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THE STRATEGIC IMPACT OF THE S-300 IN IRAN

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Executive Summary

Debate about whether or not Russia would deliver the long-promised S-300 surface-to-air missile (SAM) system to Iran has somewhat obscured the strategic implications of the delivery that is now taking place. The years-long back-and-forth between Moscow and Tehran over the issue highlighted tensions in the relationship, which appear to have been resolved.[1] The deployment of S-300 components to Iran, however, is a strategic game changer in the region, and a challenge to which international attention should now turn.

The US military can defeat the S-300, it is true, but only by devoting significantly more aircraft, including our most advanced stealth aircraft, to a major military effort aimed at eliminating that system before proceeding to any other targets. Arab and Israeli militaries do not now have the capability to reliably defeat the S-300 with conventional means. That is particularly true if Iranian reports that Russia is delivering a more advanced version of the system are accurate.

Regional militaries will need to purchase the most advanced US airframes and weapons and develop new operational approaches if they wish to retain their current abilities to conduct airstrikes into Iran. If they choose not to field those capabilities, Iran will have eliminated an important element of regional deterrence against its activities. If they do, then the S-300 deployment will have helped fuel a regional arms race.

S-300 Overview

Russia has reportedly begun delivering the missiles for the S-300 surface-to-air missile (SAM) system to Iran.[2] Separate nonmissile components of the system, including missile tubes and radars, were previously delivered and shown during Iran's Armed Forces Day Parade on April 17, 2016.[3] If Russia delivers all components necessary for Iran to have a fully functional S-300, this will have a significant impact on the balance of military power in the region.

The S-300 is a family of SAM systems capable of identifying, targeting, and shooting down multiple aircraft and missiles. Depending on the missile variant and associated components, the S-300 can be used against fixed- and rotary-wing aircraft, unmanned aerial systems, short- and possibly medium-range ballistic missiles, cruise missiles, and air-launched standoff weapons.[4] The S-300 can work as part of a larger integrated air defense system (IADS) or function as a standalone, road-mobile unit with limited off-road capability.[5] It is an advanced system that is difficult to jam or spoof. Defeating the S-300 requires a combination of manned aircraft with various capabilities as well as standoff munitions. The US military can accomplish this task, but few other militaries can.

The S-300 was first deployed in 1980 and has undergone numerous modifications and upgrades since then.[6] There are land- and sea-based variants, as well as domestic and export versions. NATO has assigned designations to some of these variants, including the SA-10 Grumble (the original S-

300 system), the SA-20 Gargoyle (the more advanced S-300 PMU-2 system, which the Russians call Favorit), and the SA-21 Growler (originally known as the S-300 PMU-3, now known as the S-400, which the Russians call Triumf).[7] The more advanced systems have significantly more capability than the earlier variants.

The S-300 consists of several major components, all mounted separately on road-mobile (but not all-terrain) vehicles. They include search radar (to find and track incoming aircraft), fire control radar (to target missiles and help guide them to their targets), command module, transporter erector launcher (TEL) unit, and missiles.[8] The Russians continually upgrade the individual components of the system. The upgrades are mutually compatible such that customers can field various "mix and match" combinations of the different components.[9] This ability to integrate older legacy components is critical to Iran, which already has significant quantities of surplus Russian equipment. It will also allow Iran to upgrade the S-300 incrementally if and when Russia provides more advanced elements of the system. Russian forces are currently upgrading their own air defenses to the S-400/S-500 systems.[10] That process will likely free up additional advanced S-300 components, which the Russians could provide to Iran.

Fundamentally Different Than Other Russian Weapons Systems in Iran

Russia and Iran have an extensive military-to-military transactional relationship going back decades. Russia has exported a number of weapons systems to Iran, including T-72 tanks, Su-24 fighter-bombers and Su-25 ground attack aircraft, MiG-29 air superiority fighters, and *Kilo*-class submarines.[11] These weapons systems are extremely capable, but do not give Iran any strategically significant advantage. Iran's Arab neighbors and Israel have more advanced tanks, aircraft, and missiles, and the *Kilo*-class submarines do not pose a serious challenge to the US Navy.

