The Iranian Missile Threat to Air Bases

A Distant Second to China's Conventional Deterrent

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The Department of Defense faces a time of transition as it works to address today's crises while preparing for tomorrow's threats.[1] One of the future concerns for US forces comes from antiaccess/area-denial (A2/AD) capabilities, defined broadly as "the ability to blunt or deny U.S. power projection—across all domains."[2] Within this broad definition, A2 capabilities compromise the ability of US forces to get to the fight whereas AD capabilities inhibit their ability to fight effectively once they arrive.[3] Some capabilities can be employed in both an A2 and an AD role. For instance, submarines could interdict forces as they attempt to deploy into a theater and could then shift to coastal choke points to deny US naval operations inside a theater. Discussions of A2/AD highlight a set of capabilities that could be employed in this manner, including cruise and ballistic missiles, quiet submarines, sea mines, modern fighter aircraft, space and cyberspace assets, and surface-to-air missiles.[4] Discussions of this threat generally cite multiple countries as potential A2/AD challenges, especially China and Iran.[5]

Grouping Chinese and Iranian capabilities within the same A2/AD rubric can obscure important variation in the possible threat to US forces in different theaters unless accompanying analysis highlights those differences. This article uses an operational analysis of the risk to air bases from conventional theater ballistic missiles (TBM) to illustrate how one critical component of the broader A2/AD threat can vary across theaters.[6] This comparative analysis indicates that the threat to US operating bases in Southwest Asia (SWA) is significantly lower than the one they face in East Asia. The geography of SWA lessens the impact of the already weaker Iranian TBM capabilities. Iran could not significantly hold US air operations at risk outside 500 kilometers (km); therefore, it poses a more modest threat to those operations in the Persian Gulf than do Chinese TBMs in East Asia.[7] The accuracy, payloads, and ranges of the weapons in Iran's ballistic missile arsenal are inadequate to seriously threaten US air operations, in part because US forces could operate from a large number of bases outside the worst threat ring (i.e., more than 500 km from Iran's border).[8] Even within 500 km, the threat posed by Iranian TBMs to air bases could be mitigated in a number of ways. For example, a prudent planner could avoid parking significant numbers of aircraft in the open, distribute parked aircraft across a wide area, and operate fighters from hardened air bases. In short, the Iranian ballistic missile threat to US air bases is exaggerated by the Iranians and likely to remain modest, relative to the threat those bases face in East Asia.[9]

This conclusion is reinforced by a secondary analysis that examines a worst-case future scenario. Even if Iran had China's existing TBM capabilities, the geography of SWA gives the United States basing options that still would entail a significantly lower threat than the one from East Asia. Prudence requires that American defense analysts closely monitor Iran's ballistic missile developments, but the superficial similarities between Iranian and Chinese capabilities should not blind them to the fact that the TBM threats in SWA and East Asia differ dramatically in both scope and quality. As a result of the more favorable geography and the potential adversary's less advanced capabilities, the United States is and should remain capable of conducting air operations in SWA. These differences indicate that substantial regional variation can exist in the nature of A2/AD threats and that overuse of the A2/AD label can obscure as much as enlighten if it is not accompanied by an appropriate analytical effort.

Overlooking regional variations in threats can cause a multitude of problems for American defense planners. First, they may overlook opportunities that exist in SWA. Basing fighters outside effective Iranian TBM attack could be a powerful component of an American war plan, but one would first have to recognize it and then act upon it to create any benefit. By misdiagnosing the Iranian TBM threat, planners could overlook this opportunity. Second, misunderstanding the regional variation of threats can produce misallocation of resources. For example, if the threat to air bases is much severer in East Asia than in SWA, then that situation implies that scarce resources for improving the resilience of air bases should be spent first in East Asia.[10] Finally, such misunderstanding can create an exaggerated sense of decline in American power. If the proliferation of threats such as TBMs is uniformly eroding the ability of US fighters to operate in the event of war, then this problem would imply a general decline in US power projection. If, however, the TBM threat to air bases is more heterogeneous across regions, then existing American power projection can remain relevant in the lower-threat regions such as SWA. For all of these reasons, it is important to have a clear understanding of the regional variations in the TBM threat to air bases.

The remainder of this article proceeds in five main sections. First, it discusses why defense planners worry about Iran's TBM forces. Second, it examines the capabilities of Iran's and China's TBMs as a means of evaluating their effectiveness at striking key targets on air bases such as runways and parking ramps. Third, the article compares and contrasts Iranian and Chinese ballistic missile doctrine, noting how each country envisions using its TBMs. Fourth, it analyzes how each country's TBM capabilities interact with the bases available to US forces in each region in order to assess the degree to which the TBM threat constrains US basing options in each theater. Finally, the article discusses conclusions drawn from this analysis and implications for US force posture, force structure, and ability to project force globally.

Iran's Theater Ballistic Missiles and the Risk to US Air Bases

Iran's ballistic missile capabilities represent an ongoing concern for defense planners in the Middle East, Europe, and the United States. In 2009 Secretary of Defense Robert Gates stated that "the threat from Iran's short- and medium-range ballistic missiles . . . is developing more rapidly than previously projected."[11] Concerns over those missiles stem from a variety of factors. Specifically, Iran's nuclear program makes its existing ballistic missiles potential delivery systems for nuclear warheads. If Iran could develop both a nuclear weapon and an intercontinental ballistic missile, then it could hold the US homeland at risk. Even if Iran had no new longer-range missiles, nuclear weapons mated to its existing TBM force could threaten Iran's neighbors. Beyond nuclear threats, its existing conventionally armed TBMs could serve as a coercive tool due to their ability to threaten the population centers of US partners in the Middle East as well as other lucrative targets such as ports and energy infrastructure. Finally, in the event of an open war, these TBMs might threaten military targets, denying Iran's opponents sanctuary from which to prepare and operate their air, land, and naval forces.

