Iran's Ballistic-Missile and Space Program: An Assessment

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Since the early 1970s, Iran has sought to develop strong missile capabilities. In recent years, Tehran's arsenal has evolved to become the largest and most diverse in the Middle East, though not the most lethal or longest-range. Israel and Saudi Arabia have also developed formidable capabilities. Iran's program, however, has attracted more political and academic controversies. The Trump administration's decision to withdraw from the 2015 nuclear deal — the Joint Comprehensive Plan of Action (JCPOA) — was partly driven by the fact that it had failed to slow the progress of Iran's missile capabilities. The U.S. withdrawal and occasional European criticism of frequent missile testing have had little, if any, impact on Tehran's determination to advance its capabilities.

This unwavering determination is due to the fact that missiles play a prominent role in Iran's defense and deterrence strategy. Three forces explain the significance of ballistic missiles. First, during Iran's war with Iraq (1980-88) Saddam Hussein's missiles targeted Iranian forces and cities. Initially, Iran was poorly prepared to retaliate, and the international community did very little to stop these attacks. In a few months, however, Tehran was able to receive missiles from foreign countries, and the war with Baghdad became the ferocious "war of the cities," with the two sides launching missiles at each other's population and industrial centers. This bitter experience has left its mark on Iranian strategists. They are determined to address their vulnerability and deter attacks.

Second, for four decades Iran has been under different kinds of bilateral and multilateral sanction regimes. Unlike its regional adversaries, Tehran does not have the financial resources or strategic options to buy the most advanced weaponry, particularly military jets. While the United States, Britain, France and other European powers have been providing Israel, Saudi Arabia and the United Arab Emirates (UAE) with state-of-the-art weapons, the Iranian air force has been under strict sanctions. Iranian leaders perceive their country as surrounded on all sides by American troops. Within this context, missiles are

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seen as a cost-effective way to match the air power of the United States and regional adversaries. As one analyst argues, Iranian leaders appear to see ballistic missiles as an "equalizer."[1]

Third, in addition to the perceived military contribution missiles make to Iran's defense and deterrence strategy, it is important not to underestimate the program's symbolic value. Surrounded by global and regional adversaries, Iranian leaders take pride in the tremendous progress their country has made in advancing its missile capabilities, particularly its indigenous industry. Being almost self-sufficient in producing a variety of missile systems is seen domestically as a symbol of the country's scientific and technological advances.[2]

Given these forces — historical experience, perceived military value and national pride — Iran's most senior leaders have shown little inclination to compromise over the missile program. Supreme Leader Ayatollah Khamenei urged his generals to "keep working on the missile program as far as you can."[3] Similarly, the commander of the Islamic Revolutionary Guard Corps (IRGC), Major General Mohammad Ali Jafari, asserted that missile power is "non-negotiable, and we will defend it."[4] Equally important, Iranian leaders have always maintained that their missile capabilities are defensive and conventional, a tool for deterring attack by threatening to punish the adversary's population and civilian infrastructure.[5]

This study examines Tehran's missile program and its historical roots, developments and capabilities, along with Iran's related space program. This will be followed by an examination of regional and global responses. The analysis suggests that, despite severe economic and political pressure, Iran is highly unlikely to accept restraints on these programs. Missiles are perceived as an essential component in the country's defense strategy and indeed to the survival of the Islamic Republic. As the current regional and global efforts to halt Iran's progress have had little impact, there is a need for a new approach.

BACKGROUND

Two developments shaped the strategic environment under which Iran's missile program was initiated. The first was the 1973 Arab-Israeli war, which was followed by what became known as the first oil shock. Arab countries cut production and imposed an oil embargo on the United States and a few other countries to punish them for their support to Israel. Iran, a major oil producer and leading member of the Organization of Petroleum Exporting Countries (OPEC), did not participate in this embargo. Rather, the Pahlavi regime sought to take advantage of this geo-economic opportunity and pumped up production. This combination of more exports and higher prices left Iran with substantial revenues.

The second development, which contributed to the birth of the missile program, was the shah's ambition to make Iran the dominant power in the Middle East and South Asia. In October 1955, Tehran joined the Baghdad Pact, of which Britain, Turkey, Iraq and Pakistan were already members, and with which the United States was closely associated. In the 1970s, Iran, along with Saudi Arabia, was the leading U.S. regional ally in what was called a twin-pillar strategy; Washington relied on Tehran, and to a lesser extent Riyadh, to protect its strategic interests in the Middle East and South Asia. The shah exploited a historical opportunity to

consolidate and further expand his regional power in the late 1960s and early 1970s, when Britain announced its intention to withdraw east of Suez. This left a power vacuum that could be filled by imperial Iran, endorsed by Western powers and fueled by oil wealth.

The Pahlavi regime sharply increased its huge military spending. Iran's air force was, by far, the strongest in the region, and the shah invested in a range of weapon systems. In 1974, the Defense Industries Organization was created as part of the Ministry of War, tasked with overseeing the production of military equipment.[6] In the mid-1970s, it began developing and testing the Arash system, a short-range unguided rocket based on the Russian Bm-11.[7] The plan to build and expand a missile capability was further consolidated through cooperation with Israel.

