSB is currently working on an AI OTAĞ report,[7] which has not been published at the time of writing of this report. However, an investigation of completed OTAĞ reports provides ideas on the possible focus of the defense AI strategy concerning research and development priorities and the technologies that Turkish defense industries will likely focus on developing.

OTAĞ reports are a foundation for the defense R&D development roadmap for a given focus area. Through these reports, Turkey determines the critical technologies that need to be indigenized, prioritizes those critical technologies, and initiates the basic technology projects.[8] However, this can only be done with assumptions about the future war. While these documents do not tell us definitively what the TSK think about the future of warfare, they provide detailed discussions by the defense industry and academia, providing some insight into how the armed forces may be thinking.

Of the various OTAĞ reports, two of them are very important. The first one is the Swarm Intelligence Development report, which mainly focuses on developing and

4 Strateji ve Bütçe Başkanlığı, "On Birinci Kalkınma Planı (2019–2023)."
5 Cumhurbaşkanlığı Dijital Dönüşüm Ofisi, "Ulusal Yapay Zeka Stratejisi 2021–2025."
6 Işık, "SSB'den yapay zeka çalıştayı."
7 STM ThinkTech, Türk Savunma Sanayiinin Adaptasyon ve Dönüşümünde Küresel Oyuncularla Rekabet, p. 12.
8 Savunma Sanayii Başkanlığı, "Odak Teknoloji Ağı (OTAĞ) Süreci."

using swarms of autonomous weapons.[9] The second document focuses on developing radio frequency technologies that would enhance the information-gathering capabilities of military systems.[10] A third report focuses on cyber security, in which AI is mentioned but not as prominent as the other two documents.[11] As the OTAĞ reports suggest, AI is closely intertwined with other emerging technologies and seen as a facilitator to increase these capabilities.

Turkey expects to acquire capabilities mainly in autonomous systems and data collection and management. Currently, STM-produced Alpagu and Kargu tactical loitering munitions[12] utilize computer imaging for targeting and machine-learning algorithms to optimize target classification, tracking, and attack capabilities without the requirement of GPS. Turkey's other UAVs, such as Bayraktar TB2, could have similar capabilities.[13] Thus, developing defense AI and integrating it with uncrewed systems would advance their capabilities, both when operating alone and as a swarm. The second gain is collecting battlefield data, data fusion, prioritization, and aiding the decision-maker.

Every capability gain brings problems with it. Literature on autonomy and AI in Turkey reveals a couple of concerns about the prospective impact of defense AI. The first concern is about how to manage expectations. Can Kasapoğlu, director of the security and defense studies program at the Istanbul-based Center for Economics and Foreign Policy Studies (EDAM), points out that although the main expectation is that defense AI would simplify tasks and operations, in reality, new weapon systems and their newfound capabilities will add to the complexities of modern warfare. Rather than a one size fits all approach, the proliferation of different weapon systems, their interconnected capabilities, and increased electromagnetic capabilities would increase the complexity, resulting in problems in managing these systems and the data they produce. New technologies would open new mission spaces that come with their own unique set of problems. Thus, militaries must find new ways to deal with these emerging problems and develop new concepts and doctrines that would fit the new operational environment.[14] To this end, for example, the Turkish Navy, in cooperation with various defense companies, is experimenting with autonomous systems, which have different mission packages, both at national and NATO exercises.[15] Although there is no open-source information on the specifics of how these concepts and doctrines would look in the

9 The report looks at the use of uncrewed systems across all domains such as Uncrewed Aerial Vehicles (UAV), Uncrewed Ground Vehicles (UGV), Uncrewed Surface Vehicle (USV), and Uncrewed Underwater Vehicles (UUV). For more, see also: Bülbül and others, Sürü Zekası Odak Teknoloji Ağı Sonuç Raporu.
10 İncel and others, RF Odak Teknoloji Ağı Sonuç Raporu.
11 Savunma Sanayii Başkanlığı and Türkiye Siber Kümelenmesi, Siber Güvenlik Teknolojileri OTAĞI Sonuç Raporu.
12 For more information on both systems, see: https://www.stm.com.tr/en/alpagu and https://www.stm.com.tr/en/kargu-autonomous-tactical-multi-rotor-attack-uav (last accessed 4 October 2022).
13 BaykarTech, "Yapay Zeka."
14 Kasapoğlu and Kırdemir, The Rising Drone Power: Turkey on the Eve of Its Military Breakthrough, p. 15.
15 İnsansız Deniz Sistemlerinin Geleceği ve Türkiye Potansiyeli.

Turkish case, the military and the defense industry face difficulties in developing autonomous systems and integrating them into the existing military structures.

The second concern refers to human-machine interaction. Despite the development of AI systems, they are not mature enough to deploy in fully autonomous systems that can coordinate independent of human control. And even when full autonomy can be reached, there is still a need for human oversight. Thus, human-machine interactions sit at the center of the development of AI-enabled autonomous systems.[16] Yet, it seems that this is the most challenging part. Industry representatives argue that coordinating a group of uncrewed systems is far easier than making machines and humans work together because adding machines into the command and control mix alters the established human-to-human command and control behavior of the military personnel.[17]

The third concern is about organizing and managing uncrewed systems within the overall military system. Currently, every service pursues its own uncrewed system projects. Yet, Gökhan Uçar, the former Head of the Unmanned and Smart Systems Department at SSB, contends that the proliferation of autonomous systems requires a new type of organization. He argues that Turkey needs to establish an "Uncrewed Systems Command," composed of military officers and civilians focusing solely on using autonomous and uncrewed systems. The new command should have uncrewed land, air, sea, and robotic soldier branches.[18] While the specifics of the new organization have not been elaborated, the suggestion of a new organization points out an awareness of the need to think differently about uncrewed systems. Such an organization could enable a more focused and coordinated approach to the development, procurement, and use of uncrewed systems as well as the development of defense AI.