Even though the role of Iran's TBMs as a coercive tool has been discussed and although defense analysts frequently mention their war-fighting utility, no operational analysis of the ability of those missiles to accomplish military missions has been conducted.[12] This deficiency is significant because the possibility of Iranian TBMs becoming a potent war-fighting force would have profound consequences on a future conflict in the Persian Gulf. US airpower has enjoyed comparative sanctuary in SWA since 1990, and the 2010 *Quadrennial Defense Review Report* highlighted the potential effects that Iranian TBM developments could have on that sanctuary:

> [Iran is] actively testing and fielding new ballistic missile systems. Many of these systems are more accurate and have greater ranges than the Scud-class missiles used by Iraq in the 1991 Gulf War. As the inventories and capabilities of such systems continue to grow, U.S. forces deployed forward will

> no longer enjoy the relative sanctuary that they have had in conflicts since the end of the Cold War. Air bases, ports of debarkation, logistics hubs, command centers, and other assets essential to high-tempo military operations could be at risk.[13]

Given the importance of air superiority to the American way of war, any compromise of the US military's ability to operate from regional air bases in the event of a conflict is exceptionally concerning.[14] Forward bases' lack of viability would create a major challenge to American war fighting.[15] Iranian rhetoric makes such a threat explicit.[16]

Despite these concerns, no rigorous tests of the ability of Iran's missile force to impede US air operations in SWA have occurred.[17] This article seeks to fill this gap in the literature by assessing the current capabilities of Iran's missiles and comparing them to those of China, which possesses the most active ballistic missile program in the world. Furthermore, it examines Iranian doctrine for its ideas on ballistic missiles before assessing their effectiveness in attacking air bases in SWA. These steps lead to the conclusion that air bases more than 500 km away from Iran have comparative sanctuary from TBM attack.

The Capabilities of Iranian and Chinese Ballistic Missiles

Iranian Theater Ballistic Missiles

Iran has the largest ballistic missile force in the Middle East. Overall inventory estimates vary, but sources generally agree that Iran has more than 1,000 ballistic missiles of various types. The capabilities of this inventory, however, are uneven. Most of the Iranian ballistic missile force is derived from Soviet Scud missiles, which, in turn, were derived from the German V-2. These are liquid-fueled missiles, which are less mobile and less responsive than solid-fueled missiles. *Jane's Strategic Weapon Systems* reports that the guidance systems of these missiles have improved, compared to those of the Soviet Scuds, but they remain relatively inaccurate.[18] The majority of Iran's inventory is composed of short-range ballistic missiles (SRBM), including a smaller number of medium-range ballistic missiles (MRBM). Currently, it possesses no intermediate-range or intercontinental ballistic missiles (IRBM and ICBM).[19]

Iran continues to develop Scud technology. Its Shahab 3 variants are scaled-up versions of shorter-range Scud missiles using similar designs, materials, and propellants. These longer-range systems require a separating reentry vehicle, a capability that has applicability on intercontinental range systems as well.[20]

Beyond Scud technology, Iran is reportedly developing three new conventional ballistic missile systems. The first of these, the Fateh-110, is noteworthy because it is the first solid-fueled system fielded by Iran. Solid-fueled systems can be more mobile and, thus, more survivable than liquid systems; moreover, they can be readied to fire more quickly, enhancing their responsiveness. This single-stage missile has a range of 200 km—sufficient to reach targets in Kuwait, Bahrain, northern Qatar, the United Arab Emirates (UAE), and eastern Oman. Additionally, the Fateh-110 evidently has impressive accuracy improvements (a reported 100 meters [m] circular error probable [CEP]) over the Shahab SRBMs (450–700 m CEP).[21] The second new system, the Ashura or Sejil MRBM, is a two-stage solid-fueled missile reportedly in development. If successfully deployed, this missile would represent a major technological advance beyond the Shahab 3–class MRBMs due to the advantages of solid-fueled systems over liquid-fueled systems, summarized above. Finally, the BM-25 MRBM, a single-stage, liquid-fueled missile, is reportedly based upon technology from a Soviet-era submarine-launched ballistic missile. One of the important differences between the BM-25 and the Shahab series is that the BM-25 evidently uses a more energetic propellant to achieve longer ranges than are possible with Shahab propellants.[22] If successfully deployed, the BM-25 could give Iran a longer-ranged, liquid-fueled missile force capable of reaching targets in Western Europe. (Table 1 summarizes the capabilities of Iran's TBMs.) Because some analysts forecast that the accuracy of Iran's TBMs will improve over time, a later section of this article analyzes the effect of a more accurate TBM force.[23]

Table 1. Iranian conventional ballistic missiles

	Land Attack Theater Ballistic Missiles							
	SRBM				*MRBM*			
	CSS-8	*Fateh-110*	*Shahab 1*	*Shahab 2*	*Shahab 3*	*Shahab 3 (variants)*	*Ashura (Sejil)*	*BM-25*
Range (km)	150	200	300	500	1,300	2,000–2,500	2,000	2,500–4,000
Warhead (kg)	250	500	985	770	800	500	900	1,200
CEP (m)	100	100	450–610	700	1,850–2,500	2,500	Unknown	1,600
2010 Inventory Estimate	175	500	150	150	12	12		
2010 Launcher Estimate	30	Unknown	12–18		12		In Development	In Development