The significant weakening of Iran's air force, in combination with Saddam Hussein's intense use of missiles against Iranian military targets and civilian population, were the major drivers of the nation's missile program.

Before the fall of the Pahlavi regime in 1979, Israel was involved in a multibillion dollar project to modify advanced surface-to-surface missiles for sale to Iran. This initiative, code-named "Project Flower," was one of six oil-for-arms contracts signed in Tehran in April 1977, less than two years before the shah was toppled. At that time, the two nations did not have diplomatic relations, but they had trade missions. Project Flower was strategically important to both sides, part of a grand scheme to turn Iran into a formidable military power. For Israel, cooperation with Iran offered a guaranteed oil supply, financing for advanced military research and close relations with an important Muslim country. In 1978, Iran made a down payment for the missiles with $260 million worth of oil from Kharg Island. Shortly after this transaction, Iranian experts began work on a missile-assembly plant near Sirjan, in central Iran. The missiles had a payload of 750 kilograms (1,650 pounds) and a range of up to 300 miles. Shortly after the shah was overthrown, Project Flower (along with other projects) was suspended. The missiles were never delivered.[8]

The 1979 Islamic Revolution was a major turning point not only in Iran's domestic and foreign policies, but in its military strategy too. The newly born Islamic Republic was banned from buying Western arms, ammunition and spare parts; training programs were suspended and foreign advisers and technicians withdrawn.[9] These developments dealt a heavy blow to Iran's armed forces. At the time, the country was heavily dependent on foreign arms suppliers, particularly the United States and, to a lesser extent, Europe. The indigenous military industry was still in its infancy and needed some time to train and build up its manpower and technical infrastructure.

The war with Iraq (1980-88) put more pressure on the Iranian military. The new leaders had not had the opportunity to develop their own capabilities or replace Western arms suppliers. Indeed, one can argue, four decades after the revolution, the air force has yet to fully recover to the level it enjoyed in the late 1970s. The significant weakening of Iran's air force,

in combination with Saddam Hussein's intense use of missiles against Iranian military targets and civilian population, were the major drivers of the nation's missile program.

The rapid degradation of Iran's air capabilities left its troops and civilians vulnerable to Iraqi air and missile attacks in the early years of the war. This prompted Iranian leaders to start rebuilding the missile program. Iran managed to import from Libya a small number of Scud-Bs (a series of tactical ballistic missiles developed by the Soviet Union in the 1960s). Iran named these missiles Shahab-1 (meteor), with which Tehran was able to retaliate against Iraqi targets and restore the balance of power. In 1985, the two sides intensified their missile attacks on each other's cities and eventually reached an agreement to suspend them. The Shahab-1s were too inaccurate to have a significant military impact, though they enabled Iran to strike deep into Iraqi territory, inciting fear among the population and boosting the morale of Iranian troops. Tehran sought to import more missiles from Libya, but the Soviet Union prevented Tripoli from fulfilling the transaction.

This Soviet objection left Iran with few options. In the late 1980s, Iran turned to North Korea. Pyongyang sold Tehran different weapon systems, including Scud-B missiles, and agreed to build a production facility in Iran. These new supplies included Scud-Cs, renamed Shahab-2, and NoDong, renamed Shahab-3.[10] The Shahab series provided the foundation for Iran's arsenal. Since the early 1990s, the improvement in Iran's missile program has been driven by two strategies: close cooperation with foreign powers (North Korea, Russia and China) and heavy investment in an indigenous missile capability. The 1990-91 war to liberate Kuwait and the 2003 war to topple Saddam Hussein further reinforced Iranian strategists' perception of the significance of ballistic missiles. In the two wars, coalition forces were forced to divert some aircraft from attacking Iraqi forces to finding and destroying Scud missiles, which Saddam Hussein was using against targets in Israel and Saudi Arabia.

In the last few decades, Iran has imported/manufactured and tested a variety of short- and medium-range and liquid- and solid-propellant ballistic missiles:

- Shahab-1, liquid-fueled, with a 300 km range and a 1,000 kg payload
- Shahab-2, liquid-fueled, with a 500 km range and a 700 kg payload
- Shahab-3, liquid-fueled, with a 1,000 km range and a 1,000 kg payload
- Fateh-110, single-stage and solid-fueled, with a 300 km range
- Kowsar, a stealth anti-ship missile, reportedly with three variants: shore-, air- and ship-launched
- Ashoura, multi-stage and solid-fueled, with a range of 2,000 km
- Ghadr-1, surface-to-surface, with a range of 1,600 km and a payload of 700-750 kg
- Sijjil, two-stage, solid-fuel, surface-to-surface, with a range of nearly 2,000 km.
- Nasr-1, anti-ship, able to carry a 130 kg warhead to a range of 38 km
- Qiam-1, liquid-fueled, with a 700 km range and a 500 kg payload
- Emad, liquid-fueled, with a 1,600 km range and 1,000 kg payload
- Zelzal-2, solid-fueled, with a 200 km range and a 600 kg payload
- Hormuz-1, solid fueled and anti-radar, with a 200 km range and a 450 kg payload