The final concern is dealing with new vulnerabilities that emerge with interconnected systems. One of the common security concerns regarding autonomous systems and AI is hacking. In other words, as the systems become more connected and computerized, they increasingly become vulnerable to cyber-attacks. Thus, the question becomes how to prevent AI-enabled systems from input manipulation, which would alter how the AI behaves.[19]

Capstone research and development documents and the discussions on defense AI also reveal foreign sources that influence Turkey's approach to defense AI. Although Turkey tries to learn from the experiences of many states, the United

16 STM ThinkTech, Entegre Harekat Ortamında İnsanlı ve İnsansız Sistemlerin Birlikte Kullanılması, p. 13.
17 İnsansız Deniz Sistemlerinin Geleceği ve Türkiye Potansiyeli.
18 STM ThinkTech, Kuvvet Çarpanı Olarak Otonom Sistemler, p. 11.
19 Bülbül and others, Sürü Zekası Odak Teknoloji Ağı Sonuç Raporu, p. 79; Kasapoğlu and Kırdemir, The Rising Drone Power: Turkey on the Eve of Its Military Breakthrough, p. 18.

States emerges as the main source of influence. The research and development documents mainly reflect the developments and discussions in the United States, as highlighted by the references quoted in these documents.[20] Similarly, discussions about the need to protect defense AI solutions against outside interference reflect and sometimes reiterate ongoing US discussions. This explains why publicly available information as well as ongoing debates seem to be generic. Yet generic discussion reveals whose discourse impacts Turkey's approach to defense AI. However, this does not imply that Turkey is seeking to emulate the United States fully. Rather, as we will discuss in the following chapters, the US serves as a point of departure, and through testing and experimenting, Turkey strives to construct its own path in developing defense AI.

20 See Bülbül and others, Sürü Zekası Odak Teknoloji Ağı Sonuç Raporu.

3 Developing Defense AI

Turkey is seeking to become a powerhouse in emerging technologies. This is reflected in general R&D priorities, which are connected to its defense AI development programs. According to the 11th Development Program, AI, the Internet of Things, Augmented Reality, Big Data, and Sensor Technologies are the priority R&D areas that would elevate the Turkish economy.[21] In line with the R&D priorities determined by the 11th Development Program, Turkish companies are also focusing on AI and AI-related technologies such as Machine Learning, Computer Vision, Natural Language Processing, Autonomous Vehicles, and Robotics.[22] Again, the general R&D priorities show how interconnected AI development is with other emerging technologies.

Robotics is the main area that Turkey's R&D currently focuses on. Since 2011, defense R&D in robotics, especially autonomous weapons, has focused on autonomous command and control. According to the UAV Technology Roadmap, automation, AI, distributed command, control, and communication technologies sit at the heart of the technology roadmap.[23] In parallel with the focus on robotics and autonomy, the same document also refers to swarm technologies.[24] Which have recently gained prominence, as observed in OTAĞ documents and the National AI Strategy.

The defense AI R&D projects focus on developing underlying technologies that increase the capabilities of AI-enabled systems. In this regard, SSB currently has the following priorities:[25]

- Social media anomaly detection
- Event analysis
- Deep learning, the big data analysis platform
- Social media analysis performance enhancement
- GPS-independent, autonomous navigation
- Identification and classification of radar-detected naval targets
- Swarm robots and autonomous reconnaissance
- Guidance and navigation
- Operational AI command assistant
- AI-based fire support and autonomous driving for land systems
- AI-based risk detection and prevention in software-based networks
- Global risk analysis

21 Strateji ve Bütçe Başkanlığı, "On Birinci Kalkınma Planı (2019–2023)," p. 81.
22 TRAI, "TRAI Startup Ecosystem Map;" Strateji ve Bütçe Başkanlığı, "On Birinci Kalkınma Planı (2019–2023)."
23 Savunma Sanayii Müsteşarlığı, Türkiye İnsansız Hava Araçları Sistemleri Yol Haritası (2011–2030).
24 Savunma Sanayii Müsteşarlığı, Türkiye İnsansız Hava Araçları Sistemleri Yol Haritası (2011–2030), p. 57.
25 Cumhurbaşkanlığı Dijital Dönüşüm Ofisi, "Ulusal Yapay Zeka Stratejisi 2021–2025," p. 55.

OTAĞ reports and Defense Industry R&D Broad Topic (Savunma Sanayi Ar-Ge Geniş Alan, SAGA) calls analyze in more detail which technologies Turkey would pursue in the future concerning the overall R&D priorities. AI SAGA calls for prioritized projects focusing on explainable AI learning methods, reinforcement learning methods, learning with sparse data, robust learning methods against data poisoning, and innovative (3rd generation) learning methods.[26] Building on the earlier SAGA call, the Swarm Intelligence OTAĞ report expresses that distributed AI, AI-based electronic warfare, and AI-based cognitive modeling should be prioritized for swarm systems.[27] The Radio Frequency OTAĞ report focuses on signals processing. Here, the development of two technologies comes to the fore: cognitive signal processing-based systems and cognitive signal processing systems for distributed systems networks.[28] Finally, the Cyber OTAĞ report prioritizes the development of an AI-based risk information sharing platform and AI-supported command and control system to increase cyber security defenses.[29] These priorities are reflected in both completed and ongoing research projects.