Source: Missile performance data from National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat* (Wright-Patterson AFB, OH: NASIC Public Affairs Office, 2013); and Duncan Lennox, *Jane's Strategic Weapons Systems* (London: Jane's Information Group, 2012). Inventory estimates based on International Institute for Strategic Studies (IISS), *The Military Balance 2012* (Washington, DC: IISS, 2012); and Department of Defense, "Annual Report on Military Power of Iran" (Washington, DC: Department of Defense, April 2012), https://fas.org/man/eprint/dod-iran.pdf. Significant differences exist among open-source estimates of Iranian TBM inventories. In particular, there are few estimates of Iran's Fateh-110 inventory. To get around this deficiency, the estimate summarized here was derived in the following way: CSS-8 and Shahab 1, 2, and 3 inventories from the IISS's *Military Balance* were totaled and then subtracted from the total inventory of 1,000 TBMs cited in the Department of Defense's "Annual Report on Military Power of Iran." Doing so leads to an inventory of Fateh-110s larger than that seen in some other sources. See, for example, Joshua R. Itzkowitz Shifrinson and Miranda Priebe, "A Crude Threat: The Limits of an Iranian Missile Campaign against Saudi Arabian Oil," *International Security* 36, no. 1 (Summer 2011): 167–201. Given that the Fateh-110 is the most accurate and thus the most capable system currently deployed by Iran, this method represents an upper bound on the capabilities of Iran's inventory.

Chinese Theater Ballistic Missiles

Although Iran has the largest ballistic missile force in the Middle East, China currently has the most active and advanced ballistic missile program in the world. It has fielded more than 1,000 highly accurate conventional SRBMs and is currently expanding its conventional MRBM force. All of these missiles are solid-fueled, road-mobile systems that possess high accuracies (less than 50 m CEPs). China has developed a wide range of payloads for these missiles, including a variety of submunitions. (Table 2 summarizes the capabilities of China's TBMs and cruise missiles.) China's most numerous type of TBM is its SRBM, but it is expanding its conventional land-attack MRBM forces. China's early DF-21/CSS-5 MRBMs were armed with nuclear warheads and had poor accuracy, but the more recent DF-21C variant has improved guidance and a conventional warhead.[24] Although China has not yet built many of these systems, the Department of Defense estimates that the People's Republic of China could double its MRBM production rate.[25]

Table 2. Chinese conventional land-attack ballistic and cruise missiles

	Land Attack Theater Ballistic Missiles								*Cruise Missiles*	
	SRBM					*MRBM*		*IRBM*		
	CSS-7		*CSS-6*			*CSS-5*				
	DF-11	*DF-11A*	*DF-15*	*DF-15A*	*DF-15B*	*DF-21*	*DF-21C*	*New IRBM*	*DH-10*	*ALCM (delivered by B-6)*
Range (km)	280–350	350–530	600	600	600–800	1,750+	1,750+	4,000	1,500–2,000	3,300[a]
Warhead (kg)	800	500	500	600	600	600	500	unknown	400	400
CEP (m)	600	20–200	300	30	5	700	50	unknown	5–20	5–20
2010 Inventory Estimate	700–750		350–400			85–95[b]	36[c]	In Development	200–500	In inventory
2010 Launcher Estimate	108		108			80	36		54	30

[a]Reflects combined range of H-6 bomber and air-launched cruise missile (ALCM)

[b]85–95 estimate includes all variants of the DF-21

[c]Estimates of DF-21C inventory; subset of total DF-21 inventory

Source: Table based upon data from Duncan Lennox, *Jane's Strategic Weapons Systems* (London: Jane's Information Group, 2012); Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China, 2011* (Washington, DC: Office of the Secretary of Defense, 2011), http://www.defense.gov/pubs/pdfs/2011_CMPR_Final.pdf; Zhang Han and Huang Jingjing, "New Missile 'Ready by 2015': Global Times," *People's Daily Online*, 18 February 2011, http://en.people.cn/90001/90776/90786/7292006.html; Doug Richardson, "China Plans 4,000 km-Range Conventional Ballistic Missile," *Jane's Missiles & Rockets*, 1 March 2011; International Institute for Strategic Studies (IISS), *The Military Balance 2011* (Washington, DC: IISS, 2011); and National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat* (Wright-Patterson AFB, OH: NASIC Public Affairs Office, 2013).

Beyond the DF-21's range (roughly 1,750 km), China does not currently possess a conventionally armed IRBM capable of ranging Guam, but it has announced its intention to develop and deploy such a system by 2015.[26] Thus, within the next decade, it is likely that all permanent US Air Force bases in the Western Pacific will lie within range of conventionally armed, precision TBMs. Meanwhile, China has demonstrated the capacity to expand its force of ground-launched cruise missiles (GLCM) at a rate of more than 100 a year.[27]

Operational Capabilities of Iranian and Chinese Theater Ballistic Missiles

This analysis compares Iranian and Chinese TBM capabilities across two dimensions: accuracy and flexibility, with the bulk of the analysis focusing on the differences in accuracy. These characteristics play key roles in determining the ability of ballistic missiles to fulfill a military goal such as hitting the runways or parking ramps of an air base.