- Khalij Fars, supersonic and anti-ship, able to carry a 650 kg warhead to a range of 300 km
- Zafar, short-range, anti-ship and radar-guided missile
- Raad, air defense system to carry missiles, with a range of 50 km; capable of striking a target at 22,000 meters
- Baran, sub-munition warhead able to evade missile-defense systems and attack multiple targets simultaneously
- Bavar 373, Iranian-built version of the Russian S-300 air defense system
- Soumar, ground-launched cruise missile with a reported range of 2,500 to 3,000 km
- Fateh-313, solid-fueled with a reported range of up to 500 km
- Khorramshohr, surface-to-surface, with 2,000 km range and 1,200 kg payload.[11]

This list is compiled from open sources, so it is likely that some of the figures are exaggerated; information on some missile systems might not be available in open sources. Furthermore, Tehran keeps working on enhancing its missile capabilities and testing new systems. Thus, this list does not provide a full account and is not exclusive; it should be seen as a work in progress. There is no reliable assessment as to how much Iran spends to develop, test and field its ballistic-missile program. The advances the Islamic Republic has made suggest that it possesses one of the largest and most diverse missile forces in the Middle East/South Asia region. It comprises a mix of short-range/medium-range, liquid-fueled/solid-fueled, anti-ship and air-defense missiles that can reach almost all countries in the Middle East, including Saudi Arabia and Israel, and even U.S. military bases and troops in the Persian Gulf, Iraq, Syria and Afghanistan.

In addition to developing an offensive capability, Iran has invested in missile-defense systems. In the late 2000s, Tehran sought to import an S-300 surface-to-air missile system from Russia. However, given the UN sanctions, Moscow imposed a ban on exporting the advanced system to Tehran (the ban was lifted in 2015 after the nuclear deal was signed; the system was eventually delivered in July 2016). Under these circumstances, Iran started investing in a sophisticated home-grown air-defense system known as Bavar-373 (belief). Iranian sources claim that the system is equipped with a vertical-launching system, uses phased-array fire-control radar and employs three types of missiles to hit targets at varying altitudes.[12] Brigadier General Farzad Esmaili, commander of the Khatam Al-Anbia Air Defense Base, claims that the Bavar-373 system is "stronger than the S-300."[13]

In order to protect its large and growing missile industry, Iran has built a number of underground production and launching facilities. In May 2017, the commander of the IRGC Aerospace Force, Brigadier General Amir Ali Hajizadeh, announced the construction of a third underground factory.[14] These efforts to diversify and consolidate their missile capabilities underscore the great pride Iranian leaders take in their program. The chief of staff of the armed forces, Major General Mohammad Baqeri, claimed that Iran has become "one of the world's biggest powers in the field of missiles."[15]

SPACE PROGRAM

This pride in the progress Iran has made in enhancing its missile capabilities is a driving force in the development of a space program. The Islamic Republic is one of a handful of nations with indig-

enous space-launching capability.[16] Since 2009, it has dedicated a National Day of Space Technology to celebrate its scientific achievements. A landmark step was taken in February 2009, when Tehran successfully used the Safir space-launch vehicle (SLV) to send the Omid satellite into space. This rocket was designed to carry a light payload into low earth orbit. A more powerful one, Simorgh, was designed to send up a heavier payload. Since 2009, Tehran's space activities have slowly progressed to include launching other satellites into orbit, such as Rassad (Observation) and Navid-e Elm-0 Sanat (Harbinger of Science and Industry).[17]

Iran's interest in outer space goes back to the late 1950s, when the UN General Assembly created the Committee on the Peaceful Uses of Outer Space (COPUOS). Iran, along with several other nations, was a founding member. COPUOS seeks to foster international cooperation and promote the exploration and use of space for global peace, security and development.[18] In 2003, the Iranian government established the Iran Space Agency (ISA) under the umbrella of the Ministry of Communication and Information Technology. Its mission is to coordinate all "peaceful space activities."[19]

The United States and other countries have been suspicious of Tehran's space program. They argue that building and developing the capacity to place satellites into earth's orbit provide Iranian engineers with critical experience that can be used to boost their ability to launch long-range missiles, including intercontinental ballistic missiles (ICBM). In other words, peaceful and military applications are inseparable. In July 2017, Iran claimed that it had successfully launched into space its most advanced satellite-carrying rocket, Simorgh, capable of reaching a higher altitude and carrying heavier payload than earlier models.[20] The U.S. National Air and Space Intelligence Center claims that the Simorgh could act as a "test bed for developing the technology needed to produce an ICBM."[21]

