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The Future of Turkey's Airpower: The Fifth Generation Challenge

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ABSTRACT *Rapid advances in technology enable incremental developments in the aerospace and defense sector, the most well-known example of which is the evolution of air power. Since the end of the Second World War, the aerospace industry has been constantly developing and providing more capabilities to air forces around the world. These developments can be grouped under 'generations' and today, the latest iteration is the fifth generation. Fifth generation combat aircraft or, in more general terms, fifth generation air power is the product of various technological elements and innovations. To fully exploit these developments, air forces need to have interdisciplinary vision and the capability to absorb, deploy and develop skills ranging from requirement definition to program management. This study aims to provide an understanding on the features of the next generation of air warfare, while presenting the status of the Turkish Air Force and offering suggestions on several challenges and opportunities.*

Keywords: Air Power, Fifth Generation, Combat Aircraft, Turkish Air Force, MMU

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Introduction

Turkey is currently working on the design and development of an indigenous combat aircraft under a project called *Milli Muharip Uçak* (MMU, National Combat Aircraft). The MMU is stated to be a fifth generation combat aircraft because it has certain features and characteristics that are incorporated in only a handful current or upcoming aircraft. The term 'generation' in air warfare implies incremental qualitative developments resulting from advances in aerospace technology. With the introduction of each new capability or performance improvement, combat aircraft generations proceed, and this progress has both direct and indirect effects on warfare in general. Many different methodologies are used to classify and describe combat aircraft generations, but according to the most widely accepted approach, the latest iteration in active service is the fifth generation. Design, development and deployment of a fifth generation fighter require multi-layered, interdisciplinary program management. In other words, a combat aircraft has become more than just a military platform; it is also a techno-political asset.

Understanding the challenges and opportunities of fifth generation aircraft and modern air warfare requires insight into the evolution of air power. Turkey's current position and prospects will be presented upon this foundation. The present article describes the main characteristics and dynamics of the evolution of air warfare and its effects on combat aircraft design. After providing an overview of these features in the first section, the second section will present the current structure and future projects of the Turkish Air Force. The final section will submit suggestions and insight on the opportunities, dynamics and challenges of the transformation of Turkey's next generation air warfare.

Transformation of Air Power

The end of the Cold War meant that the risk of all-out, global armed conflict became history. The following decades, especially the period after the 9/11 attacks, marked a new era of asymmetric warfare, operations other than war (OOTW) and counter terrorism operations. These modalities require new technologies and systems for the modern warfighter.[1] Combat aircraft design is no exception. The importance of network-enabled capability, high speed and robust information sharing through advanced data link systems and precision guided strike capabilities are at the top of the requirement lists. Tomorrow's fighter aircraft will not just be platforms to counter adversaries' equivalent platforms. Instead, they will be integrated elements of a network-centric warfighting organism.[2] In the 20th century, especially after World War II, combat aircraft were designed for specific requirements, often resulting in dedicated platforms. The performance requirements of fighters were often determined in regard to those of enemy aircraft. This was especially the case for aircraft tasked primarily with air superiority and interception missions. These aircraft's capability and performance of secondary missions such as air-to-ground or reconnaissance were limited, if not entirely neglected.

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This trend began to change in the last quarter of the past century, due to a combination of developments in technology and the need to achieve the most cost-effective combat capability. Single mission dedicated platforms have become more difficult to sustain. Budget cuts and the cost of technology, combined with the cost required to develop, manufacture and maintain the platforms have resulted in a smaller number of aircraft being procured. Training and infrastructure also have become challenging factors for planners and decision makers.[3] Advancements in technology have provided new capabilities for fighter aircraft like multi-spectrum sensors, information fusion, advanced data sharing and various forms of kinetic effect with high levels of precision. These factors have become the de facto standards of fighters of a new generation.

Air warfare saw a dramatic change toward the end of WWII with the introduction of the jet engine. During the Korean War, which started shortly afterwards, jet fighters were used extensively by both sides. The capabilities and performance of combat aircraft have increased very rapidly since then, thanks to advances in aerospace and defense technologies.[4]

As mentioned above, all of the incremental developments and capability improvements in combat aircraft design can be studied under certain groups, referred to as generations. There is not a widely accepted consensus regarding the criteria used to distinguish between generations, but according to the most common methodology, there have been five generations of combat aircraft since World War II. The most distinctive characteristics of these generations are summarized below.[5]

First generation: Jet engine aircraft of the first generation were developed between the mid-1940s to 1950s. In terms of flight characteristics, armament and manufacturing technology, these aircraft were basically the same as contemporary fighter aircraft with their piston engines replaced with the first examples of turbojet engines, which were prone to frequent failures during flight. The first test of this first generation was air war during the Korean War, which was

Fifth generation aircraft should be able to operate in an overly complex, fluid threat environment, usually in or around civilian air and sea traffic, and over or near urban areas

fought in a subsonic speed regime and in low to medium altitudes. The F-86 (United States), Mystère (France) and MiG-15 (Soviet Union) were among the members of the first generation.

Second generation: Developed between the mid-1950s to the early 1960s, second generation fighter aircraft introduced the first examples of guided air-to-air missiles, using infrared and semi-active radar seekers. Advances in aerodynamics, materials and engines resulted in sustained supersonic flight and much higher operational altitudes. The combat aircraft of this generation also incorporated more complex avionics and navigation equipment; another major improvement was the introduction of fire control radars, enabling fighter aircraft to find and engage targets without aid from ground radar or an early warning system. The F-104 and F-5 (United States), Mirage III (France) and MiG-21 (Soviet Union) are the most well-known examples of this generation.

Third generation: The combat aircraft of this generation were developed between the early 1960s and 1970s. There were significant developments in terms of maneuverability, communication and navigation equipment and radar. More advanced radar incorporating Doppler technology provided 'look-down, shoot-down' capability over longer ranges. Air-to-air missiles with more capable seekers enabled beyond visual range engagements while electro-optical seekers and targeting systems drastically increased air-to-ground strike capability, through the introduction of the first examples of precision guided bombs and missiles. These developments resulted in the elimination of the necessity to visually acquire targets, both in the air and on the ground. The F-4 (United States), Mirage F1 (France) and MiG-23 (Soviet Union) are among the members of the third generation.

Fourth generation: These aircraft were designed between early 1970s until the late 1980s and incorporated giant leaps in electronics and software fields. Aircraft cockpits were equipped with modern displays, while flight control systems were supported by electro-mechanic actuators and computers. Fourth generation aircraft were able to switch between missions, being able to be equipped with different types of air-to-air and air-to-ground weapon and mission systems. The F-15 and F-16 (United States), Mirage 2000 (France) and MiG-29 (Soviet Union) are well-known fourth generation fighters.