Accuracy. The first operational consequence of the differing Chinese and Iranian ballistic missile capabilities arises from their relative accuracies. Most Iranian systems are so inaccurate that they likely could not hit military targets. To illustrate, we begin by considering how many missiles would need to be fired to hit a notional target of 100 m in diameter (e.g., a sizable building on an air base, such as a very large hangar). As figure 1 illustrates, between one and three of the most modern Chinese TBMs would be sufficient to have a greater than 80 percent chance of striking a target of this size. It would take 10 of the most accurate Iranian TBMs (Fateh-110s) to realize a similar probability of hitting the same target. Moreover, 10 Scud-derived Shahabs wouldn't have even a 10 percent chance of success.[28]

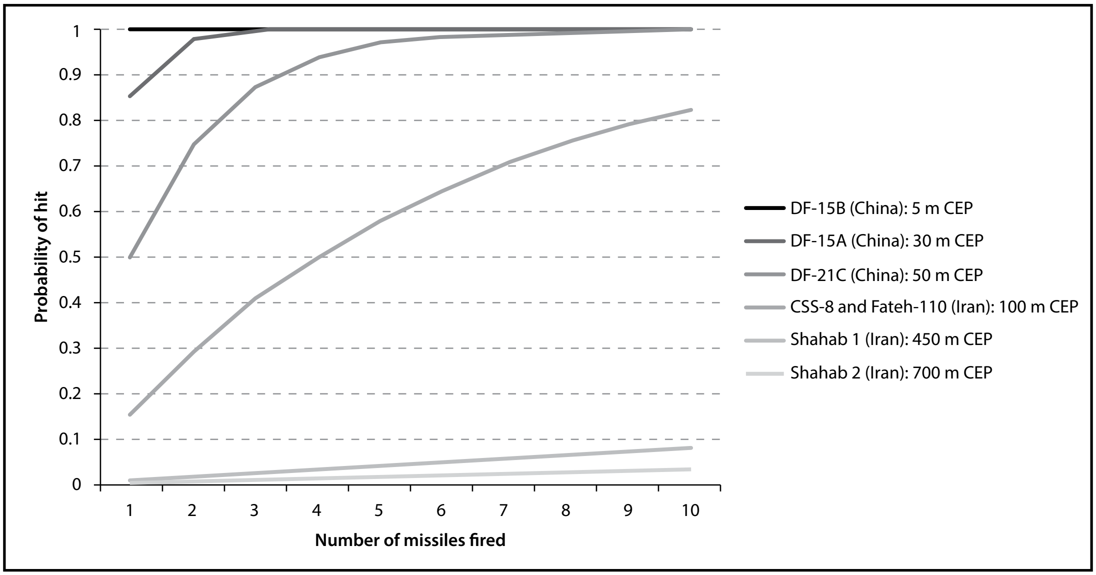

Figure 1. Cumulative probability of Iranian and Chinese ballistic missiles hitting a target of 100 m in diameter. (Figure from author's calculations based on accuracies reported in tables 1 and 2.)

As mentioned earlier, one way to compensate for an inaccurate delivery system is to employ submunitions—particularly useful for attacking area targets on air bases, such as runways.[29] Here, the objective is to damage the runways sufficiently to deny a minimum operating surface (MOS)—the least amount of space an aircraft requires to become airborne. For a fighter, a nominal MOS is 5,000 feet long and 50 feet wide.[30] Not knowing the types of antirunway submunition payloads (if any) with which the Iranians have armed their TBMs, this analysis uses a representative antirunway payload derived from munitions that the United States developed decades ago. This assessment assumes that each missile is armed with 82 10-pound runway-penetrating submunitions dispersed across a circle with a 300-feet radius around the missile impact point.[31] This scenario produces a pattern of submunition impacts sufficiently dense that the probability of leaving a fighter MOS 50 feet wide on a runway 150 feet wide is extremely low (assuming the TBM was aimed at the center point of the runway). Effectively, this means that as long as the missile lands within 225 feet of the center of the runway, its submunition pattern will fully cover the width of the runway and a fighter will be unable to operate over that section until it has been repaired. With this payload, figure 2 depicts the probability of Iranian TBMs doing sufficient damage to a runway to deny a fighter MOS.[32] In the runway-attack case, this mission remains challenging even when inaccurate systems are armed with submunitions. However, it is less demanding than the attack on the target 100 m in diameter with a unitary warhead. Three Fateh-110 systems are adequate to have an 80 percent chance of cutting the runway whereas 10 of those missiles were required to have the same chance of hitting a target 100 m in diameter. The Shahab-class systems, though, still cannot break a 70 percent chance of cutting the runway with a salvo of 10 TBMs.

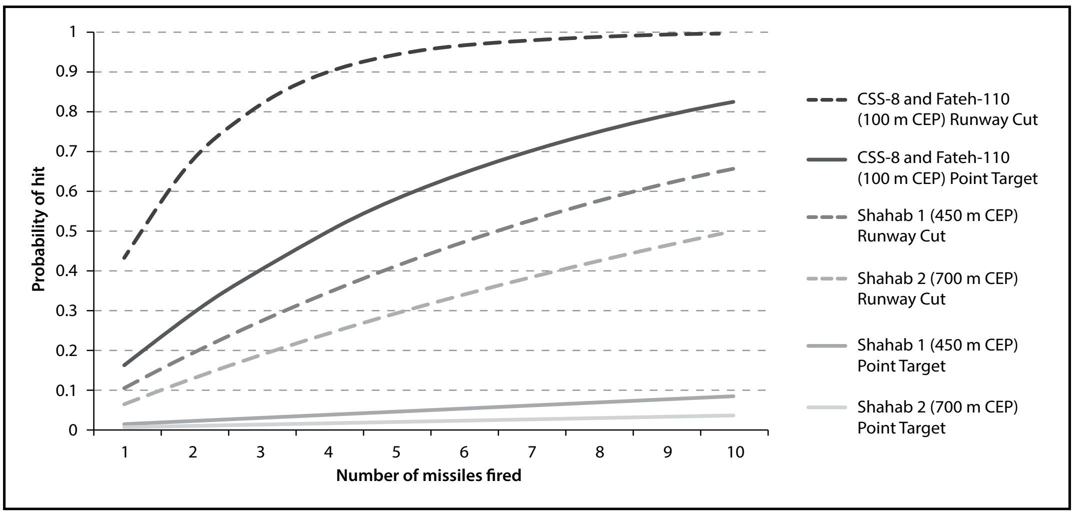

Figure 2. Cumulative probability of hitting a point target 100 m in diameter or severing a single runway using Iranian ballistic missiles. (Figure based on author's calculations using accuracies reported in table 1.)