The S-300 is another story entirely. It gives the Iranian military a significant strategic advantage against regional states and significantly complicates US air operations in the airspace protected by the S-300. The S-300 is the most advanced SAM system available for export to potential enemies of the United States, and significantly alters planning assumptions for potential US military operations. The S-300 may prevent the US from attaining air superiority as quickly as it has in the past, protracting air operations and potentially increasing the risk of losing aircraft and pilots.[12] The US military can destroy or neutralize the S-300, but it would need to devote significant assets and time to do so.

US air operations in the Middle East over Syria and Iraq are not currently constrained by any requirement to use stealth aircraft. Because stealth aircraft have higher operational and maintenance costs and generally carry less ordnance than nonstealth aircraft, the US does not typically assign stealth aircraft to routine operations in uncontested airspace, such as the current campaign against ISIS. In the absence of the S-300 system, nonstealth aircraft currently assigned to conduct air strikes against ISIS could, on a very short timeline, be retasked to conduct operations against Iran. The presence of the S-300 in Iran means the US would need to recalibrate its current mix of airframes in the Middle East to include stealth aircraft and accept the corresponding higher costs and lower ordnance loadouts or accept the operational restriction that any potential strike against Iran would be delayed until adequate numbers of stealth aircraft were moved into the region. None of the US allies in the region can reliably destroy or neutralize the S-300 using standard military tactics with existing assets.

Iran to Receive S-300 PMU-2 Variant?

Russia first started delivering nonmissile components of the S-300 system to Iran in April 2016. Reports at the time indicated that those components were part of the PMU-1 variant.[13] However, on July 18, the Tasnim News Agency, which is affiliated with the Islamic Revolutionary Guard Corps, reported that Iran would be receiving the PMU-2 variant.[14] If this report is correct, Iran will obtain a much more capable air defense system than previously assumed.

Determining which S-300 variant Iran receives will be difficult until pictures of a deployed system become available. Most components are derivative of previous models and have demonstrated significant levels of interoperability with previous iterations of the S-300 in Russia service. The specific combination of S-300 elements that Iran receives may be unique to Iran, and its actual capabilities may be greater, or less, than the expected capabilities of the PMU-2 variant. The basic functionality of the key components of both variants are listed and described in Table 1.

Operational Characteristics, S-300 PMU-1 vs S-300 PMU-2

The S-300 system is deployed as one or more battalions each consisting of up to six batteries. Each battery can have up to eight TELs (missile-firing platforms). The number of TELs determines the number of different targets that the system can engage simultaneously or in close succession. Deploying more TELs also complicates efforts to suppress the system because they can disperse over a wide area. It is not clear how many TELs Iran will receive or how it will organize and deploy them.

Table 1. S-300 Components

Mission/Function	S-300 PMU-1	S-300 PMU-2
Battalion Search Radar	64N6E Big Bird	64N6E2 Big Bird
Battery Search Radar	76N6E Clam Shell	96L6E

Battery Fire Control Radar	30N6E Flap Lid	30N6E1 Flap Lid or 30N6E2 Tomb Stone
Command Module	54K6E	54K6E2
Transporter Erector Launcher (TEL)	5P85SM	5P85SE
Missiles	48N6E/9M96E1 and legacy missiles	48N6E2/9M96E2 and legacy missiles

Source: Carlo Kopp, "Almaz S-300P/PT/PS/PMU/PMU1/PMU2 Almaz-Antey S-400 Triumf SA-10/20/21 Grumble/Gargoyle" Air Power Australia, April 2012, http://www.ausairpower.net/APA-Grumble-Gargoyle.html.

Battalion Search Radar. At the battalion level, normally comprising six batteries, the PMU-1 uses the 64N6E Big Bird 3D long-range search and acquisition radar. This is a phased-array, frequency agile radar that is conceptually similar to the US Navy SPY-1 series of Aegis-class radars. While no radar is completely impervious to electronic jamming, the Big Bird incorporates a number of features that make it difficult to jam, including a single panel with two radar arrays facing in opposite directions. This "Janus face" arrangement combines mechanical rotation of the radiating element with electronic beam steering for target search. The radar is capable of detecting ballistic missiles, cruise missiles, and fixed and rotary-wing aircraft, and it may be capable of detecting air-launched standoff weapons. It can detect up to 100 targets simultaneously at a range of up to a 150 nautical miles, and pass cueing data for six targets to the fire control radar.[15]