Bayraktar AKINCI's first prototype, named PT-1, within the scope of the ongoing tests of TİHA (Attack Unmanned Aerial Vehicle), successfully completed the High Altitude System Identification Test conducted at Bayraktar AKINCI Flight and Training Center located at Çorlu Military Airport, August 22, 2020.

Baykar / AA

Advances in technology, especially in the fields of electronics and software, enabled further advanced avionics and subsystems for combat aircraft. Combat aircraft that were introduced in the late 1980s and early 1990s had all the features of the fourth generation while incorporating new capabilities and increased performance, thus being ahead of the fourth generation but not necessarily members of an entirely new one. Sometimes referred to as 4.5 generation or 4+ generation, these combat aircraft were controlled predominantly by computers. In addition to their multi-mode radars, they were equipped with electro-optical search and tracking systems. The first examples of Active Electronically Scanned Array (AESA) radar systems are seen on these fighters. Features of this sub-group are also applied to fourth generation fighters through extensive avionics and structural upgrades. The Gripen (Sweden), Typhoon (multinational) and Rafale (France) can be regarded as 4.5 generation.

Fifth generation: Starting in the late 1990s, the fifth generation introduced a number of ground-breaking technologies such as low observability, sensor fusion, advanced data link and communication systems, thrust vectoring control (TVC) and advanced flight control systems. The F-22 Raptor is considered the first, truly fifth generation combat aircraft, followed by the F-35 Lightning II. China and the Russian Federation have been working on fifth generation fighters, respectively the J-20, which is recently entering service, and Su-57, which is currently at the initial stages of serial production.

Since the late 1980s, unmanned aerial vehicles or drones have undertaken a wide range of tasks, from traditional imagery intelligence and target acquisition missions to precision strikes against time-critical or high value targets

One of the most important characteristics of fifth generation fighters is increased situational awareness through a fusion of the aircraft's own sensor data and information gathered from other friendly air, sea and land assets. Fifth generation aircraft are capable of creating, updating, processing and sharing a tactical picture. This capability enables the fighter to engage enemy targets from long ranges without being detected.[6] Such complicated features require computers taking command of almost all of the functions of the aircraft, through the seamless functioning of a human-machine interface. In other words, in fifth generation combat aircraft the pilot is assisted and sometimes directed by complex software and hardware, driven by millions of lines of code running in real time.

Major Themes in Next Generation Combat Aircraft Design

Based on the main features and characteristics summarized above, further analysis of the characteristics of fifth generation combat aircraft will provide insight on the challenges and requirements of modern air warfare.

First and foremost, fifth generation aircraft should be able to operate in an overly complex, fluid threat environment, usually in or around civilian air and sea traffic, and over or near urban areas. Improvements in radar and electro-optical sensors, missiles, and command and control systems mean that enemy air defense early warning and weapon systems have become more capable of detecting and intercepting aircraft over longer ranges. In other words, fifth generation aircraft are under increasing threat of more complicated integrated air defense systems.

One of the most prominent features of fifth generation combat aircraft is low observability (LO). Often used as a synonym for 'stealth' to describe the ability to evade detection by radar, LO in fact describes multi-spectral design features covering measures against radar, electro-optical systems and other types of detection and situational awareness systems. Such a wide spectrum capability requires coherent design and manufacture techniques, technologies and, overall, a conceptual approach. Design in geometry, materials used and tooling techniques should be supported by sensor fusion, emission control (EMCON) and ability to gather data regarding electromagnetic transmission around the aircraft.

Since the early 1980s, there have been significant developments in the fields of electronics and computing, enabling an increase in the performance of airborne sensors, communication and navigation equipment. One of the major achievements is the introduction of active electronically scanned array (AESA) radar, which has the ability to scan large sectors over long distances without mechanically steering the radar antenna and by digitally manipulating radar signals. AESA technology enables combat aircraft radar to do multiple tasks simultaneously, turning the equipment into a multi-role target acquisition and intelligence collection system.[7]

Another important piece of equipment that characterizes the fifth generation fighter is the infrared search and track (IRST) system, which scans, detects and tracks targets without emitting electromagnetic signals, thereby decreasing the aircraft's risk of being detected by enemy sensors. Integrating the target data collected by both radar and IRST further increases the situational awareness of the pilot by providing a more accurate tactical picture.

A crucial element underlying all the sub-systems and equipment of the fighter aircraft is the inclusion of advanced, robust, high-speed communication and data-link systems that provide real time intelligence and target information sharing. These systems provide the capability to plan, coordinate and execute long-range precision strikes, the engagement of enemy airborne targets over long ranges and intelligence collection and dissemination in real time. They also compensate individual aircraft performance disadvantages or deficiencies. All in all, real time robust communication and data-link systems form the backbone of an information organism in which the combat aircraft act as the tip of the spear, building up and directing kinetic effects.[8]

One major theme in modern air warfare is the constantly increasing role of unmanned systems. Since the late 1980s, unmanned aerial vehicles (UAV) or drones have undertaken a wide range of tasks, from traditional imagery intelligence (IMINT) and target acquisition missions to precision strikes against time-critical or high value targets. With advances in materials, power plant and sensor technologies, UAVs of tactical, operative and strategic classes are being equipped with multiple sensors; they carry lightweight guided weapons and stay airborne for longer durations. Developments in artificial intelligence (AI), artificial neural networks and adaptive autonomous decision-making algorithms paved the way for autonomous armed UAVs to perform high-risk combat missions in coordination with other manned and unmanned platforms. Another byproduct of this trend is the 'loyal wingman' concept in which UAVs equipped with guided weapons and/or sophisticated electronic warfare systems fly in close formation and coordination with combat aircraft and execute strikes in contested airspace. Fifth generation combat aircraft thus need to be able to fully integrate into a network with UAVs.[9]

TurAF actively participates in many multinational operations and exercises in the region surrounding Turkey, contributing to building and sustaining security