3.1 Current Defense AI Projects

Turkey currently has nine[30] defense AI-related projects, which are also Turkey's ongoing defense AI procurement priorities:

- **AI Commander Assistant Developing Course of Action Project (HAMLE)**
  HAMLE is an AI-based war gaming platform developed by ASELSAN. It uses reinforcement learning and AI algorithms to provide operational suggestions for corps, brigades, and battalions at the tactical level through different game modes. The system could learn from wargames and assume the role of an instructor in personnel training. As the system learns, it could be used in military decision-making.[31]

- **AI-Assisted Fire Control Support and Autonomous Driving for Land Vehicles Project (Karagöz)**
  The system uses information from Lidar, radar, ultrasonic sensors, and electro-optic sensors to enable autonomous driving (route planning, moving/stationary target detection, geographical information systems integration, passage recommendation in confined spaces, and collusion detection),

26 Savunma Sanayii Müsteşarlığı, "Ar-Ge Geniş Alan Çağırısı Duyurusu: Yapay Zeka Teknolojilerinin Geliştirilmesi", p. 4.
27 Bülbül and others, Sürü Zekası Odak Teknoloji Ağı Sonuç Raporu, p. 193.
28 İncel and others, RF Odak Teknoloji Ağı Sonuç Raporu, p. 203.
29 Savunma Sanayii Başkanlığı and Türkiye Siber Kümelenmesi, Siber Güvenlik Teknolojileri OTAĞI Sonuç Raporu, p. 39.
30 There is no publicly available information about the SSB-backed Social Media Analysis Performance Development Project (PERGEL). See: Kökçü, "SSB'den 17 yeni Ar-Ge projesi."
31 Aselsan, "Hamle Hareket Tarzı Geliştiren Yapay Zekalı Komutan Asistanı."

observation (tracking, 360 degrees vision and friend-or-foe identification), and fire support (target range detection, target, and target class detection, and ammunition recommendation). The system is based on machine and deep learning, sensor fusion, and computer vision.[32]

- **Autonomous Discovery, Guidance, and Navigation with Collaborative Robots Project (Robo-Tim)**
  The Robo-Tim project aims to develop a heterogenous swarm system that integrates three UAVs and three UGVs to engage cooperatively in adaptive exploration and autonomous navigation. The system would enable swarm systems to simultaneously position themselves and operate in GPS-denied areas. It uses AI-based work sharing and object and friend/foe recognition to facilitate the cooperative working of UAVs and UGVs and improve operational swarm capabilities. The project aims to enable UAVs to land on moving UGVs. Automatic charging would allow UAVs to continue their operations. Finally, the project will form a foundation for swarm communication capabilities.[33]

- **Identification and Classification of Radar-Identified Surface Targets Project (GÖRÜ)**
  The project aims to develop AI that detects, classifies and identifies surface targets based on the data from synthetic-aperture radar (SAR) sensors.[34]

- **Image Analysis and Automatic Target Recognition System Project (HASAT)**
  The project aims to develop an image recognition system that could identify, recognize, and classify targets. It will be able to analyze and evaluate images and detect targets based on the data acquired from electro-optic systems and SAR of satellite and air platforms.[35]

- **Advanced Imagining Technologies Project (TUYGUN)**
  The project aims to develop multispectral and hyperspectral imaging software and target analysis for various platforms.[36]

- **Artificial Intelligence Technologies for Swarm vs Swarm Air Engagement Development Project (SUMRU)**
  The project, led by İTÜNOVA TTO,[37] aims to develop an AI-based guidance system that would enable swarms to operate independently of central command and control and disable the adversary's swarm systems.[38]

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32 Savunma Sanayii Başkanlığı, "Robotik/Otonom/Sürü Zekası Teknolojileri - Ar-Ge İnfografikler."
33 STM ThinkTech, Entegre Harekat Ortamında İnsanlı ve İnsansız Sistemlerin Birlikte Kullanılması, p. 27.
34 Görü Projesiyle Su Üstü Hedefler Yapay Zekayla Tespit Edilecek.
35 Savunma Sanayii Müsteşarlığı, "Görüntü Analizi Ve Otomatik Hedef Tanıma Sistemi (HASAT) Projesi."
36 Savunma Sanayii Müsteşarlığı, "İleri Görüntüleme Teknolojileri (TUYGUN) Projesi."
37 Savunma Haber, "Siber Güvenlikten Kompozit Teknolojilerine."
38 Kaplan, "SSB'de 13 Ar-Ge Projesi için imza töreni yapıldı."

- **Detection of Border Violations by Artificial Intelligence Enhanced UAVs Project (AHLAT)**
  The project, led by Bitlis Eren University,[39] aims to develop an observation system based on mini-UAV swarms with deep reinforced learning. At the optimum time and route along the border, these swarms would conduct area sweep and detect illegal activities around military unit.[40]

These technologies are likely to be integrated into Turkey's other autonomous system projects. TUYGUN and HASAT seem to be service and system agnostic. Others seem to be service-related but platform agnostic. GÖRÜ is for the Turkish Navy, while Karagöz and AHLAT are for the Turkish Army. Robo-Tim technology has the potential to be used by all three services to integrate their autonomous systems, although the project in its current form mainly focuses on cooperation between UAVs and UGVs. SUMRU could also be used by all three services as an air defense solution. Some of these technologies are likely to be integrated into and form the basis of autonomous capabilities of the following three weapon system projects:

- **Bayraktar Kızılelma**
  Bayraktar Kızılelma is a Turkish uncrewed fighter aircraft.[41] Conceptually, it is unclear whether it will operate like a Loyal Wingman or be controlled from a ground station.[42] If it was operationalized like a Loyal Wingman – as foreseen by other countries developing similar technology –Kızılelma would work with Turkey's TF-X fifth-generation fighter plane and be used for dangerous air operations that require penetration of heavily defended areas to conduct suppression of enemy air defense (SEAD). In addition, it is planned to conduct intelligence, surveillance, and reconnaissance (ISR) and counter-air missions.[43] It has a stealth design and is powered by turbofan engines. There will be different versions of Kızılelma, which would use various engines and engine configurations, and thus have additional capabilities. Furthermore, Baykar Technology also plans to have a naval version capable of operating from the TCG Anadolu, an amphibious assault ship.[44]
  Kızılelma is also expected to be AI augmented.[45] It is argued that the system can learn from its environment, find new patterns, develop new behavior, and facilitate human-machine integration.[46] Yet, apart from these generic expectations, not much is clear about the specifics of the AI that the Kızılelma would use. However, Baykar Technology's previous work on AI suggests that Kızılelma

39 Savunma Haber, "Siber Güvenlikten Kompozit Teknolojilerine."
40 Kaplan, "SSB'de 13 Ar-Ge Projesi için imza töreni yapıldı."
41 Cenciotti, "Turkey's First Indigenous Unmanned Fighter Aircraft Carries Out Autonomous Taxi Tests."
42 Newdick, "Turkey's Fighter-Like Drone Emerges For Taxi Tests."
43 Newdick, "Turkey's Fighter-Like Drone Emerges For Taxi Tests."
44 Kasapoğlu, "Bayraktar Kızılelma yeni bir harekat tasarısının habercisi."
45 Jennings, "Turkish 'loyal wingman' conducts taxi and take-off trials ahead of first flight."
46 Kasapoğlu, "Bayraktar Kızılelma yeni bir harekat tasarısının habercisi."

would have visual posture detection, basic object detection, landmark recognition and operate beyond the line of sight (BLOS).[47] These technologies have not been developed only for Kızılelma, but also for other systems, such as TB2, Akıncı, and other Baykar UAVs. Kızılelma would have more advanced versions of these technologies – an important test for Baykar's AI capabilities. Other SSB-funded technologies discussed above could be integrated into the system.

- **FNSS Shadow Rider UGV**

  FNSS Shadow Rider is an optionally crewed UGV based on the M113 platform. Its AI-based autonomy kit enables the system to patrol, track and return to the military base. It could be used in reconnaissance and surveillance, logistic support, tactical deception, fortified position reconnaissance, communication relay, medical evacuation, and fire support missions. The armed versions do not fire on targets autonomously, but as argued earlier, always keep the man-in-the-loop. Its autonomous capabilities include leader-follower capabilities in GNSS-denied areas and obstacle detection and avoidance.[48] We can expect Robo-Tim technology to be integrated into the Shadow Rider.

- **Aselsan-Sefine Marlin USV**

  Turkey has been investing in various types of USVs. Currently, Turkey has four armed USVs (Ares Shipyard-Meteksan Defense ULAQ, Aselsan-Sefine Marlin, Dearsan Shipyard SALVO and Yonca-Onuk Shipyard-Havelsan Sancar) programs and Aselsan is working on the Albatros-S – Sefine MIR USV swarm project.[49] With its electronic warfare capabilities, Marlin USV emerges ahead of other competitors in its class. The system can be fitted with different types of payloads such as lightweight torpedoes, light guns, medium-range surface-to-surface missiles, electronic warfare modules, sonobuoys, satellite, line of slight, and underwater communication.[50] AI could enhance the system's autonomous capabilities if needed.[51] The system is also capable of conducting anti-submarine warfare. During NATO exercises "Robotic Experimentation and Prototyping Exercise by Maritime Unmanned Systems" (REMPUS) and "Dynamic Messenger 22," Marlin detected the undersea target simulator through the processing of signals from different sonobuoys and reported back to NATO HQ.[52]

47 BaykarTech, "Yapay Zeka."
48 FNSS, "Shadow Rider Unmanned Ground Vehicles."
49 Ozberk, "Here are the four USV programs Turkiye is working on."
50 Ozberk, "MARLIN USV."
51 Yanık, "MARLIN SİDA, üstün teknoloji yetenekleriyle sınıfında rakip tanımıyor."
52 Aksan, Güngürmüş, and Daban, "NATO tatbikatında şov yaptı."

Although these examples are not exhaustive, they show that Turkey's defense AI approach is inherently linked to robotics and uncrewed systems. Increasing production capabilities and recent successes of Turkish weapon systems, such as Bayraktar TB2 UAVs, resulted in an increased focus on the development of autonomous weapon systems. We expect that SSB-funded, as well as company-funded, AI technologies will be integrated into these systems. Although there is little information on which technologies would be integrated and how, the growing AI-related industry shows the direction of future Turkish expectations.

Increased focus on uncrewed systems resulted in more companies entering the market,[53] resulting in more systems that could be tested. Thus, Turkey currently engages in constant experimentation to construct new concepts and doctrines for autonomous systems. For example, Arda Mevlütoğlu, a Turkish engineer and scholar, contends that Turkey's use of UAVs for electronic warfare in coordination with multirole aircraft and artillery, as highlighted during the spring 2019 operation in Idlib, signifies novel battlefield tactics that result from exploring and developing new concepts by the TSK.[54] Thus, Turkey is increasingly focusing more on its specific needs and limitations while developing new weapon systems. Hence, we expect that there will be a divergence between the United States and Turkey in terms of development and concepts in the deployment of autonomous systems and, therefore, defense AI.