The PMU-2 search radar is the 64N6E2 Big Bird, shown in Figure 1, which is an evolutionary upgrade to the 64N6E radar.[16] Key PMU-2 upgrades in the long-range search radar include longer detection range, ability to detect more targets, and ability to pass cueing data for more targets to the fire control radar. This radar is mechanically similar to its predecessor and achieves performance improvements primarily through improved software and upgraded microprocessors. This improved radar can detect up to 200 targets simultaneously at a range of over 200 nautical miles, and pass cueing data from 12 targets to the fire control radar. If subjected to active electronic jamming, it can detect accurate bearing data and possibly range to jamming sources. The PMU-2 search and acquisition radar is significantly more difficult to jam than its predecessor.[17]

Figure 1. S-300 PMU-2 SAM Complex

Author's note: Left to right, 64N6E2 Big Bird Battalion Search Radar, 54K6E2 Command Module, and 5P85SE TEL. Not shown, Battery Search Radar and Battery Fire Control Radar.
Source: "S-300PMU2 complex," Wikimedia Commons, https://commons.wikimedia.org/wiki/File:S-300PMU2_complex.jpg.

Battery Search Radar. At the battery level, comprising up to eight TELs, the PMU-1 uses the 76N6E Clam Shell low-level early warning/search/acquisition radar. This radar is optimized to differentiate between ground clutter and very small radar cross section (RCS) targets operating at high velocities and low altitudes, particularly cruise missiles. It can operate in a highly contested electronic countermeasures (ECM) environment.[18]

At the battery level, the PMU-2 uses the 96L6E search and acquisition radar. This radar offers better performance in all parameters than its predecessor, including longer range to detection, a lower minimum RCS required for detection, and the ability to pass targeting data to the fire control radar much quicker. This radar is capable of detecting low-flying cruise missiles and air-launched standoff weapons even in a highly contested ECM environment, and cueing the fire control radar to missile engagement.[19]

Battery Fire Control Radar. The battery fire control radar used by the PMU-1 is the 30N6E Flap Lid phased-array fire control radar, which can control engagements against six targets simultaneously, including "dual shot" targeting two missiles against one target. This fire control radar uses track-via-missile guidance.

The fire control radar used by the PMU-2 is either the 30N6E1 upgraded version of the Flap Lid or the 30N6E2 Tomb Stone. The Tomb Stone radar can track up to 100 targets simultaneously and, like the Big Bird search radar, is very difficult to jam.[20] It has excellent long-range capabilities, tracking out to 200 miles, as well as short-range characteristics, with a minimum engagement range of just 3 miles. It can simultaneously track 100 targets and control 12 missile engagements. This means that the Tomb Stone radar can track and provide fire control against any inbound weapon other than a gravity bomb dropped from directly overhead. The radar is capable of tracking short- and medium-range ballistic missiles, cruise missiles, fixed- and rotary-wing aircraft, and air-launched standoff weapons.

Command Module. The 54K6E command post vehicle passes data from the long-range search radar to the fire control radar and activates the missile-firing sequence.

The 54K6E2 command post vehicle incorporates numerous digital processing upgrades resulting in faster handoff from search radar to fire control radar and quicker missile-firing sequence.[21] Key PMU-2 upgrades in the command post include numerous control processes that have been digitized and automated, yielding quicker, more reliable command decisions. This is especially important when directing PMU-2 fire against cruise missiles or standoff weapons with minimal time between target detection and engagement.

Transporter, Erector, Launcher (TEL). The PMU-1 uses the 5P85S/5P85T series TELs, which are equipped with four launch tubes per TEL and loaded with a combination of missiles. Some older missiles are large enough that each launch tube can take only one missile; some newer missiles are small enough that four missiles can fit into a single TEL.

The PMU-2 uses the 5P85SE series TELs, which is equipped with four launch tubes per TEL and loaded with a combination of missiles, as shown in Figure 2. As with its predecessor, some older missiles are large enough that each launch tube can only take one missile; some newer missiles are small enough that four missiles can fit into a single TEL. Improvements over the PMU-1 TEL are primarily electronic and include faster targeting data upload for quicker launch time in the "detect to engage" cycle.