In fact, as table 3 indicates, a salvo of 13 Shahab 1s would be necessary to have a 75 percent chance of making a single runway cut. By way of contrast, the Chinese would have to use only a single reliable conventional TBM to have the same confidence in making such a cut. The story gets even worse for the Iranians because multiple cut points are generally needed to deny all MOSs at an air base. Al Dhafra in the UAE, for example, has two runways, each approximately 12,000 feet long.

Therefore, missiles would have to make two cuts on each runway in order to deny a nominal fighter MOS of 5,000 feet, as illustrated in figure 3. This requirement implies a salvo of 52 Shahab 1s, roughly one-third of the Iranian Shahab 1 inventory.[33] Perhaps if US Air Force aircraft were massed in Al Dhafra, however, it would still be an attractive target. Nevertheless, Iran would have trouble making this attack because it lacks a sufficient number of launchers. The International Institute for Strategic Studies assesses that Iran has only 12–18 launchers for its Shahab 1 and 2 force (i.e., it does not have enough launchers to mount a raid on more than one runway cut point at a time).[34] Because these calculations do not include any active defenses (such as Patriot batteries, operated by both the UAE and US militaries) or missile reliability factors (a fraction of all weapons systems fail—sometimes large fractions), the real challenge is even greater for the Iranians to overcome than these already pessimistic results imply.

Table 3. Required salvo sizes for runway and parking-area attacks for Iranian and Chinese ballistic missiles

Country	*Missile Type*	*Salvo Size Required for 0.75 Probability of Cutting a Single Runway*	*Salvo Size Required to Cover 75% of a 770,000 Sq. Ft. Parking Apron*
Iran	CSS-8	3	1
	Fateh-100	3	1
	Shahab 1	13	2
	Shahab 2	21	4
	Shahab 3	71	27
	Shahab 3 (variants)	71	27
China	CSS-7	1	1
	CSS-6	1	1
	CSS-5	1	1

Source: Table from author's calculations based on data reported in tables 1 and 2.

After runways, another major target set on an air base consists of parked aircraft. If not located in hardened shelters, then these aircraft are vulnerable to small submunitions.[35] Armed with one-pound submunitions, a TBM can blanket hundreds of square feet densely enough that every fighter-sized aircraft in the open will likely sustain damage. Arming the Iranian TBM force with this sort of payload produces the salvo sizes in the final column of table 3.[36] Because of the larger footprint of these submunition payloads, feasible salvos can cover 75 percent of a single parking apron of 770,000 square feet. An air base will generally have multiple parking aprons, so all of those would have to be targeted. Still, this analysis indicates that within Shahab 2 range (500 km), Iran could carry out an effective submunition attack on aircraft parked in the open on a single parking apron. Consequently, planners would be wise not to park large numbers of unsheltered aircraft within 500 km of

Iranian launch sites in the event of a major combat operation involving Iran. Fortunately, as discussed in greater detail below, many potential basing options inside 500 km have hardened aircraft shelters; moreover, options exist outside 500 km, which is within range of relevant targets in Iran. Thus, the United States could base its aircraft outside the reach of this threat.

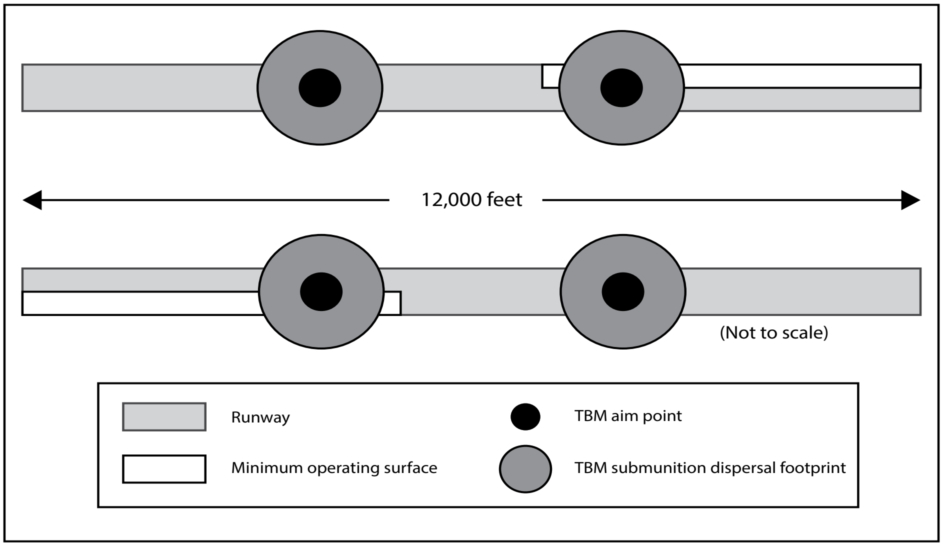

Figure 3. Illustration of runway cut points

Since Iran's TBMs seem so poorly suited for striking military targets, what are they good for? Specifically, their accuracy is sufficient to hit large targets like cities. The downtown area of Dubai, for example, is at least 5 km in diameter—greater than or equal to the CEP of all of Iran's missiles. A TBM falling inside this area would create a great deal of fear, regardless of how many people died directly as a result of the TBM strike.[37] Shahab 1 and 2 TBMs would have near certainty of hitting this target (ignoring, as before, missile reliability and missile defenses), and three Shahab 3 missiles would have a cumulative probability in excess of 80 percent of striking a target of this size. Thus, the capabilities of Iran's TBMs align well with a conventional psychological deterrent mission and poorly with a direct military war-fighting mission against adversary air bases.