A close examination of Iran's declared space program provides ambiguous results. Despite some progress, the country still has a relatively weak space-industrial base. It has demonstrated the ability to launch and operate satellites, but many other technological hurdles still need to be overcome before it can fully incorporate its space program into its armed forces. On the other hand, Iran has an "extensive record of using electronic forms of attack against space systems, including jamming and spoofing."[22] It has demonstrated an ability to intervene with hostile satellite signals. Finally, despite some similarities between the technology necessary to manufacture satellite-carrying rockets and the one required to make ICBMs, there are fundamental differences as well. ICBM technology has been developed since World War II. Since then, there have been several examples of states converting ICBMs into SLVs or developing the two technologies in parallel. However, SLVs have never been transformed into ICBMs. A study published by the Nuclear Threat Initiative in late 2018 concluded that Iran's missile program "remains a proliferation concern, but it is primarily a conventional and regional one."[23]

FOREIGN HELP, INDIGENOUS ABILITY

It is unclear how powerful Iran's missile program is in comparison with those of other regional and global powers. What is clear, however, is that since the early 1980s, Tehran has demonstrated a high degree of both patience and persistence. In

building its missile program, the Islamic Republic has implemented three interconnected strategies: a) cooperation with foreign suppliers, particularly North Korea, China and Russia; b) establishment of a highly sophisticated illicit procurement network; and c) creation and development of indigenous capabilities.

As discussed above, in the early years of its war with Iraq, Iran imported missiles from North Korea, including Scud-Bs and Scud-Cs (both developed by the Soviet Union in the 1960s) and Nodong (developed by North Korea in the 1980s). In the 1990s, North Korea continued to provide missile supplies as well as maintenance infrastructure, spare parts, training and the sharing of flight-test data. Tehran adopted the foreign technology to meet its strategic needs.[24] The main drivers of this decades-long collaboration between Pyongyang and Tehran can be found in their dire economic conditions, being under severe economic sanctions, and their shared perception of the United States as a security threat.[25] Despite close cooperation, "there is little evidence to indicate the two nations are engaged in deep missile-related collaboration, or pursuing a joint-development program."[26]

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Since the early 1980s, China and Iran have developed a broad partnership across a spectrum of political, security and economic interests. Beijing's non-interventionist and anti-hegemonic foreign-policy orientation, economic and technological vitality, and diplomatic leverage in the UN Security Council and other international forums are highly valued by Tehran and other countries. On the other hand, given the decades-long animosity between Iran and the United States and the close ties Washington has with the Arab countries of the Persian Gulf, Tehran can serve to consolidate China's presence in the region and resist U.S. domination. Within this context, it is important to point out that Chinese leaders have always valued their complicated strategic and economic ties with the United States more than those with Iran. Furthermore, Beijing also has to balance its close cooperation with its relations with Tehran's regional rivals like Israel, Saudi Arabia and the UAE, among others.

In the 1980s, as China was modernizing its defense industry and looking for export markets, Iran emerged as a major importer of Chinese arms. China's Silkworm anti-ship missiles played a significant role in the war against Iraq. In the aftermath of the Iran-Iraq War, China has managed to strike a balance between observing sanctions on Iran and maintaining strategic cooperation. Occasionally, Chinese leaders chose to terminate missile-transfer contracts with Iran. Instead of selling whole missiles, China sold the means of production — including engines and other components — trained technicians, and helped set up factories to assemble and produce indigenous variants of imported missile designs.[27] The severe sanctions imposed on Iran prior to the signing of the JCPOA in 2015 significantly slowed down Sino-Iranian missile cooperation. Since the

Trump administration's withdrawal from the nuclear deal in 2018, Beijing is again trying to strike a balance between Washington and Tehran.

A close examination of Beijing's contribution to Tehran's missile program indicates that the missile and know-how transfers have played an important role in enhancing Iran's program, particularly anti-ship missiles and anti-access/area-denial missions (A2/AD,[28] ability to deter or counter adversary forces from deploying to or operating within a defined space). Iran's indigenous missile industry largely reflects close cooperation with China.[29] This partnership between the two nations is likely to endure in the coming few years and demonstrate changes inside each capital as well as how they interact with regional powers and the United States.

Iran's missile cooperation with Russia is similar to that with China. United by their strong opposition to U.S. hegemony, Iran and Russia have forged strong military cooperation since the early 1990s. This cooperation can hardly be described as a "strategic alliance"; however, their long history underscores a great deal of suspicion. As Clement Therme argues, "Since 1979, Iran has often been obliged to rely on Soviet/Russian partners, whom it has good reason to mistrust."[30] Military cooperation between the two was consolidated shortly after the end of the war with Iraq in 1988. Russian companies were reported to have exported missiles, spare parts and warheads to Iran and provided training in the development, design and manufacture of ballistic missiles. In response, the Gore-Chernomyrdin Commission was created to investigate and stop this cooperation. Like China, however, Russia has managed to observe international sanctions against the Islamic Republic, while maintaining broad cooperation in the missile program and other military initiatives. It is hard to accurately assess the impact of Russia on Iran's missile program, but it is almost certain that interacting with Russia, China, North Korea and other countries has substantially enhanced Tehran's missile capabilities and its indigenous industry.