An increasingly defining factor in modern air combat is electronic and cyber warfare, often employed in coordination with each other and in an integrated manner. Electronic warfare describes techniques, tactics and assets that prevent the enemy from using the electromagnetic spectrum while exploiting it for intelligence collection, analysis and information sharing purposes. Cyber war has the same aim as electronic warfare, but targets the computers and information networks of the enemy.[10] The increasing dependence of air, sea, land and space assets on information and communication technologies poses a threat to the resiliency of joint operations. The ability of combat aircraft to detect, analyze, classify, track and share information on the cyber-attacks against friendly assets is a critical requirement for air power planners. To meet this requirement, in addition to radar and electro-optical sensors, combat aircraft need to be equipped with specific systems such as radar warning receivers, radar frequency jammers, missile warning systems etc. Due to advances in electronics, antennae and power systems, it has become possible to combine multiple types of systems into one multi-purpose electronic and cyber warfare system. Monitored, driven, and managed by real time software, such multi-purpose systems can undertake various tasks simultaneously.[11]

Despite modern battlespace being dominated by techniques and tactics in the electromagnetic spectrum and cyberspace, weapons with kinetic effect, i.e. missiles, rockets and bombs are still the main weapons of combat aircraft. Sensor and guidance systems have dramatically advanced in performance and accuracy, enabling ever-increasing precision strikes over longer ranges. Asymmetric warfare, which consists of operations against terrorist and non-state armed groups especially in or around urban areas, necessitates the use of extremely accurate weapon systems that help ensure minimum, if not zero collateral damage to civilian individuals and assets.[12] In the air-to-air domain, increased maneuverability, low-observability and sensor fusion of enemy aircraft require long-range, energy-efficient air-to-air missiles. Within visual range, air warfare, also known as dogfighting, may not be entirely over but it will be increasingly difficult for combat aircraft to come within close range because of long-range sensors and missiles.[13]

The above-mentioned capabilities, requirements and trends are just part of what is expected of a fifth generation combat aircraft. Design, manufacture and logistic support processes have become increasingly complicated, expensive and demanding to plan and manage. Therefore, modern combat aircraft development and manufacture programs have become more prone to budget and schedule overruns. Their economic, technological and military features and qualities directly contribute to their political value. In other words, the geopolitical importance of fighters has been on the rise.[14]

The Turkish Air Force Today

Founded in 1911, the Turkish Air Force (TurAF) is one of the oldest air forces in the world. The service is responsible for deterring the violation of Turkish airspace and preventing any attack on the country from the air. After entering NATO, TurAF underwent a large-scale reorganization and modernization process. The first jet engine aircraft entered into service just before Turkey's formal introduction to the alliance when T-33 Shooting Star training jets were transferred from the United States. The T-33 model was followed by large quantities of F-84 Thunderjets, F-86 Sabres, F-100 Super Sabres, F-5 Freedom Fighters, and F-104 Starfighters. In terms of the number of aircraft and frontline squadrons, TurAF had quickly become one of the NATO's largest air powers, defending the alliance's southern flank. Starting from the late 1970s with the introduction of high-performance jets and guided weapons, TurAF's modernization gained new momentum.

TurAF actively participates in many multinational operations and exercises in the region surrounding Turkey, contributing to building and sustaining security. The service has been actively involved in counter-terrorism operations inside Turkey and in Northern Iraq and Syria, while protecting Turkey's national interests in the Eastern Mediterranean by displaying determination and deterrent power. TurAF is one of the very few air forces in the world incorporating advanced technology and platforms such as airborne early warning and control (AEW&C) aircraft, precision-guided weapon systems, armed unmanned aerial vehicles (UAVs), and advanced datalink capability.

Today, the backbone of TurAF consists of around 245 F-16C/D Fighting Falcon and 48 F-4E 2020 aircraft. These combat aircraft are supported by seven KC-135R tankers and four E-7T *Barış Kartalı* airborne early warning and control aircraft.[15]

Aircraft and Equipment

F-4E 2020

A total of 236 F-4E and RF-4E Phantom II aircraft had entered service with the TurAF between 1974 and 1991.[16] With the Phantom II, TurAF was introduced to precision ground attack capability through AGM-65A/B Maverick television guided missiles, GBU-10/12 Paveway I/II laser and GBU-8 Hom-

With the Presidential Defense Industry project, this domestic probe rocket became the first Turkish vehicle to cross the space border, August 31,2020.

Presidency of Defense Industry / AA

ing Bomb System (HOBOS) guided bombs, as well as Pave Spike laser target designation and AN/ALQ-119 electronic warfare pods. For enhancement of air-to-air capability, large numbers of AIM-9 Sidewinder and AIM-7 Sparrow missiles were also procured.[17]

After the failed attempt to purchase 40 Panavia Tornados from the United Kingdom in 1986, Turkey began looking for alternative solutions for enhanced deep strike and interdiction capability. According to a contract signed with Israel Aircraft Industries (IAI) of Israel in 1997, a total of 54 F-4E Phantom IIs were to be modernized in two batches under a program called 'F-4E 2020 Terminator.' The first batch of 26 aircraft was to be sent to IAI facilities and the second batch of 28 was to be upgraded at the 1st Air Supply and Maintenance Centre (ALMC) at Eskisehir. The contract also covered the installation of a System Integration Laboratory (SIL) and avionics test and integration facilities at 1st ASMC.

The Terminator program saw the structural upgrade of the aircraft to prolong their service life until at least 2020 (hence the official designation, F-4E 2020) and advance their avionics. The aircraft also received the capability to use Elta EL/L-8233 Integrated Self-Defense System (ISDS) ECM pod and fire Popeye I guided missiles, 46 of which were procured in 2002 under a $90 million deal. Deliveries were completed between 2000 and 2003.[18]

F-16

In the late 1970s, Turkey started a procurement project to modernize its rapidly ageing fleet of combat aircraft, which had already suffered from a shortage of spares due to the U.S. arms embargo after the Cyprus Peace Operation. The

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evaluation process resulted in the selection of the General Dynamics F-16C/D Fighting Falcon. The Letter of Acceptance (LoA) for 160 F-16C/D aircraft was signed on December 9, 1983. Designated as Peace Onyx I, the program covered the local assembly of 152 aircraft, after the manufacture of the first eight at the General Dynamics assembly line in Fort Worth, Texas.[19] The first aircraft was delivered to the TurAF on July 17, 1987. Following the delivery of the remaining seven General Dynamics manufactured aircraft, the first TUSAS Aerospace Industries (TAI) assembled aircraft entered service on November 27, 1987. The last F-16 of Peace Onyx I was delivered in 1995.[20]

A follow-on program, Peace Onyx II began in 1992. Saudi Arabia, Kuwait and the United Arab Emirates (UAE) provided financial support for the program as a goodwill gesture in return for Turkey's support to the Coalition during Operation Desert Storm in 1991. The LoA for 80 F-16C/D Block 50 aircraft was signed between Turkey and United States on March 26, 1992. The assembly and deliveries of the Peace Onyx II aircraft were completed by the Turkish Aerospace Industries TAI between 1996 and 1999.[21]