Flexibility. In addition to their greater accuracy, Chinese TBMs are more flexible than Iran's arsenal because China's entire force is solid fueled, possessing satellite navigation capabilities and a high degree of mobility. The following discussion briefly considers each of these three factors in turn.

Solid-fueled systems enjoy multiple advantages over liquid-fueled systems, which must be fueled before they can fire, therefore complicating the launch process and requiring more support vehicles than those needed by solid-fueled missiles. This additional time can give an adversary a greater opportunity to find and attack the missiles before they fire. The fact that liquid-fueled missile batteries must have propellant vehicles can increase the signature of a unit, making it easier for an adversary to find. Solid-propellant missiles are also safer (highly energetic liquid rocket fuels can be extremely toxic) and easier to maintain in the field, producing a more effective force. Further, solid-fueled missiles can be fired more quickly than liquid systems, helping them strike fleeting targets (assuming adequate accuracy and targeting). Solid systems also accelerate more quickly during their boost phase, making them harder to hit with boost-phase intercept systems and thus more survivable. Clearly, China's all-solid-fueled force is more responsive, flexible, and survivable than Iran's largely liquid-fueled force.

Satellite navigation updates enable a missile to know its position precisely, based upon an external frame of reference. Therefore, missile accuracy is less dependent upon presurveyed sites and precise azimuth alignment before firing, leading to more potential launch sites, harder-to-find sites, faster launches, and more accurate missiles.

All of China's conventionally armed TBMs are fired from transporter erector launchers, but some of Iran's Shahab 3 MRBMs launch from fixed sites and others from mobile erector launchers. An adversary can presurvey fixed sites and attack at the onset of hostilities. Because mobile missiles are harder to find, they are more difficult to attack, but all mobile missiles are not equal. Mobile erector launchers can have less off-road capability than transporter erector launchers, shrinking their potential operating area and possibly making it easier for an adversary to find them.[38]

A Comparison of Ballistic Missile Doctrine

Iranian Ballistic Missile Doctrine

The threat posed by ballistic missiles depends at least partially upon how a country plans to employ these weapons. Iran's ballistic missile program dates back to the mid-1980s. Spurred by Iraqi attacks on Iranian cities, Iran obtained Scud B SRBMs from Libya and North Korea, ultimately launching approximately 100 TBMs at Iraqi cities over the course of the war.[39] This experience shaped Iranian thinking on the role of ballistic missiles, viewing them as part of a multifaceted deterrence strategy.[40] Iran "seeks to deter aggression against it by using exaggeration, ambiguity, and obfuscation about its ability to exact a prohibitive cost from potential aggressors, especially the United States," with ballistic missiles playing a key role.[41] Although Iran logically would want to hinder the flow of US forces into the region in the event of conflict and disrupt operations once forces arrived in-theater, analysts assess that its leaders believe that ballistic missile strikes "have psychological effects disproportionate to their destructive power."[42] This leads to an emphasis on deterring Gulf Cooperation Council states from providing access to US forces through the threat of cost imposition rather than denial. Overall, Iran's defense doctrine concentrates more on countering invasion and occupation than on projecting power. The TBM force is one of the few power-projection capabilities that Iran does possess, but its current role is to threaten and "mete out punishment" (in conjunction with unconventional attacks) rather than militarily deny air operations from an air base.[43] When Iran has used violence to influence the region, it has relied upon its considerable irregular capabilities such as the

Quds Force (an elite branch of the Iranian Revolutionary Guard Corps that specializes in providing military assistance to nonstate partners), ties to terrorist actors, and regional allies such as Hezbollah in Lebanon. For example, when Iran was displeased about the US military involvement in the Lebanese civil war in the early 1980s, it relied upon its partner Hezbollah to carry out the 1983 Beirut truck bombing of the US Marine Corps barracks instead of staging a conventional military attack. More recently, Iran provided weapons, training, and financing to Shiite militias in Iraq as a means of curtailing US influence in SWA.[44]

Another factor that could hurt Iran's ability to employ TBMs as part of an integrated military strike is its command and control structure. Iran's ballistic missiles are under the control of the Iranian Revolutionary Guard Corps. The fact that the vast majority of Iran's aircraft, however, are operated by the Islamic Republic of Iran Air Force could complicate the planning and execution of a coordinated air and TBM attack.[45]

Chinese Ballistic Missile Doctrine

In contrast to Iran, China's People's Liberation Army (PLA) has developed a doctrine for employing conventional TBMs as part of integrated military campaigns. The Second Artillery Corps was established in 1958, and until the early 1990s it was primarily concerned with nuclear-armed ballistic missiles.[46] With the fall of the Soviet Union and the development of precision-guided weapons, however, the Second Artillery added a conventional role that has expanded dramatically over the past two decades. [47] During this period, the PLA expended a great deal of effort on studying the American way of war and searching for ways to counter it. Chinese military writings identified command, control, communications, computers, intelligence, surveillance, and reconnaissance as well as logistics in general—and forward air bases in particular—as key US vulnerabilities.[48] PLA writers cite conventional ballistic missiles as especially effective for attacking air bases and discuss hitting them with ballistic and cruise missiles in addition to special operations forces and aircraft armed with precision-guided munitions.[49] Much of this writing has addressed Taiwanese air bases, but Second Artillery officers have suggested there "would be opportunities to launch missile strikes against the air force of an 'intervening superpower' in a Taiwan conflict."[50]

These types of attacks likely would come as part of a broader campaign. Two examples of campaigns from PLA doctrine with prominent roles for TBMs are the Joint Anti–Air Raid Campaign and the Joint Firepower Campaign.[51] The former envisions using attacks on adversary air bases as part of a broad effort including fighters, land- and sea-based surface-to-air missiles, and airborne early warning to prevent air strikes on the Chinese mainland.[52] The Joint Firepower Campaign envisions integrating precision strikes from air and missile forces to support anti-air-raid operations or other campaigns.