Since the inception of the Islamic Republic in 1979, the country has lived under different types of bilateral and multilateral sanctions. There is no doubt these have complicated and impeded socioeconomic development and defense capabilities, but Tehran learned a new skill. In December 2018, Foreign Minister Mohammad Javad Zarif stated, "If there is an art we have perfected in Iran, and we can teach it to others for a price, it is the art of evading sanctions."[31] Over the last few decades, Tehran has managed to smuggle or buy the necessary components and spare parts for its missile program. Iranian military leaders claim that the country has become self-sufficient and is able to domestically produce all its missiles. Available evidence suggests that Iran has succeeded in building a sophisticated industrial infrastructure; if not already self-sufficient, it is capable of manufacturing most of what it needs.

In February 2019 the *New York Times* reported that, for several years, the United States has sought to sabotage Iran's missile program by slipping faulty parts and materials into Iran's aerospace supply chains. These efforts started under President George W. Bush, were eased when Obama Administration was negotiating the nuclear deal and have been accelerated since President Trump took office.[32] Iranian military leaders claim that they have been aware of these clandestine efforts and have taken the necessary measure to protect their missile program.[33]

Despite this impressive progress in Iran's indigenous missile industry, many analysts refer to a major shortcoming: the accuracy of its missiles is highly questionable. This limits their military utility. Iranian military leaders, however, claim that their missiles enjoy a high level of precision. The IRGC's commander, Major General Mohammad Ali Jafari, claims that nearly all of the IRGC's missiles "can hit the target with pinpoint accuracy."[34] The chief of staff of the armed forces, Major General Mohammad Baqeri, agreed: "Iran is capable of producing and using missiles that can land no more than 10 meters away from their targets."[35]

In late 2017, Ayatollah Ali Khamenei said his country will not develop ballistic missiles with a range exceeding 2,000 km.[36] Since then, Tehran has focused more on enhancing the accuracy of its missiles and less on increasing their range, as most of Iran's adversaries lie within it. With a 2,000 km range, the missiles can reach U.S. military bases in the Gulf Cooperation Council (GCC) states, Iraq and Afghanistan, as well as Israel, but pose little threat beyond the Middle East. Finally, the official interest in improving accuracy underscores Tehran's claim that the missiles are not designed to carry nuclear warheads. Nuclear-armed missiles do not need to be accurate, due to their disproportionate destructive power. For conventional purposes, however, lack of accuracy severely limits the missiles' military utility.[37]

REGIONAL SETTING

The evolution of Iran's missile program and the country's growing capabilities demonstrate the significant role of missiles in the broad defense strategy. However, given the difficulties the program faces, including range limitation and questionable accuracy, it seems that it raises more regional than global concerns. A number of regional powers have been alarmed by Tehran's growing missile capabilities and have adopted strategies to counter them. Thus, Iran's program cannot be examined in isolation from those of other regional powers. The United States, as a major security partner to many Middle Eastern countries, has played a major role in formulating and implementing these strategies. Other European countries and China have also contributed to these missile programs.

Since the late 1940s, the United States has been developing and deploying ballistic-missile defense systems against potential attacks. In the late 1960s and early 1970s, Washington deployed a limited nuclear-tipped missile-defense system to protect a portion of its land-based nuclear ICBM force in order to preserve a strategic deterrent against a Soviet nuclear attack on the homeland. That system was dismantled in 1975 because of concerns over cost and effectiveness. Under the Reagan administration in the early 1980s, renewed efforts were made to develop and deploy missile-defense systems.[38] The Missile Defense Agency is charged with developing, testing and fielding an integrated layered ballistic-missile defense system to protect the United States and its deployed forces, allies and friends against all ranges of enemy ballistic missiles in all phases of flight.[39] The United States has a long history of working with Middle East partners and allies, particularly Israel and Saudi Arabia, to build their missile capabilities.

Israel

As with other countries, it is hard to provide an accurate assessment of Israel's missile capabilities. Still, it is believed

to have one of the most technologically advanced missile arsenals in the world. Two characteristics of the program are salient. First, Israel has developed a layered and multifaceted arsenal of offensive and defensive missile systems to address aerial threats from both state and non-state adversaries, operating from different geographic locations and equipped with different types of weaponry.[40] Second, it has often offset the high cost of developing and maintaining its missile capabilities both by entering into partnerships with other regional and global powers and by exporting and licensing its missile technology.[41]

The roots of Israel's missile program go back to 1948, shortly after the country was born, when Rafael was established as the defense ministry's national research and development laboratory. Initially, the company's main focus was the development of missile technology. Since then its operations have expanded to include a variety of weapon systems for both the Israeli military and foreign customers.[42] In the aftermath of Israel's creation, its leaders were concerned about its survival. One survival strategy was to develop a massive retaliation capability that would deter adversaries. In the late 1950s and early 1960s, Israel was engaged in an arms race, including missiles, with its main Arab foe: Egypt under President Gamal Abdel Nasser. Within this context, Rafael launched Israel's first rocket — the Shavit-2 — and entered into a partnership with the French company Dassault Aviation to produce the Jericho-1 missile.[43] The program, however, was aborted in January 1969 following a weapons embargo against Israel for the 1967 war.[44] This abrupt termination of the program prompted Israel to produce the missiles indigenously.[45] Based on this combination of foreign assistance and domestic industry, the Israeli missile arsenal includes:

Missile	Range
Delilah	250-300km
Harpoon	90-240km
Gabriel	35-400 km
Lora	280km
Popeye Turbo	1,500km
Jericho-3	4,800-6,500km
Jericho-2[46]	1,500-3,500km
Jericho-1	500km[47]

In late February, Rafael unveiled a new advanced bunker buster missile called Rocks. This new air-to-surface long-range missile is equipped with a penetration or blast fragmentation warhead that is capable of destroying targets above the surface of deep underground in heavily surface-to-air defended areas.[48] In addition to these offensive missile systems, Israel has developed and deployed defensive ones. Given the country's small size and relative lack of "strategic depth," Israeli leaders consider ballistic missiles an existential threat. Thus, in collaboration with the United States, Israel has created a multilayered missile-defense apparatus that is one of the most advanced in the world. The U.S. Congress and successive administrations have demonstrated strong support for partnership with Israel on missile-defense projects designed to thwart a diverse range of threats from both non-state actors (Hezbollah and Hamas) and states (Iran and Arab countries). According to the latest Memorandum of Understanding (MOU) on U.S. aid to Israel (FY 2019 to FY 2028), signed by the Obama administration in September 2016, Washington pledged to provide $38 billion in military aid, including $5 billion

in defense appropriations for missile-defense programs.[49] These U.S.-Israeli joint missile-defense programs include:

- The Patriot, first used in Israel during the 1990-91 Gulf War, when Iraq fired Scud missiles at Israel (and Saudi Arabia). The system was developed by Raytheon and Hughes, initially demonstrated poor performance and was upgraded to Patriot Advanced Capability (PAC-2 and PAC-3). These new systems have been proven more reliable and have recently been deployed against Hezbollah, Hamas and Syria.
- The Arrow, jointly developed since 1988 by Israel Aerospace Industries (IAI) and Boeing. It became operational in 2000 to protect against long-range conventional missiles, and in 2008, the two sides started developing Arrow III to protect against missiles with nuclear warheads.
- Iron Dome, a short-range anti-rocket system developed by Rafael and originally produced in Israel. It was declared operational in early 2011 and was deployed against Hamas in 2012. As the United States began financially supporting Israel's development of Iron Dome in FY 2011, its interest in becoming a partner in its co-production has grown. In early 2019, the U.S. military announced plans to buy and test out the Iron Dome system.
- David's Sling/Magic Wand, jointly developed by Rafael and Raytheon, is designed to counter long-range rockets and slower-flying cruise missiles. The system was successfully tested in 2015.[50]

Saudi Arabia

Unlike Iran and Israel, Saudi Arabia has not invested in developing a robust missile program. The country is not known to have its own missile industry and has, instead, relied almost exclusively on foreign powers to build relatively modest offensive and defensive missile capabilities. In the 1980s, under pressure from pro-Israel lobbyists, the U.S. Congress refused to sell missiles to the kingdom. In response, Riyadh turned to Beijing and bought the Dongfeng-3 (DF-3; NATO: CSS-2). These missiles have a 2,500 km range and were customized to carry conventional warheads. The missiles have been deployed close to Riyadh and are maintained by Chinese technicians.[51]

These highly inaccurate missiles seem to have very limited military value. Accordingly, in 2007, Saudi Arabia purchased Dongfeng-21 (DF-21; NATO: CSS-5). This purchase was widely seen as a replacement or update of the DF-3 missiles.[52] They have a shorter range than their predecessors but greater accuracy.[53] Furthermore, the kingdom bought two air-launched cruise missiles, the anti-ship AGM-84L Harpoon, developed and manufactured by McDonnell Douglas, and the land-attack Storm Shadow, made in the United Kingdom.[54]

In addition to these offensive missile systems, Saudi Arabia began pursuing a ballistic-missile defense capability following the first Gulf War (1990-91), in which Saddam Hussein launched missiles against Saudi targets. Since then, Riyadh has largely relied on PAC-2 and PAC-3 to defend against missile attacks. In 2015, Lockheed Martin announced that Saudi Arabia would order the Terminal High Altitude Area Defense (THAAD), regarded as America's crown jewel in missile defense. It is designed to shoot down attacking short- and medium-range missiles during their final or terminal phase. The system is built to provide broad area

coverage against threats to population and industrial centers as well as military forces. After three years of negotiations, Saudi and U.S. officials signed a $15 billion government-to-government agreement in late 2018, paving the way for the massive sale of 44 THAAD launchers, missiles and related equipment.[55]

Four conclusions can be drawn from this missile-proliferation discussion. First, Saudi Arabia is not the only GCC country to pursue THAAD and other systems. The UAE has one of the most powerful missile-defense systems in the region. Like other GCC states, it has deployed PAC-3 and was the first country outside the United States to deploy THAAD.[56] In 2012, Qatar offered to purchase two THAAD fire units and associated equipment, parts, training and logistical support for an estimated $6.5 billion.[57] This very high spending on missile-defense systems demonstrates heightened alarm over Iran's growing capabilities.