In order to increase the capabilities of the F-16 fleet with modern weapon and avionics systems, Turkey started a modernization program. Designated as Peace Onyx III, the extensive upgrade project was based on the Common Configuration Implementation Program (CCIP) of the United States Air Force (USAF) F-16 fleet. The Peace Onyx III program began in July 2007. Under the project, all of the Block 40 and Block 50 model fighters of the TurAF F-16 fleet (165 aircraft) and 35 Block 30 aircraft also received a limited upgrade. The TAI delivered the first aircraft to TurAF on November 2, 2011; the project was completed in April 2015. [22]

To compensate for attrition losses and to fill the gap until the induction of next generation aircraft, Turkey decided to order additional F-16s. In May 2007, an agreement with the United States was reached and 30 F-16C/D Block 50+ aircraft were ordered under the Peace Onyx IV program. One of the most distinctive features of these aircraft is their capability to carry additional fuel tanks on the airframe. These conformal fuel tanks (CFT) increase the range and thus the combat radius of the aircraft. The Peace Onyx IV aircraft were delivered between 2011 and 2012.

Turkey has also undertaken various upgrade and modification projects for the F-16 fleet. The most important of these is the *Özgür* Project, which started on December 15, 2010. The project aims at the development of a national mission computer and national avionics for the F-16 fighters. With the nationalization of mission computers, the project aims to ensure the integration of national air-to-air and air-to-ground munitions. The experience will be used in the *Hürjet* and MMU projects. ASELSAN is responsible for the hardware of the mission computer to be used in modernization, and Turkish Aerospace will develop the mission computer software. An F-16C Block 30 was used as the prototype aircraft for the project. The cockpit of the aircraft was updated, and a new full-color multifunction display (MFD), middle cockpit display and engine display were added.[23]

KC-135R

Turkey's post-Cold War military modernization process was underlined by the requirement for long-range force projection capability. Turkey has been an active participant in both NATO and United Nations operations; regional conflicts also dictated such a need. As one of the alliance's largest countries, Turkey, starting from the early 1990s, began plans to achieve long-range aerial force projection. The requirement for such a capability was solidly identified during Operation Deny Flight, which began in April 1993 to enforce an NFZ by NATO over Bosnia and Herzegovina. TurAF participated in the operation with F-16 Fighting Falcons. However, the combat air patrol (CAP) times achieved by the fighters over Bosnia were low, since most of the fuel was spent during transit from bases in mainland Turkey to the mission area. The requirement further justified when TurAF participated in the subsequent Operation Deliberate Force aerial bombing campaign from Dalaman and Bandırma bases.

Another factor that pushed the need for aerial tanker was the fight against separatist terrorism spearheaded by the PKK in the southeastern region of the country. Turkey's struggle against the PKK involved high numbers of sorties for close air support, precision strikes and tactical reconnaissance missions by F-16, F-4E and RF-4E aircraft. The main bases responsible for these missions in the region were the 7th and 8th Main Jet Bases. However, aircraft from other bases in the country were deployed on a rotational basis to keep mission availability rates high. Aerial refueling would thus provide a force multiplier in long-range deployments. The capability was also necessary to support Turkey's power projection capability by increasing the combat radius of its military aircraft.

Negotiations with the United States to acquire tanker aircraft were focused on the KC-135 type. An initial arrangement was made on the procurement of ten KC-135As under the Southern Region Amendment (SRA), which allows the acquisition of surplus military equipment free of charge to upgrade NATO armament in the Mediterranean area, although the recipient must pay for all overhaul, modification and delivery costs. Under an agreement reached on April 18, 1995, a total of seven KC-135As were to be delivered after being converted to KC-135R standard. The KC-135As were to be selected from storage at the Aircraft Maintenance and Regeneration Center (AMARC) at Davis Monthan AFB in Arizona. The deal also covered the lease of two United States Air Force (USAF) KC-135R Stratotankers for training and early operations in the interim.

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The two leased aircraft were delivered on July 22, 1995 and entered service with the newly formed 'Tanker Filo' in Incirlik base. The seven KC-135Rs entered service with the TurAF between 1997 and 1998.

Airborne Early Warning and Control Aircraft

To fulfill the operational requirements for an aircraft capable of providing airborne early warning coverage over a large area, Turkey selected a Boeing-led team in November 2000 for the E-7 platform. A contract was signed in June 2002 and the project officially started in July 2003. The program, known as *Barış Kartalı* (Peace Eagle), covered the acquisition of four 737 airborne early warning and control (AEW&C) aircraft, designated E-7T, plus ground support segments for mission crew training, mission support and system maintenance support. Verification testing of the system began in 2011 in labs, on the aircraft on the ground and in flight and is proceeding as planned. All four aircraft were delivered in 2014. [24]

Unmanned Aerial Vehicles

Turkey first acquired unmanned aerial vehicles (UAV) in the mid-1990s to support counter terrorism operations. A small number of GNAT 750 and I-GNAT UAVs were purchased from the U.S. company General Atomics and were used for imagery intelligence (IMINT), target acquisition and UAV operational familiarization missions. Upon seeing the benefits of such platforms in intelligence, surveillance and reconnaissance missions, Turkey decided to invest more in this field.[25]

To meet TurAF's reconnaissance and IMINT requirements, Turkey started a tender for the off-the-shelf procurement of operative class UAVs in the early

The Stand-Off Missile, developed by TÜBİTAK SAGE is one of the most important products of the Turkish defense industry in the air-launched weapon category

2000s. After an evaluation process between the two candidates, General Atomics and Israel's joint venture Elbit-IAI, the latter was selected and a contract for the procurement of ten Heron 1 UAVs was signed in December 2004. The drones were equipped with uprated engines to provide performance at 30,000 ft altitude as well as ASELFLIR-300 electro-optical cameras by ASELSAN. After a protracted and controversial integration and test phase, the Heron fleet finally entered service in 2010.[26]

As part of the indigenous Medium Altitude Long Endurance (MALE) Development Project, which started to meet the Turkish Armed Forces' intelligence, surveillance and reconnaissance requirements, a development contract was signed between TAI and the Presidency of Defense Industries (*Savunma Sanayii Başkanlığı,* SSB). This project was designed to ensure the development of an operative class UAV family and its delivery to the Turkish Armed Forces service.