Figure 2. 5P85SE TEL

Source: Vitaly V. Kuzmin, "5P85SE TEL," Wikimedia Commons, https://commons.wikimedia.org/wiki/File:5P85SE_TEL_at_MAKS-2007.jpg.

Missiles. The 48N6E missile has a large footprint; each TEL tube can hold only one. It has a 150 kilometer range and a 150 kilogram warhead. It uses a combination of radio command guidance and semi-active radar homing guidance. When this missile was introduced, it was relatively inaccurate and compensated for its poor accuracy with a 150 kilogram warhead. The early versions of the US Patriot SAM had a 90 kilogram warhead by contrast.[22] A large warhead requires a larger and heavier missile, reducing range and speed. The 48N6E is a large general purpose missile with a large blast fragmentation warhead that can engage threats across the spectrum from low-altitude cruise missiles to high-altitude short-range ballistic missiles. This missile is loaded one per TEL tube.

The 9M96E1 missile has a much smaller footprint than the 48N6E: each TEL tube can hold up to four. It has a much smaller warhead of just 24 kilograms, as shown in Figure 3. This missile is essentially a "hit to kill" vehicle with a small blast fragmentation warhead that functions almost like a shaped charge, with timed detonation reacting to angle of impact with the target. This missile combines command guidance from the fire control radar with semi-active radar homing, a range of 21.6 nautical miles, and a capability to engage targets as low as 15 feet or as high as 66,000 feet.

Figure 3. S-300PMU2

Author's note: Although the larger missile depicted is a 48N6E3 and is technically part of the S-400 systems and is not currently offered for export to Iran, it is the same size as the 48N6E2 missiles that Iran is scheduled to receive as part of the S-300 PMU2 system, and shows the contrast in size with the smaller 9M96E missile.
Source: "S-300PMU2," Wikimedia Commons, https://commons.wikimedia.org/wiki/File:S-300PMU2_48H6E3_and_9M96E.jpg.

Key PMU-2 upgrades in the missiles result in a system that, when loaded with both the 48N6E2 and the 9M96E2, can essentially function as a traditional SAM platform against fixed-wing and rotary-wing threats at all altitudes, an antiballistic missile platform that can engage both short- and medium-range ballistic missiles, and a point defense system against low-flying cruise missiles and air-dropped standoff weapons.

The 48N6E2 missile is the same physical size and shape as the 48N6E, but improvements in the propulsion section extend range out to 200 kilometers. Faster data transfer from the fire control radar increases the engagement envelope to include all short-range ballistic missiles and possibly intermediate-range ballistic missiles. All other targets—including fixed- and rotary-wing aircraft, cruise missiles, and air-launched standoff weapons—are included in the engagement envelope with higher probability of kill due to faster data rate transfer from the fire control radar. The original version of this missile had a large 150 kilogram warhead to compensate for relatively poor accuracy; this upgraded version has much tighter accuracy, but still keeps the relatively large warhead. The result is a big, fast, reliable and accurate missile that can credibly engage all targets from the very-low-altitude cruise missile to very-high-altitude medium-range ballistic missile. The 9M96E2 missiles are evolutionary upgrades to the 9M96E1 missiles, with increased range out to 64.8 nautical miles and altitude capability from a low of 15 feet up to 66,000 feet and 100,000 feet, respectively.

Transloader. While both the PMU-1 and PMU-2 can be reloaded in the field, the PMU2 22T6E2 Missile Transloader introduces key upgrades in its all-terrain capability. It is an all-wheeled vehicle, rather than a wheeled chassis, which improves its ability to move across unimproved terrain. It can reload four missile tubes (with up to 16 missiles total, if using the 9M96E2 missiles) in less than 30 minutes.[23]

Overall PMU-2 Upgrades. PMU-2 is more capable than the PMU-1 at detecting more targets of smaller size at greater ranges, can pass targeting data to fire control radars at a faster rate, can fire missiles faster and control more missiles, can employ missiles of greater range and accuracy, and can reload missiles faster. In one 30-minute cycle, a single PMU-2 battery of six TELs, each with four tubes, each loaded with four 9M96E2 missiles, could theoretically expend 96 missiles and be reloaded with 96 replacement missiles.