The Second Artillery serves as a critical enabler for many PLA operations. For example, in a Taiwan scenario, it could use its SRBMs to make a massed and simultaneous strike on all Taiwanese air force bases at the outset of the conflict.[53] The result of such a leading-edge attack could greatly simplify the air superiority mission of the People's Liberation Army Air Force (PLAAF) by pinning or destroying a large portion of the Taiwanese air force at the outset of the conflict. The US Air Force could face a similar fate were it to posture itself forward during a crisis, inviting preemption by parking large numbers of highly capable aircraft in the open within TBM and cruise missile range from China.[54] Conventional ballistic missiles serve as an enabling force for the PLAAF, filling a role similar to that of US Air Force stealth assets that can penetrate enemy air defenses early in a conflict and strike key points to enable follow-on attacks by more conventional aircraft.

Comparing Iranian and Chinese Doctrine

Realist international-relations theorists focus on capabilities rather than intentions since the latter are inherently uncertain, difficult to discern, and more quickly changeable than capabilities. On the one hand, in theory a cataclysmic event or sudden shift in threat perception could cause intentions to change overnight. On the other hand, developing, testing, and fielding a new military capability can take years. Concentrating on the capabilities of a potential adversary and ignoring intentions constitute a conservative, risk-averse approach that errs on the side of overestimating vulnerability. Given the stakes involved in potential wars, this approach is prudent. For this reason, this article first considered capabilities.

Addressing capabilities exclusively, however, can ignore the importance of organizational culture. How militaries talk and think about using force shapes their actual employment of capabilities. In the case of Iran and China, a stark contrast exists between how they have talked about the utility of conventional TBMs. Iran discusses them as a psychological deterrent with effects in excess of their physically destructive power while China's doctrine views them as a war-fighting capability expected to destroy military targets and thus attain objectives as part of an integrated military campaign. Both forces could be seen as deterrents, but the Iranian approach seeks to deter through cost imposition while the Chinese approach seeks to deter through denial. This difference implies that, without a major discontinuity (examined by the worst-case analysis in the following section), one would expect Iran to continue to develop a threat-in-being while China will continue to develop a war-fighting capability.[55]

Potential Basing Locations

Although the capabilities and inventories of TBMs can change, geography is largely immutable. The geography of SWA makes it more difficult for Iran to plan a TBM campaign against US air bases in SWA than for China to do so in the Western Pacific. SWA offers a host of possible basing locations. A total of 422 airfields with runways longer than 7,500 feet lie within 2,800 km of Iran.[56] Of these 422 runways, 331 remain outside Shahab 2 SRBM range (i.e., they face no effective military threat). As figure 4 illustrates, SWA offers not only a large number of airfields but also a great diversity in potential partners—in turn increasing the probability that at least one country would provide access to the United States.

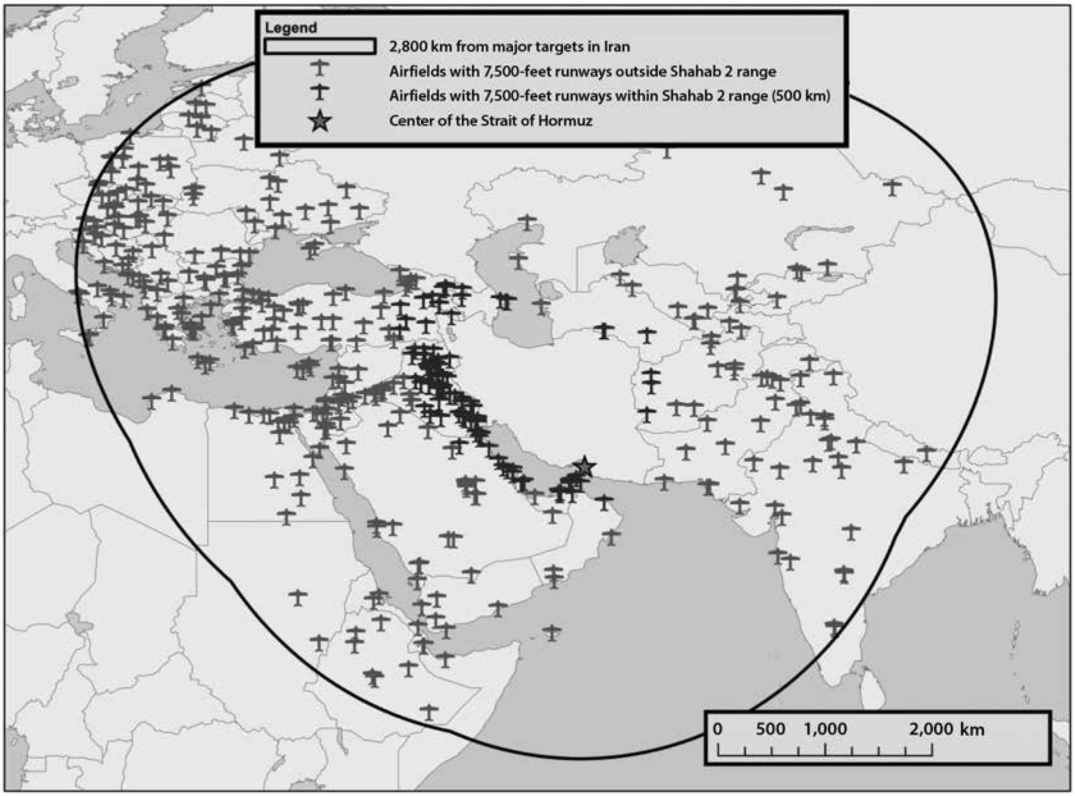

Figure 4. Airfields with 7,500-feet runways within 1,500 nautical miles of representative Iranian targets. (TBM ranges from table 1 and airfield locations from the Department of Defense's Automated Air Facility Information File.)