3.2 Defense AI Ecosystem

Turkey has a nascent but growing AI ecosystem. While some companies are working with the defense industry in developing defense AI, the overall management of the ecosystem is decentralized. The National AI Strategy aims to encourage AI clusters that would increase the synergy and cooperation between different companies and industries. Consequently, various organizations seek to improve the relations between industrial partners, universities, and government institutions. For example, TÜBİTAK Artificial Intelligence Institute seeks to encourage cooperation and technology transfer between universities, state research centers and the private sector through establishing clusters focusing on financial technologies, smart production systems, smart agriculture, food and husbandry, climate change, and e-trade technologies.[55] SSB also seeks to construct an ecosystem focusing on defense through the Defense Industry Artificial Intelligence Platform.[56] Fur-

53 See Presidency of Defence Industries, Turkish Defence Industry Product Catalogue, pp. 44–49, 102–103, 141–151; Defense Here, "Türkiye'nin yerli ve milli insansız kara araçları hünerlerini sergiledi."
54 Mevlütoğlu, "Türkiye'nin SİHA deneyimi"; #tolgaozbek Türk tipi İHA Operasyonu.
55 Yapay Zekâ Enstitüsü, "Ekosistem Yapısı"; Yapay Zekâ Enstitüsü, "Hakkımızda."
56 Savunma Sanayii Yapay Zekâ Platformu, "Yetenekler ve Altyapımız."

thermore, the Turkish AI Initiative (TRAI), a non-governmental organization, also seeks to improve the AI ecosystem in Turkey. The effectiveness of these disparate groups is questionable because of structural repetition. At the same time, some companies are part of more than one ecosystem initiative.

Overall, the defense AI ecosystem comprises a few prominent companies, including STM, Havelsan, Aselsan, Bites, and Baykar. These companies have already fielded AI-based autonomous systems and are working on developing new technologies. Havelsan is especially important as it is very competent in developing AI-based wargaming, which could also be transformed into an AI-based decision support system. However, it is difficult to separate neatly between pure defense and civilian companies due to the dual-use nature of AI and robotics technologies. For example, defense companies that focus on AI development cooperate with other defense partners, such as the shipyards of Sefine and Yonca-Onuk, as well as civilian companies to develop and field AI-integrated platforms.

Turkey has a primarily dual-use AI technology ecosystem. As of October 2022, there are 254 AI startups listed in the TRAI database.[57] Since AI is a general-purpose technology that could be applied to different settings, various companies have products for both civilian and defense sectors. Thus, it is not surprising to see civilian companies also cooperating with defense companies, partnering in defense AI research. Some prominent examples include Selvi Technology, OBSS, Kuartis, and Titra.[58] Universities also play an essential role in developing defense AI and acting as centers for guidance and knowledge transfer. METU Center for Image Analysis and METU-TAF Modsimmer are the two most prominent research centers with close links to Turkey's defense and military sectors, but there are many more. In parallel with the development goals and the National Artificial Intelligence Strategy, the number of AI-focused programs and research has increased.

In line with its push for greater self-sufficiency Turkey does not seek international partners in developing its local defense AI capabilities but is willing to participate in NATO initiatives. In 2022, TÜBİTAK BİLGEM and SAGE have been selected as test centers under NATO's Defense Innovation Accelerator for the North Atlantic (DIANA) initiative.[59]

Civilian AI initiatives, by contrast, are encouraged to seek and increase international partnerships. Turkey mainly cooperates with the United States and Euro-

57 TRAI, "TRAI Startup Ecosystem Map."
58 For more on these companies, see https://www.selvitechnology.com/; https://obss.tech/en/; https://kuartis.com/en/; https://titra.com.tr/en (last accessed 27 December 2022).
59 Gökkoyun, "TÜBİTAK BİLGEM ve TÜBİTAK SAGE, NATO tarafından test merkezi olarak seçildi"; TÜBİTAK SAGE, "TÜBİTAK SAGE, NATO DIANA Test Merkezi Seçildi."

pean Union member states, in particular Germany.[60] International cooperation is essential for Turkey's overall AI ecosystem. However, due to the transferability of the skills, experience gained through these partnerships could be transferred to building defense AI.

Although Turkey does not partner with other countries on developing defense AI, interoperability is nonetheless a major concern. Interoperability of swarming systems is particularly important as interoperable swarm communication is said to increase operational effectiveness. To this end, the Swarm Intelligence OTAĞ report suggests:[61]

- Determining software and hardware requirements
- Choosing common components and interface requirements
- Securely controlling and managing data links.
- Establishing package structures for the communication between uncrewed systems that have different characteristics and data
- Analyzing the optimum bandwidth values and frequency based on data package and size based on standards
- Bringing different characteristics from NATO standards and STANAG documents for control station functional architecture and data link systems.

Turkey seeks to incorporate NATO standards while integrating different Turkish autonomous weapon systems. This suggests that Turkey considers the need for allied interoperability while developing autonomous systems as this could also improve the export prospects of Turkey's autonomous system to NATO allies. Turkey strives to advance arms exports to sustain its indigenous defense industrial base. As a part of its export policy, Turkey actively incentivizes its companies to participate in NATO-supported projects as well as committees and working groups of the Conference of National Armaments Directors (CNAD).[62] Overall, Turkey appears to follow a structured and project-based technology development path to incorporate defense AI into its emerging technologies.

60 Cumhurbaşkanlığı Dijital Dönüşüm Ofisi, "Ulusal Yapay Zeka Stratejisi 2021–2025", p. 52.
61 Bülbül and others, Sürü Zekası Odak Teknoloji Ağı Sonuç Raporu, pp. 182–183.
62 Savunma Sanayii Müsteşarlığı, 2017–2021 Uluslararası İşbirliği ve İhracat Stratejik Planı (2017–2021 International Cooperation and Export Strategic Plan), pp. 8–9.