Tactical Considerations to Defeat the S-300

The S-300 PMU-2 system, regardless of its final configuration once it reaches initial operational capability in Iran, will represent a significant increase in Iranian defensive capabilities. While the S-300 PMU-2 is an extremely capable system, it is not invincible. A US strike could destroy the Iranian S-300 PMU-2 system, but such a strike would require significant planning and assets. The S-300 is beatable, but if Iran fields it, the S-300 immediately becomes the "alpha target." The S-300 must be destroyed before any other air operations can safely take place. At a minimum, the following systems would be required to defeat the S-300 PMU-2.

Suppression of Enemy Air Defenses (SEAD). US SEAD aircraft, primarily the EA-18G Growler, can jam the Big Bird and Tomb Stone radars, but would need multiple aircraft working on multiple threat axes to ensure successful jamming. The EA-18G would normally be supported by EC-130 Compass Call aircraft, which in this scenario would jam communication between the S-300 and higher headquarters or the rest of the Iranian IADS. None of the Gulf Cooperation Council (GCC) air forces have any dedicated SEAD aircraft. The Israeli Air Force (IAF) has a partial SEAD capability using multifunction aircraft that have SEAD as a secondary mission by carrying ECM pods. The IAF does not have a specific airframe, such as the EA-18G Growler, dedicated solely to SEAD. Several NATO allies have a partial SEAD capability using the Panavia Tornado Electronic Combat Reconnaissance aircraft, but do not train to the mission as extensively as the US does. The most realistic option for using allied aircraft in the SEAD mission is as a supporting element of a US-led strike. It is highly unlikely that any other country or coalition absent the US could successfully jam the S-300.

Intelligence, Surveillance, and Reconnaissance (ISR). ISR aircraft include the E-8 JSTARS. Initial location of control units, radar units, and firing units would be required to ensure SEAD aircraft are appropriately positioned. The JSTARS Ground Moving Target Indicator radar would be necessary as the S-300 system is fully road mobile and partially off-road capable. GCC air forces have limited ISR assets; IAF and NATO have extensive ISR assets, but the most realistic option for allied forces to participate in the ISR mission would be as a supporting element of a US-led strike.

High-Speed Anti-Radiation Missile (HARM). Using HARM aircraft, such as the F-16 CJ, to shoot HARM missiles, which home on the S-300 radar, frees up EA-18 Growler aircraft to carry maximum fuel tanks and jamming pods. GCC countries have limited proficiency in this mission, and given the lack of organic SEAD aircraft and no stealth capability, it is unlikely that GCC air forces would risk coming close enough to the S-300 to employ HARM. The IAF has significant experience shooting missiles similar to HARM: during the 1982 Lebanon War, the IAF successfully used Shrike missiles, a predecessor to HARM, to destroy Syrian SAM sites.[24] NATO air forces regularly train to employ HARM in support of US-led SEAD missions.

Tactical Standoff Weapon. Tactical Standoff Weapon aircraft—such as the nonstealthy B-1, F-15E, and F18E—are vulnerable to the S-300. These aircraft, once the S-300 is being jammed and its detection and tracking range reduced, could employ the Joint Standoff Weapon (JSOW), an air-launched glide bomb that has a range of 70 miles when launched directly on the threat axis and at maximum aircraft altitude. Because the S-300 can detect and engage standoff weapons, multiple JSOW launches would need to target each S-300 radar to ensure a "soft kill" of the system, meaning the system is degraded, but not destroyed. For a complex and highly capable system such as the S-300, an attacking force would first need to achieve a soft kill to establish a permissive environment for aircraft to approach close enough to deliver large gravity bombs to achieve a "hard kill" (complete destruction) of the system. GCC air forces have recently acquired standoff weapons, but have exhibited limited proficiency in their use. IAF is extremely capable with standoff weapons, as are NATO air forces.