Second, the GCC states already have some of the most sophisticated missile- defense systems in the world. As one analyst argues, "In terms of interceptors and the radars to support them, there is quite a lot of capability already in the inventories of the GCC."[58] The challenge, however, is the lack of coordination and collective strategy to share timely data and intelligence information. For several years, U.S. officials have sought, with mixed results, to persuade their GCC counterparts to pool resources by integrating key elements of defense systems at a regional level. A major challenge is the lack of a common threat perception. And, despite broad cultural, economic and political similarities, there is a level of mistrust among the royal families. The rift between Qatar and other GCC states since June 2017 is an illustration of this deep-rooted suspicion.

Third, Israel has usually opposed selling sophisticated arms to Arab countries, including the GCC states, and has exerted pressure on the United States to block such deals. In the last several years, however, Iran has been perceived as the common enemy of both Israel and some GCC states (Saudi Arabia, the UAE and Bahrain). Secret cooperation between the two sides has been reported, as have some public visits by senior officials, including Prime Minister Netanyahu's visit to Oman in October 2018. This cooperation has apparently softened the Israeli objection to arms sales to GCC states. In late 2018, unconfirmed reports claiming that Saudi Arabia had purchased the Iron Dome system from Israel were circulated.[59]

Finally, the missile race between Iran and its Israeli and Arab adversaries underscores the fact that missiles do have offensive and defensive military value. Furthermore, despite significant improvement in missile-defense systems, it seems they are not perfect, at least not yet. The available evidence suggests that the current defense systems still cannot intercept every attacking missile. Perhaps "perfect performance" is unattainable. This suggests that the technological race to improve missile defense should be accompanied by international efforts to further regulate the proliferation and use of missiles.

INTERNATIONAL SYSTEM

Since the early 1980s, Iran has shown unshakable determination to consolidate its ballistic-missile capabilities. Its regional adversaries have demonstrated a similar determination to acquire missile systems (both offensive and defensive). Iranian leaders have insisted that their missile programs are totally separate from their

nuclear program, that their missiles are not designed to carry nuclear warheads but to defend their country and deter potential aggressors. Some regional and global powers do not accept these assurances and have sought to stop or slow Tehran's progress. These international efforts can be divided into two categories: voluntary international initiatives such as the Missile Technology Control Regime, Hague Code of Conduct and Proliferation Security Initiative; and multilateral and bilateral efforts focused on Iran (UN Security Council resolutions and sanctions).

The Missile Technology Control Regime (MTCR) is an informal and voluntary partnership among 35 countries, including many of the world's key missile manufacturers.[60] Established in 1987, the MTCR seeks to restrict the production of missiles, complete rocket systems, unmanned air vehicles and related technology for those systems capable of carrying a 500 kg payload at least 300 km, as well as systems intended for the delivery of weapons of mass destruction.[61] Iran and its regional adversaries are not members of the MTCR.

The Hague Code of Conduct (HCoC) against Ballistic Missile Proliferation was established in November 2002. The number of signatories has increased from 93 to 138 (2018). Its aim is to establish a norm against missiles that could be armed with chemical, biological or nuclear warheads. Participating countries are to annually exchange information on their ballistic- missile or space-launch vehicles as well as provide advance notice of any launches.[62] The HCoC does not call for the destruction of missiles; rather, it is an agreement between states on how they should conduct their trade in missiles. It is meant to supplement the MTCR.[63] Iran and its regional adversaries have not endorsed the HCoC.

The Proliferation Security Initiative (PSI) was launched in May 2003, and by 2018 more than 100 countries had endorsed it. It seeks to involve all states that have a stake in the nonproliferation of WMD and their delivery systems, if they are able and willing to take steps to stop the flow of such items at sea, in the air, or on land.[64] Since its inception, the PSI has embraced a wide array of proliferation-security issues such as customs enforcement, export control, proliferation finance and technology transfer.[65] Unlike several of its neighbors, Iran has not endorsed the PSI.

An accurate assessment of these initiatives is complicated. Some major players in missile proliferation, such as China, North Korea and Iran, have not endorsed some or all such initiatives. Furthermore, there is no legally binding international treaty banning the manufacture of and trade in ballistic missiles. Still, one can argue, these voluntary initiatives and global norms have made it harder and more costly for Iran and other countries to obtain the necessary materials and know-how they need to build and develop their capabilities.