4 Organizing Defense AI

Turkey currently has a distributed organizational approach to AI. Each government agency is setting up its own AI organization with overlapping responsibilities. Here is a list of established agencies:

- Department of Big Data and Artificial Intelligence Application under the Digital Transformation Office of Presidency
- General Directorate of National Technology under the Ministry of Industry and Technology
- TÜBİTAK Artificial Intelligence Institute
- General Directorate of Health Information System under the Ministry of Health
- Unit of Artificial Intelligence and Wearable Technologies under National Projects Management Coordinatorship
- Branch Office of Process Management and Artificial Intelligence Application under the Directorate of Communication and Information Technologies of the Ministry of National Defense

Currently, the SSB has not established an AI-specific organization, although the Department of R&D manages AI-related R&D projects, while the Department of Unmanned and Smart Systems manages platform-related projects. Based on open information currently available we do not know how these organizational structures enable defense innovation or organizational reforms. SSB's forthcoming AI Strategy document might shed light on these issues if it becomes public. Until then, it is difficult to know how military services approach defense AI and how they plan to change their organizational structure.

5 Funding Defense AI

Turkey has been increasing its R&D budget since 2006. According to TurkStat, Turkish R&D spending has increased from TL17.326 billion (US$1.957 billion) in 2006 to TL59.534 billion (US$6.727 billion) in 2020.[63] While state funding remains low, the primary funding source comes from private industry, which is also leading most R&D projects. Most private R&D spending is in the production sector, with TL22.027 billion (US$2.488 billion) in 2020. The information and communication sector is the second biggest spender, with TL11.144 billion (US$1.260 billion) in 2020. R&D in this sector involves research on AI and machine learning, big data, and data analytics, among others. While the specific R&D budget for AI is unclear, the National AI Strategy shows that large companies are leading AI development.[64]

In 2021, TÜBİTAK determined eight areas as priority R&D and innovation topics. These were information and communication technologies, energy, agriculture and food, machine production, automotive, health, and other areas (mining, advanced metallurgy, and chemistry). Within information and communication technologies, big data and data analytics, robotics and mechatronics, and AI were the prioritized research areas. AI research areas prioritize AI technologies (a very general term) and artificial vision, image, and video procession (more specific technology). Within the robotics area, AI is also prioritized. One of the topics in this area is new-generation AI-based robots.[65] Even though TÜBİTAK mainly focuses on developing technologies for civilian use, with the notable exception of defense-specialized institutes, we can assume that the TÜBİTAK-funded AI R&D projects would spill over to the defense area.

Against this background Turkey could seek to increase R&D spending on AI as it wants to grow its AI ecosystem and create jobs for highly qualified experts. Thus, SSB could buy more autonomous systems and lift its overall R&D spending. However, the biggest challenge is the current economic crisis, which limits the government's financial leeway. At this point, company initiatives would become important, especially for defense companies. Growing arms trade volumes could facilitate more R&D investments, but still companies would look for a return on investment to justify growing R&D spending.

63 2021 constant price. Average exchange rate for 2021: US$1 = TL8.850 (OECD exchange rates, https://data.oecd.org/conversion/exchange-rates.htm, last accessed 27 December 2022).
64 Cumhurbaşkanlığı Dijital Dönüşüm Ofisi, "Ulusal Yapay Zeka Stratejisi 2021–2025", p. 46.
65 TÜBİTAK, "BTY İstatistikleri."

6 Fielding and Operating Defense AI

Turkey seeks to augment a variety of capabilities with the development of defense AI. The first set of priorities emerged in 2018. According to the AI SAGA call, Turkey prioritizes the improvement of Smart Decision Support (including Command and Control, Risk Assessment and Prioritization, Fast Decision Making, Intelligence, Reconnaissance and Surveillance Systems, Identification of Friend or Foe vehicles and people), Cyber Security, Border Security, Electronic Warfare and Radar, New Generation Guided Systems and Learning Through War Gaming.[66]

In addition, OTAĞ reports illustrate how developing defense AI would augment specific national capabilities. For example, the Swarm Intelligence OTAĞ report focuses on improving autonomy by leveraging Turkey's recent success in robotic systems.[67] The Radio Frequency OTAĞ report focuses on using defense AI to improve signals processing to enhance Turkey's intelligence-gathering capabilities through distributed sensors and the ability to operate under electronic warfare.[68]

While these priorities show future intentions and act as future roadmaps, we currently observe that Turkey is taking initial steps that would create the building blocks for future capabilities. Six currently deployed systems show how Turkey is building future capabilities.

- **STM Loitering Munitions**
  STM Alpagu and Kargu tactical loitering and attack systems use machine learning algorithms "to optimize target classification, tracking, and attack capabilities without the requirement for a GPS connection"[69] and use computer imaging for targeting. These loitering munitions can operate autonomously, but the human operator decides to attack the target.