Tomahawk Cruise Missiles. If launched in small numbers in an isolated attack, the Tomahawk cruise missile cannot reliably defeat the S-300 PMU-2. Tomahawk cruise missiles, if employed as part of a combined "alpha strike" against a PMU-2, along with active jamming, HARM missiles, and air-launched standoff weapons, should be able to achieve at least a "soft kill" against the S-300 PMU-2. While several NATO countries have sea-launched cruise missile capability, only the US Navy has the depth of resources to conduct a massed or saturation attack.

Stealth Aircraft. The B-2 and F-22 are the only aircraft that can reliably approach an active S-300 with large gravity bombs. If employed as part of an alpha strike with SEAD, ISR, HARM missiles, air-launched standoff weapons, and cruise missiles that achieve a soft kill against the S-300, the B-2 and F-22 should be able to achieve a hard kill using gravity bombs.

Defeating the S-300

The US military can defeat an S-300 system, but it would require a large, dedicated strike package using a multiple round simultaneous impact (MRSI) saturation attack combining cruise missiles, HARM missiles, and air-launched standoff weapons to achieve a soft kill partially damaging the system, followed by large gravity bombs delivered by stealth aircraft to guarantee a hard kill. It is a difficult but doable mission.

The introduction of the S-300 into Iran changes the strategic balance of power because no other country in the world except the US can reliably launch an attack against an S-300 system with a "soft kill morphing into hard kill approach." Only the US has enough of the specialized equipment and weapons required to conduct a saturation attack with multiple weapons approaching on multiple axes. Any other country or coalition of countries attempting to attack an S-300 system using existing weapons and tactics would suffer significant losses. Any country or coalition of countries going up against an S-300 would at least consider nonstandard tactics including cyberattack and espionage to defeat the S-300.

Future Growth

Russia designed the S-300 to be compatible with future upgrades. The entire family of missile systems is designed to be operable with all past components and all future components. Iran could establish operational proficiency with the S-300 PMU-2 and very quickly assimilate more advanced versions and larger quantities of missiles. Russia is in full production of the S-400/S-500, the S-300 follow-on systems.[25] As Russian units are equipped with these modern anti-access area-denial (A2/AD) systems Iran will likely gain access to significant quantities of legacy S-300 components.[26]

Conclusion

The exact composition, capabilities, and quantity of the Iranian S-300 are still undetermined. It seems certain, however, that Russia really is exporting an operable S-300 to Iran. With cooperation between Russia and Iran deepening and Russia building S-400/S-500 systems for its own use as fast as it can, it is reasonable to assume Iran will use this initial S-300 shipment to build proficiency in its military and position its military to accept and employ greater quantities of surplus Russian S-300 components in the near future.

Because the S-300 is built to be compatible with both previous components and future upgrades, it is also possible that in the near future Russia may export the more capable S-400 and S-500 A2/AD systems to Iran, and that Iran would quickly establish proficiency on these systems. Prior to exporting the S-300 to Iran, Russia repeatedly tried to use the threat of exporting the S-300 as leverage during negotiations with the United States.[27] Once Iran has established proficiency on the S-300, there will be no technical restrictions on Russia exporting an S-400 to Iran. Because the S-400 is air-deployable via the Antonov-124 heavy cargo aircraft, Russia could export the S-400 on short notice to Iran and have the system operational in a matter of days.[28] With the financial windfall associated with the relief of sanctions, Iran appears to be in position to purchase whatever systems Russia will sell. Once Iran gains proficiency with the S-300, it is possible, perhaps likely, that Russia will try to use the threat of exporting the S-400 to Iran as leverage against the United States.

The Iranian nuclear program, while not impervious to a first-strike air attack, is well protected because Iran's nuclear facilities are geographically dispersed and in some cases buried far underground.[29] In a post–Iran nuclear deal scenario, the presence of the S-300 would make it far more difficult to strike Iran's nuclear facilities.

The result of these developments will be a dramatic increase in Iran's ability to defend its airspace against all attackers, including the United States. Iran's neighbors will need to consider upgrading their air and missile forces if they wish to retain the capability to strike targets in Iran, and the US will need to plan for a much more expansive strike package simply to defeat the S-300 before moving on to striking any other targets in a conflict with Iran. The S-300 is a strategic game changer in the region, and US policymakers and military planners need to begin to revise their assumptions accordingly.

Notes

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