The maiden flight of the prototype of Anka UAV, designated Anka Block A, took place on December 30, 2010. With a length of 8 meters and a wingspan of 17.3 m, Anka Block A is equipped with a 155 bg engine and one electro-optic camera as payload. The Block B version with synthetic aperture radar (SAR) made its maiden flight on January 30, 2015.[27] TurAF, SSM and TUSAS signed a contract on October 25, 2013 for ten Anka S drones. The first Anka S made its maiden flight on September 25, 2016, and the first two Anka S drones were delivered to TurAF in February 2018.

The most important feature of Anka S is its Satellite Communications System (SATCOM), through which it can exchange data with the distant ground control station. This allows for controlling the aircraft and obtaining its intelligence in real time even beyond line of sight (BLOS). This capability also offers a certain degree of protection against electronic jamming that might be attempted on the communication between the base station and the UAV. The maximum takeoff weight of Anka S, which can stay in the air up to 24 hours at 30,000 feet, is 1,660 kg and the payload capacity is close to 200 kg.[28]

Another major UAV system, the Bayraktar TB2 was developed by Baykar Makina under a project to procure tactical UAVs for Turkish Land Forces. The first TB2 made its maiden flight on April 29, 2011. Delivery of the first batch was completed between 2014 and 2015. In December 2015, carriage and release tests with MAM-L guided bombs began and in April 2016, the first test firing was done with a live warhead. TB2 was swiftly put into use in internal operations; after its contributions became apparent, new orders were placed for the Navy, Police Force and Gendarmerie.

The Anka S and TB2 platforms both played crucial roles in operations in Syria, especially during the Operation Spring Shield in March 2020, where scores of Syrian regime armored vehicles and Pantsir air defense systems were destroyed by Anka S and TB2 launched guided munitions.[29]

Weapon Systems

With the help of Turkey's rapidly developing national defense industry, it became possible to focus on more advanced indigenous precision weapon systems starting in the early 2000s. Within the framework of a strategic vision to develop and manufacture all types of guided weapon systems locally, Turkey began a process to go step by step in this field, starting with air-launched guided bombs, which are very useful in supporting counter terrorism operations in rough terrain.

The first product of this trend is the *Hassas Güdüm Kiti* (HGK, Precision Guidance Kit). Developed by TÜBİTAK SAGE, the HGK is a kit installed on conventional gravity bombs to increase their accuracy. The Inertial Navigation System (INS) and Global Positioning System (GPS) on board the kit are used to generate course correction commands for the moving wings of the bomb to accurately hit the target. The HGK can be installed on Mk84 type bombs weighing 2,000 lbs as well as penetrating type NEB (*Nüfuz Edici Bomba*) bombs. The HGK also has versions suitable for 1,000 lbs Mk83 and 500 lbs. Mk82 bombs.[30] A laser guided version, LHGK was also developed to further increase the accuracy. Teber, another guidance kit, was developed by ROKETSAN. It has INS/GPS guidance systems and laser seekers and can be installed on Mk81 and Mk82 general purpose bombs. Depending on the altitude from which the bomb is released, Teber has a maximum range of 28 km and has been used by TurAF since 2018.[31]

Another guidance kit system, the *Kanat Güdüm Kiti* (KGK, Wing Assisted Guidance Kit) was developed by TÜBİTAK SAGE. Based on the HGK design, KGK gives 1,000 lb Mk83 and 500 lb Mk82 gravity bombs a gliding ability through an INS/GPS guidance system. With this add-on, the free fall distance and, therefore, the hit range of the bombs greatly increases, allowing accurate hitting from long distances. After being released from the aircraft, the wings unfold, and the bomb can achieve accurate hitting of the target from a 100 km range.[32]

Turkey officially became a partner of the F-35 project in the Concept Demonstration phase with the signature of a Letter of Acceptance worth $6.2 million in 1999

The Stand-Off Missile (SOM), developed by TÜBİTAK SAGE is one of the most important products of the Turkish defense industry in the air-launched weapon category. The SOM is an air-launched cruise missile designed as a high-precision attack system against steady land and mobile sea targets, that can be deployed without entering the effective range of hostile air defense systems.

SOM is an inclusive designation for a missile family of varying capabilities whose members have been used by the Turkish Armed Forces since 2011. The 620 kg SOM A and SOM B1 are used against fixed targets; they have integrated guidance-control system that include INS/GPS and a terrain-referenced navigation system. The SOM B2 is a version of SOM B1 with a tandem warhead effective against hardened shelters and bunkers.[33] The SOM C1 and C2, which are currently undergoing the development process, will be used against moving and sea surface targets with the help of the data link system *Kement* developed by Meteksan.[34] Serially produced by ROKETSAN, the SOM family has another member, SOM J, being developed to be carried in the internal weapon compartment of F-35 jet fighters and F-16s.[35]

In the air-to-air missile field, TurAF's inventory consists of U.S.-made AIM-9 Sidewinder within visual range (WVR) and AIM-120 AMRAAM beyond visual range (BVR) missiles. TÜBİTAK SAGE has been working on the Göktuğ family of air-to-air missiles. The Bozdoğan variant is a WVR missile with an imaging infrared (IIR) seeker, whereas the Gökdoğan with its active radar seeker and two-way datalink is a BVR missile.[36] Both versions are scheduled to enter service in 2021.[37]

Major Modernization Projects

MMU

Turkey initiated an indigenous combat aircraft development program, designated *Milli Muharip Uçak* (MMU, National Combat Aircraft) in December 2010. A conceptual design contract was signed between SSM and TUSAŞ in August 2011. This phase was followed by a development contract in August 2016.[38]

The MMU program covers the development of a fifth generation combat aircraft to meet TurAF requirements beyond the 2030s and replace the F-16

HURKUS C, (Basic and Primary Trainer Aircraft) designed and upgraded by Turkish Aerospace Industries shoots off flares during a test flight over Ankara on December 27, 2018.

Presidency of Defense Industry / AA

Fighting Falcons. Within the scope of the MMU program, Turkey aims to become one of the few countries possessing the technology, infrastructure, human resources and manufacturing capabilities for advanced combat aircraft, thereby significantly developing its aerospace industry. [39]

MMU is slated to incorporate most of the characteristics of a standard fifth generation aircraft, such as low observability, internal weapon bays, sensor fusion, and advanced datalink and communications systems. The aircraft is expected to be rolled out in 2023 and perform its maiden flight in late 2025.[40] MMU is planned to serve until the 2070s.[41]

The current contract covers the initial four years of the program, which will be concluded with the completion of the preliminary design phase. After the initial the design and development of MMU is completed, the program will focus on engineering capabilities, technology development activities, the establishment of test and evaluation infrastructure and the performance of certification processes.[42]

F-35

To modernize its air force with fifth generation fighter aircraft and replace the ageing F-4E 2020 fleet, Turkey opted for the F-35 Lightning II. As part of a wider strategy to improve the capabilities and revenues of its local aerospace industry, Turkey not only chose to be a consumer of the aircraft, but also to participate in its development and production.