- **Multi-Dimensional Radio Communication Signal Analysis Platform Project (Kaşif)**
  The system is a signals intelligence platform that captures communication signals between 10Mhz and 6Ghz and detects the direction, distance, and movement of the signal source using AI algorithms.[70]

- **Defense Industry Capability Inventory (YETEN)**
  YETEN aims to facilitate cooperation and technology transfer between different defense companies and improve defense production and procurement management. The system collects data on financial, human resources, products, and production and testing infrastructures of defense companies and organizations. The system provides an overall capability inventory of Turkish

66 Savunma Sanayii Müsteşarlığı, "Ar-Ge Geniş Alan Çağırısı Duyurusu: Yapay Zeka Teknolojilerinin Geliştirilmesi," p. 4.
67 Bülbül and others, Sürü Zekası Odak Teknoloji Ağı Sonuç Raporu.
68 İncel and others, RF Odak Teknoloji Ağı Sonuç Raporu, p. 26.
69 Kasapoğlu and Kırdemir, The Rising Drone Power: Turkey on the Eve of Its Military Breakthrough, p. 26.
70 TÜBİTAK Bilgem, "Çok Boyutlu Telsiz Haberleşme İşaret Analiz Platformu."

defense industries, which will be used to meet TSK demands locally and determine technology areas that need to be improved. Its AI-based suggestion system identifies candidate companies that could produce required parts and components locally with or without a technology transfer. Furthermore, the system helps peacetime defense management and supports decision-making mechanisms during mobilization and wartime.[71]

- **Data Tagging Platform (Veri Kovanı)**
  The platform provides fundamental tagged data (video, images, text, voice) that would be used to develop AI-based algorithms in areas such as robotics, autonomous driving, remote sensing, and biomedicine. The platform will act as a qualified data pool, which will help to increase workforce efficiency in AI development while reducing project time.[72] The platform uses crowdsourced data tagging[73] and also acts as a central source for disseminating these data clusters.[74]

- **Virtual Forces with Learning Artificial Intelligence Project (FIVE-ML)**
  FIVE-ML is an AI-based simulator that will be incorporated into the T-129 ATAK helicopter, ATAKSIM, ANKA, and UMTAS simulators. It will replace rule-based behavior infrastructure with AI-based behavior infrastructure.[75]

- **Global Positioning System Independent Autonomous Navigation System Project (Kerkes)**
  The Kerkes project is a navigation system that enables UAVs to continue operating when GPS and datalinks are unavailable. The system uses data acquired from platform optic systems and fuses the incoming data to determine the platform's location. It uses image recognition and deep learning to recognize landmarks to determine the platform's position and enable effective navigation.[76] In July 2022, the project was completed and accepted by SSB.

These projects show that Turkey is building its defense AI capabilities from the ground up and it is not limited to uncrewed weapon system development. Another important aspect is that ongoing projects are a source of gaining experience and developing new concepts and doctrines. For example, continuing projects on USVs are tested during military exercises, which help to experiment and understand how autonomous systems could be used and integrated into the existing military structures and crewed systems. Furthermore, Turkey is also experimenting

71 Savunma Sanayii Başkanlığı, "YETEN."
72 SavunmaSanayiST, "SSB'den yapay zeka için 'Veri Kovanı' hamlesi."
73 Any Turkish citizen, subject to approval from SSB, can participate in data labelling within the platform. Initial user base will include 250 users.
74 Savunma Sanayii Başkanlığı, "Veri Kovanı."
75 HAVELSAN, "HAVELSAN Yapay Zekâlı Simülatör Geliştirecek."
76 Savunma Sanayii Başkanlığı, "Alternatif Konum Bulma - Ar-Ge İnfografikler."

with different payloads for different mission sets. Thus, experimenting before deploying provides valuable information in shaping the future force structure. Most importantly, the use of defense AI is not limited to weapons systems. Turkey also seeks to increase its effectiveness in managing defense industry capabilities through projects such as YETEN. This is vital for developing a sustainable and robust defense AI industrial base and shows that the use of defense AI impacts the overall military structure and defense planning.

7 Training for Defense AI

Training and managing a skilled workforce are essential to building the indigenous AI development capacity that Turkey is looking for. This has two components. First are the human resources that would develop and produce defense AI capability. Second is the training of military personnel that would use defense AI.

7.1 Academic and Workforce Training

In training human resources to develop and produce defense AI, different organizations pursue various programs to improve Turkey's education and increase employment in the AI sector. The Higher Education Council prioritizes AI research under an interdisciplinary 100/2000 Ph.D. project, which aims to increase the employment of research assistants and faculty members in Turkish universities. Since 2018, Turkey has initiated four undergraduate, fourteen graduate, one Ph.D. program(s) in AI, and twenty-four graduate and five Ph.D. programs in big data, robotic and smart systems. Turkey's Open-Source Platform encourages projects focusing on natural language processing through peer learning. To increase employment, the Ministry of Treasury and Finance initiated the "1 million employment" project, which would provide free online training in IT, including AI, and an open CV database for employers.[77]

Apart from these initiatives, the following two competitions are important to grow and develop defense AI talents:

- **Teknofest**
  Teknofest is an all-inclusive technology competition focusing on high-technology areas deemed necessary for Turkey's defense and civilian sectors. There are a variety of Teknofest competitions, such as smart transportation, helicopter design, mixed swarm robots, fighter UAV, AI in healthcare, AI in transport, and Turkish language processing. Teknofest also has a broad participation base ranging from students (primary school level to graduate level) to private sector professionals. Its wide reach facilitates the development of human resources in high-technology sectors by igniting interest in younger generations, encouraging innovative ideas, and supporting the winners of competitions. For example, winners of the fighter UAV competition will be provided with internship opportunities in Turkey's technology institutions. In other words, these competitions not only work for experimenting with new ideas but also act as a talent pool for Turkey's technology companies. As Vice-Minister of the Ministry of Na-

77 Cumhurbaşkanlığı Dijital Dönüşüm Ofisi, "Ulusal Yapay Zeka Stratejisi 2021–2025," p. 41.

tional Defence (Official use) Muhsin Dere contends, Teknofest will serve as one of the critical sources for the future workforce of Turkish defense industries.[78]