Since the inception of the Islamic Republic in 1979, the country has been under different kinds of sanctions. Some are related to allegations of sponsoring terrorism, others to accusations of violating human rights; most are against the nuclear program. In the late 2000s, when President Mahmoud Ahmadinejad was in office, the international confrontation with Iran intensified and the UN Security Council passed a number of resolutions imposing restrictions on Tehran's missile program. The list includes Resolutions 1696 (2006), 1737 (2006), 1747 (2007), 1803 (2008) and 1929 (2010). The last resolution used the strongest language: "The Security Council

decides that Iran shall not undertake any activity related to ballistic missiles capable of delivering nuclear weapons and that all states shall take all necessary measures to prevent the transfer of technology or technical assistance to Iran."[66]

The JCPOA made significant changes in how the international community addressed the missile program, but during the negotiations that led to the signing of the nuclear deal in July 2015, Tehran successfully resisted any restrictions on its missile capabilities. There are no provisions within the JCPOA prohibiting Iran from pursuing ballistic missiles. On July 20, 2015, six days after the signing of the agreement, the Security Council adopted Resolution 2231, endorsing the nuclear deal. The resolution superseded all previous Iran-related resolutions and used much softer language than Resolution 1929. Instead of "require," Resolution 2231 "calls on" Iran to refrain from developing or testing ballistic missiles designed to deliver nuclear weapons until October 2023 (or until the International Atomic Energy Agency concludes that Iran's nuclear activities are purely peaceful).[67]

Within this context, Iran has continued to pursue a missile capability and test new systems. Iranian leaders claim that missile tests do not breach Security Council resolutions, since they are not designed to carry nuclear warheads.[68] President Rouhani stated that Iran needs "no one's permission to build missiles."[69] Some analysts argue that Iran's missile tests should be seen as a provocation, not a violation.[70] On the other hand, France, Germany, the United Kingdom and the United States have continued to condemn missile tests and Tehran's efforts to boost its capabilities. In May 2018, shortly after President Trump announced his decision to withdraw from the JCPOA, Secretary of State Mike Pompeo articulated the U.S. post-nuclear- deal strategy toward Iran. For severe economic sanctions to be lifted, Pompeo listed 12 conditions. One was a demand that Iran "must end its proliferation of ballistic missiles and halt further launching or development of nuclear-capable missile systems."[71]

The experience of the last few decades underscores the limitations of a global missile-export regime and economic sanctions. Voluntary international agreements and UN Security Council resolutions have failed to stop the growing capabilities of Iranian missiles. Similarly, economic sanctions have not weakened the determination of Iranian leaders to further enhance these capabilities. One can argue that the global initiatives, Security Council resolutions and sanctions have forced Tehran to pay a higher price and slowed the progress of its nuclear program. However, the central role missiles play in Iran's grand defense strategy, and indeed in the mere survival of the Islamic Republic, demonstrate the limitations of these tools. Iranian leaders have shown no signs of compromising over the missile program.

CONCLUSION

With their relatively low operating costs, their potential to penetrate defense systems, and their value as a symbol of scientific and technological progress, ballistic missiles are likely to maintain their key role in Iran's defense and deterrence posture. The analysis of the program and the regional and global efforts to halt it suggest the following conclusions. First, the fact that Iran's interest in missiles started under the Pahlavi regime suggests that the program is not driven by alleged ideological ambition to export the Islamic Revolution or promote Shiism and destabi-

lize Sunni countries. Rather, one can argue, Iran, under any regime, perceives itself as a major regional power, and missiles (along with other weapons systems) play a role in power projection.

Second, the military value of Iranian missiles should neither be overestimated nor underestimated. Since the end of the Iran-Iraq War, Iran has launched a handful of missile attacks targeting non-state actors, most significantly the Mujahideen e-Khalq (MEK) in 2001 and the Islamic State in 2017. It is not clear how effective these missiles would be if they were employed against a major regional power or American forces in the region. On the other hand, the missiles, even with this questionable accuracy, put population centers, critical infrastructure and military bases at risk. Third, the available evidence does not prove the claim that Iran has ICBMs. These capabilities require years of testing. If Tehran decides to develop ICBMs, the international community will have enough time to address this challenge. Rather, it seems clear that the missile program is conventional, meant to deter regional powers and American forces in the Middle East.

Fourth, the rapid advances in missile technology add uncertainty to the regional and global efforts to address Iran's missile program. For example, hypersonic missiles, currently being developed mainly by the United States, Russia and China, are considered by some military analysts as game changers.[72] They fly at extreme altitudes and astonishingly high speed with great maneuverability. These characteristics mean that they can pose tremendous challenges to missile-defense systems. Iran is not known to have this hypersonic capability today; however, if history is any guide, technology does proliferate. Iran will likely have access to hypersonic and other game-changing technologies in the coming years.

Finally, since the inception of the missile program, regional and global powers have essentially focused on curtailing supplies to Iran. Equal efforts are needed to address the demand side. Tehran's determination to acquire and develop missile capabilities and its willingness to pay a high price need to be examined. The huge disparity in defense expenditures between Iran and its neighbors suggests that the broad regional military balance needs to be negotiated. Iran's missile program cannot be separated from the regional arms race and can only be adequately addressed within a broad discussion of the regional security landscape.

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