Being developed by Baykar Makina, *Akıncı* (Raider) is a twin turboprop engine UAV in the high-altitude long endurance class. *Akıncı* has been envisaged as a strategic platform that is able to perform multiple tasks with various payloads

Turkey officially became a partner of the F-35 project in the Concept Demonstration phase with the signature of a Letter of Acceptance (LoA) worth $6.2 million in 1999. This was followed by Memorandum of Understanding (MoU) agreements signed to make Turkey a Level III partner of the System Development and Demonstration phase on July 11, 2002 and the Production, Support and Follow on Development (PSFD) phase on January 25, 2007.[43] A Letter of Intent (LoI) covering business opportunities for the Turkish aerospace industry was signed between the SSM and Lockheed Martin on February 6, 2007. The total workshare for the local contractors is estimated as high as $12 billion. A total of ten Turkish aerospace and defense companies have been partners of the project, taking responsibility for the development and manufacturing of several parts and components of the airframe, subsystems and avionics.[44]

A total of 100 F-35As were planned to be acquired for TurAF. Additionally, the Turkish Navy planned to induct the short take-off and vertical landing (STOVL) version of the aircraft, designated F-35B, to be deployed on board the TCG Anadolu amphibious assault ship. On June 22, 2018, Turkey received its first F-35A at the Lockheed Martin facilities in Fort Worth, Texas.

Turkey's involvement in the F-35 project became a subject of controversy after Ankara's procurement of the S-400 air defense system from the Russian Federation. The United States' reaction was to halt all delivery processes of the aircraft, divert those on the serial production and assembly line to United States Air Force orders, stop all training activities for Turkish personnel in the United States and begin preparations to remove Turkish companies from the supply chain, thereby completely removing Turkey from the project.[45]

Aksungur

Developed by TUSAŞ as a twin engine derivative of the Anka, the *Aksungur* is a medium-altitude long endurance (MALE) class UAV, capable of performing intelligence, surveillance, reconnaissance and strike missions with electro-optical and electronic warfare payloads. The *Aksungur* is powered by two PD-170 turbodiesel engines, which are developed and manufactured by TEI.[46]

The first prototype made its maiden flight on March 20, 2019. The aircraft performed live fire tests with indigenous guided weapon systems, including

Teber precision-guided bombs. *Aksungur* will be able to be equipped with sonobuoys, a capability that will enable the drone to perform anti-submarine warfare missions.[47]

Akıncı

Being developed by Baykar Makina, *Akıncı* (Raider) is a twin turboprop engine UAV in the high-altitude long endurance (HALE) class. Akıncı has been envisaged as a strategic platform that is able to perform multiple tasks with various payloads. The company states that the Akıncı design incorporates dual artificial intelligence avionics to support signal processing, sensor fusion and situational awareness in real time.[48]

Akıncı is designed to undertake electronic intelligence, communications intelligence, electronic warfare and strike missions. Among the mission systems it will carry are dual satellite communication systems (SATCOM), an electro-optical camera, collision avoidance radar and synthetic aperture radar.[49]

The aircraft will be able to operate at altitudes up to 40,000 ft and have an endurance of more than 24 hours. Its triple redundant flight control system will be supported by a fully autonomous take-off, flight and landing system that incorporates a GPS-independent navigation and positioning system. The *Akıncı* has an 881 lb (400 kg) internal and 2,094 lb (950 kg) external payload capacity, combining the overall combat load to a maximum of 2,976 lb (1,350 kg). Powered by two 450 hp (340 kW) or 750 hp (560 kW) turboprop engines, its large 66 ft (20 m) wingspan ensures 5.5 tons maximum takeoff weight.[50]

The first prototype of the *Akıncı* made its first flight on December 9, 2019. It is scheduled to enter service in 2021.[51]

MİUS

Baykar Makina is reportedly working on an unmanned combat aircraft project, designated MİUS (*Muharip İnsansız Uçak Sistemi,* Unmanned Combat Aircraft System). According to Selçuk Bayraktar, the chief technology officer at Baykar Makina, the MİUS design has a maximum take-off weight of 4.5 tons with a service ceiling of 40,000 ft and an endurance of around 4 to 5 hours. The jet-powered MİUS is being designed to carry 1,000 kg of weapons and achieve a maximum speed of around 0.8 mach.[52] First flight is expected to take place before 2023.[53]

The Future of Turkish Air Power: Challenges and Opportunities

In order to cope with complex security challenges in an already complex geopolitical environment, the Turkish Armed Forces has been undergoing an extensive reorganization and reformation process.[54] TurAF is no exception; to increase effectiveness, flexibility and deterrent power and to meet the requirements of modern battlespace it has to incorporate innovative technologies, doctrine and equipment. There are several internal and external challenges and opportunities that effect this transformation; the major ones are summarized below.

Operational Experience

Turkey is one of the very few NATO countries that is actively involved in a number of concurrent operations and overseas deployments. For the past 40 years, the Turkish Armed Forces have been involved in counter terrorism operations, and the TurAF has actively participated in them through close air support (CAS), precision strikes, intelligence and reconnaissance missions. TurAF has been monitoring the situation to prevent airspace violations and security threats along the Turkish-Syria border since the outbreak of the civil war. Cross-border operations in Syria since 2016 have seen extensive use of air-to-ground strikes as well as intelligence and reconnaissance flights. For the past decades, TurAF has also worked to defend Turkish national interests in the Aegean Sea against Greek claims. Moreover, Turkey is one of the most active members of NATO, participating in many joint operations. Within this contribution effort, TurAF took part in several NATO operations such as peace keeping operations in Bosnia and Herzegovina and Kosovo.[55]

Such an active operational tempo at both national and multinational levels has contributed to building up invaluable experience with regard to joint operations planning, precision strike coordination and execution, requirements and expectations from weapon and mission systems as well as survivability, air warfare command and control.