- **Yenilikçi Yazılımlar Yarışıyor Y3 (Innovative Software Competing)**
  Y3, a part of SSB's Defense Industries AI Platform, has a similar goal to Teknofest, though its audience and participants are more limited. Its competitions are open to companies, organizations, and researchers focusing on AI applications to encourage sustainable cooperation between them. Competitions show similarities with SSB's continuing projects and future goals. For example, the UYDU 2019 and 2020 competitions focused on automatic object recognition (such as buildings, ships, helipads, aircraft, bridges, tunnels, and runways) from electro-optic satellite images. GAG 2020 was also an automatic object recognition (person, large vehicles, and automobiles) competition based on large field observation images. The 2022 competitions focus on swarm strategy development with reinforcement learning (SÜRÜ 2022), synthetic data production with generative adversarial networks (GAN 2022), and route fusion for moving target tracking (GEZİNGECİK 2022).[79]

7.2 Military Training

Against this broader national background, defense AI is also slowly becoming part of the TSK's training activities. The HAMLE and FIVE-ML projects are the best examples of how AI is integrated into military training. Furthermore, we expect that number of AI-based training systems in the military's inventory will increase. In line with the goal to accelerate the OODA loop, the increasing integration of data and advanced data-sharing among different platforms would necessitate a new approach to the military decision-making hierarchy. Military decision-makers will have to evaluate the situation from multiple perspectives to succeed in future battlefields.[80] To prevent data from overwhelming the decision-makers, we expect militaries to use AI-based systems and take some of the cognitive load from the decision-makers.

The increasing use of AI-based systems will require new training approaches especially to prepare military personnel for human-machine interactions, as these constitute a very challenging part of developing and integrating autonomous systems into the overall military systems. For example, it is expected that in naval warfare, air, surface, and undersea platforms (both autonomous and crewed

78 Defense Here, "Milli Savunma Bakanı Yardımcısı Muhsin Dere ile röportaj (2.bölüm)."
79 Savunma Sanayii Başkanlığı, "Yenilikçi Yazılımlar Yarışıyor."
80 Mevlütoğlu, "Sorunlar... Ve Çözüm?'"

platforms) would interact with each other. While realizing this interaction with only machines are relatively straightforward, integrating the human elements proves to be more difficult[81] because the existing command and control systems are not suitable for managing the integration of machines. The core problem for all states is the lack of concepts and doctrines for human-machine interactions. Turkey is currently experimenting with different concepts on its own and in cooperation with NATO allies. However, as far as the author knows, there isn't any open resource on how these expectations of future warfare, integration of autonomous systems, and defense AI reflect on Turkey's approach to defense AI-specific training in the military. We expect that the training will evolve as new concepts and doctrines emerge with the further integration of autonomous systems into the military.

81 İnsansız Deniz Sistemlerinin Geleceği ve Türkiye Potansiyeli, p. 23:30–26:28.

8 Conclusion

AI, as Michael C. Horowitz contends, is a general-purpose technology, an enabler, that can operate in several dimensions, such as to direct physical objects to assist in processing and interpreting information and to create new forms of command and control.[82] Turkey's approach to defense AI reflects upon the enabling nature of AI. In Turkey, developing defense AI is closely linked to advances in autonomous weapon systems – Turkey's current defense priority.

Recent successes of Turkish UAVs in contemporary conflicts encourage Turkey to invest in this niche market. Turkey's usage of UAVs increased the combat effectiveness of the Turkish military as well as the users of Turkish UAVs. Especially following the Second Nagorno-Karabakh War, international interest in Turkish UAVs has been on the rise. Thus, the successes in the operational area result in increased exports, which is critical for sustaining the Turkish defense industrial base. Encouraged by operational successes and increased sales, Turkey is now significantly investing in autonomous systems, as reflected in the growing number of projects. In the long-run, however, Turkey's ambition to boost its arms exports could be subject to change as defense AI is increasingly integrated into Turkey's autonomous weapon systems.

Turkish arms trade decision-making remains opaque. Officially, Turkey is encouraging its defense companies to export through sales and take part in international projects within NATO. Yet, it is not clear how individual export decisions are made. In other words, except for compliance with international agreements, we do not know the clear principles for arms exports. Based on the sale of armed UAVs Turkey is willing to sell to any state, except to states that are in direct conflict of interest with Turkey, such as Egypt and Russia. But it is not clear if current arms export logic would also underpin future exports of AI-enhanced autonomous systems or other defense AI products.

While Turkey likely seeks to sustain or even expand current levels of supplying foreign customers with export versions of state-of-the are weapon systems, NATO countries could emerge as the most likely customers of AI-enhanced systems. Turkish defense industry already follows NATO standards and is aware of the significance of interoperability, which is reflected in the development of new weapon systems and technologies. All the services seek interoperability with each other, between the different assets, and with NATO members.

Regarding concept development on defense AI, it is difficult to say which service is leading as detailed information about service-specific approaches is missing. We know that SSB is preparing a defense AI strategy, which would reflect approaches

82 Horowitz, "Artificial Intelligence, International Competition, and the Balance of Power," pp. 39–41.

of different services. But this document has not been made public. In terms of defense AI projects, TUYGUN and HASAT seem to be service and system agnostic, while both the Navy and Army have their specific projects. Based on existing uncrewed systems projects, each service pursues AI-based systems and seeks to integrate these systems. Each service is experimenting with new technologies in cooperation with the defense industry. As these systems enter service, we would have a clearer picture of concept development.

Proper human-machine interaction remains one of the key challenges in developing and fielding of AI-enhanced systems. Industry representatives and government reports underline the pressing need to tackle this challenge. Industry, in particular, highlights how difficult it is to integrate autonomous systems into existing structures that rely on existing paradigms of human-human interaction. Moving forward, human-machine interaction would be one of the core issues that needed to be solved through a combination of organizational change and developing new technologies.

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