Development of Indigenous Air Warfare Doctrine and CONOPS

Doctrine can be defined as a set of fundamental principles by which the military forces plan, organize and execute their actions. Therefore, air doctrine or doctrine related to air power focuses on tenets of exploiting the air domain of the battlespace. Air as a battlefield, and the platforms, equipment and weapons used in air warfare have been rapidly developing in terms of capabilities and performance, and these changes have impacts on the doctrinal level. Fifth generation combat aircraft have introduced a number of breakthrough technologies that dictate a fundamental shift in paradigm for the preparation of air warfare doctrine. Such extensive transformation can only be managed through national, indigenous ways of thinking, since the tools, method and assets that drive air warfare doctrine are shaped by national requirements and conditions such as geography, the geopolitical environment, internal and external threats, and economic, technological and industrial resources.

The Turkish defense industry, with the help of its young and dynamic human resources has built up a significant experience base through many major, complex projects such as the MilGem corvette, the T129 attack helicopter, the *Anka* UAV and the *Hürkuş* trainer

Accordingly, the concept of operations (CONOPS) for an indigenous fifth generation combat aircraft can only be prepared through novel thinking, a multi-disciplinary approach and an indigenous assessment of the requirements. A comprehensive CONOPS should clearly define the design purpose, mission, performance and system requirements, constraints, strategies and policies that incorporate the aircraft and a clear roadmap for the integration of the aircraft into the air force and the armed forces to conduct joint operations. Preparation of a CONOPS for a complex 'system of systems' such as a fifth generation aircraft is not possible through importing the best qualities of existing or proposed fighters or embedding the CONOPS of successful designs.[56]

Regional Competition

Turkey is located at the intersection of three continents, one of the world's most active geopolitical fault lines. Especially for the last 20 years, the region around Turkey has seen many conflicts, civil wars, revolts, political crises and popular movements. Since 2011, civil wars in Syria and Libya have had drastic effects on regional and global politics and security. Turkey has two nuclear powers in close vicinity, namely the Russian Federation and Israel. A third, Iran, has been actively pursuing an ambitious nuclear program in recent years. Furthermore, countries like Greece and Egypt have assertive agendas in the Eastern Mediterranean, and the Black Sea basin has been one of the fronts between NATO and Russia. The latter has been involved in two wars in the region, one of which was undeclared, and both resulted in an annexation of land by Russia.[57]

In such a complicated security environment, it is no surprise that countries in the region have significantly increased their defense spending and investment in air power. Table 1 summarizes the recent combat aircraft procurement and upgrade programs of Turkey's neighboring countries.

Table 1: Current Combat Aircraft Projects of Turkey's Neighbors

Country	Project	Quantity	Remarks
Azerbaijan	M-346LFFA		Reportedly ordered a light attack version of the M-346 advanced training jet from Italian Leonard in early 2020.
Armenia	Su-30SM	4	Delivered December 2019. Plans for additional four reported.
Bulgaria	F-16V	8	Equipped with AESA radar and advanced datalink. Contract award to Lockheed Martin given in April 2020.
Egypt	Rafale	24	Ordered in 2015, delivered between 2016-2019. Negotiations for an additional 12 reported.
	Su-35	24+	Order for at least two dozen reported.
	MiG-29M/M2	50	Ordered 2014. Deliveries underway.
	Eurofighter Typhoon	24+	Negotiations with Italy for at least 24 aircraft reported in early 2020
Greece	F-16V	85	85 F-16C/D of the Greek Air Force will be upgraded to F-16V level, to be equipped with AESA radar and advanced data-link systems. Work started late 2019.
	F-35	20-25	Intention for procurement of at least 20 F-35 has been stated by both Greek and U.S. officials. Formal procedure expected to be started in 2021.
Iraq	F-16IQ	36	Derivative of Block 52 with some features and capabilities removed. Delivered between 2014 and 2019.
Iran	Azaraksh, Kowsar	N/A	Locally manufactured or modified derivatives of F-5 fighters entered service during the Shah era. Exact numbers and capabilities unknown.
	JF-17	N/A	Open source information on possible acquisition from China after the lifting of the UN arms embargo in October 2020.
Israel	F-35I	20 (+30)	F-35A model with Israeli-made electronic warfare and guided weapon systems. Deliveries started in 2016.
	F-15IA	N/A	Reportedly planning to order next generation version of F-15I with AESA radar to supplement the F-35 fleet.
Romania	F-16AM/BM	12	Purchased second-hand from Portugal.
	F-35	N/A	Reported as planning purchase in the long term. Meanwhile, a 20-year investment plan to upgrade the Mihail Kogalniceanu air base to support F-35s was approved in September 2019.
Russia	Su-57	76	Order announced June 2019. Low rate initial serial production started.
	Su-35	88 (+50)	Advanced derivative of legacy Su-27 with new engines, avionics, and weapon systems. Entered service in 2014. Production and deliveries underway
	MiG-31BM upgrade	N/A	Started in 2010. Upgrade to turn MiG-31 interceptor aircraft to multi-role fighters through new guided weapons and advanced data-link systems.
	Su-30 upgrade	90	Upgrade of Su-30 multirole fighters to Su-30SM standard through new engines, avionics and communication systems. First batch to be delivered in 2021.
	Okhotnik	N/A	Jet engine unmanned combat aircraft. Development underway. First flight August 2019. Planned to perform operations alongside Su-57.
Syria	MiG-29	N/A	Russia delivered an unknown number of MiG-29 fighters in May 2020 to reinforce Syria's existing MiG-29 fleet. Possibly a MiG-29SMT version with advanced avionics.
Ukraine	MiG-29 upgrade	11	Upgrade contract with Israeli firm Elbit Systems signed in August 2019.
	New fighter	100+	Plans to acquire new generation fighter complying with NATO standards announced in May 2020.

Source: *Compiled from author's own work*

This table clearly shows that there is significant competition among regional countries in the air domain. Even those with financial constraints allocate resources to procure modern aircraft. There are two main reasons for this procurement policy: First, modern combat aircraft contribute to the deterrent power of the country and second, through the acquisition of such complex, expensive platforms, the customer country establishes or reinforces diplomatic-military relations with the manufacturer country, a factor that is especially useful when the customer country requires the military and political support of the source, which is often a great power such as Russia or the United States.

Defining requirements for developing, producing, procuring, and sustaining a fifth generation combat aircraft poses a challenge for those countries that have regional ambitions and face multiple threats

It is noteworthy that Israel is currently the only country in the region possessing fifth generation combat aircraft.

Quality versus Quantity

Modern combat aircraft are equipped with many state-of-the-art systems, and face challenging requirements with regard to mission execution and performance, necessitating sophisticated manufacturing processes and technologies, high technology systems, components and project management methodologies. In other words, the design, development, production and sustainment of modern combat aircraft have become more and more expensive and time consuming. A typical combat aircraft since the time of the fourth generation takes one or two decades from conceptual design to achieving full operational capability (FOC). These factors, together with shrinking defense budgets after the end of the Cold War, mean that fewer resources are available for aircraft development and procurement programs.

On the other hand, developments in electronics, software and power plant and sensor technologies have enabled combat aircraft to undertake more missions with even more effectiveness than their predecessors. One single aircraft with a couple of precision guided weapons can execute a pinpoint strike to a high-value target, which would have required a mission package of several strike and support aircraft in the past.

Based on these factors, fifth generation air combat poses a challenge for air power planners and decision makers: Achieving a delicate equilibrium in which multiple balances must be negotiated between requirements versus available resources, costs versus schedules, and ultimately, quality versus quantity.

Multi-Layered, Fluid Threat Environment

Today's wars are not necessarily or solely fought between states on confined battlefields. There have been many new definitions or derivatives of war. To name a few, 'hybrid war,' 'proxy war' and 'asymmetric war' have become ordinary concepts in the military-political realm. States not only execute military operations by themselves, but also through increased use of private military contractors (PMC), non-state armed groups or even, in many cases, terrorist organizations. As a result, many global hotspots and crisis areas are stages for these actors.

Turkey is located in the middle of many of the crisis centers and hotspots of the world, some of which are the Crimea, the Eastern Mediterranean, Syria, the Persian Gulf and the Caucasus. The nature, belligerents, rationales for and effects of these conflicts vary. In order to secure national sovereignty, national interests and security, all of the branches of the Turkish Armed Forces need to be trained, prepared and equipped to meet multi-layered threats that occur, impact and evolve extremely rapidly, mainly because of information and communication technologies and socio-political factors. The air force is no exception. All in all, air power in modern warfare is not merely responsible for shooting down enemy aircraft or striking enemy ground targets. It has far more complicated responsibilities that require multi-disciplinary thinking capabilities and dynamic adoption abilities.

Multiple Areas of Responsibility

As mentioned above, Turkey is neighbor to a number of crisis and conflict areas. As a direct result, Turkey's Armed Forces, intelligence and security agencies are responsible for monitoring, gathering information and conducting operations over a large geographic area. Today, Turkey is directly involved in operations, military training, transformation processes and overseas deployments in Libya, Syria, Somalia, Qatar, Azerbaijan, Afghanistan, etc. In these areas, the Turkish Armed Forces have been conducting various types of military activities and operations other than war (OOTW). Supporting these activities requires TurAF to be able to project and sustain power; collect, analyze, and disseminate real-time intelligence; execute kinetic operations; and achieve and sustain air superiority and air dominance. All areas of responsibility (AOR) have their own characteristics and environmental, geographic and demographic conditions, which dictate the necessity of flexible strategic, operative and tactical thinking.

Local Industry

The Turkish Defense Industry has made significant achievements since the early 2000s. Turkey has been pursuing an ambitious armament program and local industry is the powerhouse of this vision. For the past several years, many projects of this phase have concluded their development stages and entered service, proving their worth in internal security operations and cross-border operations in Syria.

The Turkish Defense Industry, with the help of its young and dynamic human resources has built up a significant experience base through many major, complex projects such as the MilGem corvette, the T129 attack helicopter, the *Anka* UAV and the *Hürkuş* trainer. Based on the experience and infrastructure of the projects of the past two decades, the Turkish defense industry has initiated works on more challenging programs, the most important of which is the MMU.

Despite the achievements, dynamism and flexibility of its defense industry, however, Turkey faces significant complications in the period to come. First and foremost, the sustainment of human resources, especially a skilled and experienced workforce, is a major challenge. Those individuals who had worked in the ambitious, complex projects of the past two decades are today's team leaders, leading and mentoring junior level engineers, technicians and other staff that will undertake new programs. Without the presence of medium-level leaders and managers, it will be extremely difficult, if not impossible, to sustain and complete such formidable projects.

Training, Testing, and Evaluation Infrastructure

TurAF has been consistently investing significant resources in evaluation and training infrastructure. The most important of these efforts is the establishment of the Anatolian Eagle test and exercise range in Konya. The range is also home to Turkey's electronic warfare test and training center, EHTES (*Elektronik Harp Test ve Eğitim Sahası*), which is used for the training, development and testing of electronic warfare techniques and tactics against various air defense systems.

Additionally, TurAF has recently established a squadron for flight tests, namely the 401st Squadron. Based in Eskişehir, the 401st works in close coordination with other units of the Armed Forces and local defense industry companies to test and evaluate new indigenous weapon and mission systems. The experience accumulated by the 401st will be especially useful during the development and testing of the MMU.

Conclusion

War is an ever-changing, dynamic phenomenon. Throughout centuries, armies have prepared for the next war using the experience and lessons from the previous ones. Due to constant developments in technology, each new war, whether in the form of a major inter-state battle or a low intensity conflict, has caused many surprises and shocks to those who considered themselves as having mastered the new way of warfighting. Since its inception in the early 20th century, air warfare has been a subject in which technological advances have made an impact more rapidly and profoundly than any other area. To keep pace with the competition, and thus achieve superiority against the enemy, a country has to develop multidisciplinary foresight on science and technology involving air power.

Defining requirements for developing, producing, procuring and sustaining a fifth generation combat aircraft poses a challenge for those countries that have regional ambitions and face multiple threats. It is no easy task to devise a robust doctrine for air power that involves sea, land and space assets while predicting the course, quality and nature of emerging or potential threats in an ever-unpredictable world. Financial issues, technology or infrastructure aside, this alone is the major challenge for a country, like Turkey, that aims to develop next generation air power through indigenous fifth generation combat aircraft.

In conclusion, for the transformation of its air power, Turkey is facing a number of challenges across the military, technology and industry domains. First, other regional powers have been continuously investing in upgrading and reinforcing their own air forces with advanced technologies, and Turkey is politically and militarily active in many theaters in the surrounding region. Second, advances in technology require dynamic adoption and flexibility of both the air force and the industry to cope with the competition. Third, the capacity of the local industry to provide adequate solutions for the air force is a challenge in terms of human resources, infrastructure and experience. Turkey needs to devise, develop and execute an inter-disciplinary military-industrial strategy to meet these challenges indigenously.

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