This article has demonstrated the limited capability of Iran's existing missile inventory, but that country could significantly improve its TBM capabilities, either through indigenous development or increased outside assistance. Therefore, it is important to understand how enhanced Iranian TBM capabilities would affect the vulnerability of US air bases and the ranges at which Iran could threaten air operations. To examine this situation, the following discussion first compares the capability of Iran's current TBM arsenal with the total number of runway and parking aim points on air bases within a given range from Iran.[57] Then, given the accuracies and inventories of each class of TBM, it calculates how many salvos could be fired against those aim points. Finally, the examination increases Iran's TBM arsenal to one comparable to that of China today and conducts the same analysis.

The results for Iran's current TBM arsenal are shown in figure 5. The light-shaded bars show the potential number of runway and parking-area aim points in a given range bin while the dark-shaded bars represent the fraction of those aim points that can be attacked.[58] Outside 500 km, Iran's current TBM capabilities do not pose a serious military threat because the Shahab 3 lacks the accuracy and inventory to compose even a single salvo against one runway aim point or parking area. Inside

500 km, Iran's existing capabilities can muster only a small number of salvos. A combination of missile defenses, hardened aircraft shelters, and combat engineering could further degrade the effectiveness of these salvos, enabling the US Air Force to weather them and then operate unimpeded. In short, Iran's current TBM capabilities represent a manageable threat to air bases within 500 km and effectively no threat to those outside that range.

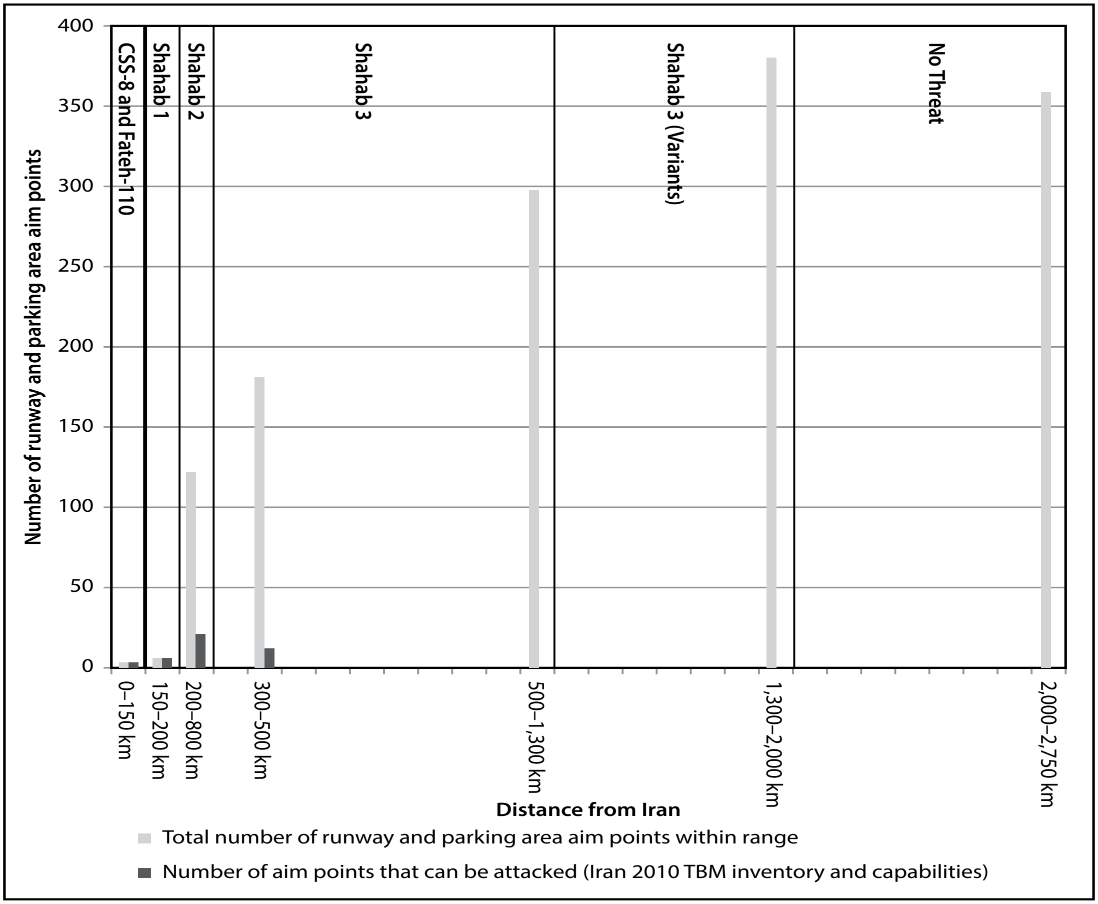

Figure 5. Iran's ability to attack runways and parked aircraft as a function of range (2010). (From author's analysis using Iranian TBM capabilities reported in table 1 and airfield locations from the Department of Defense's Automated Air Facility Information File.)

Iran's TBM capabilities could expand in many ways. Given that China has the most capable conventional TBM program in the world, equipping Iran with China's TBM force provides an extreme upper bound on the capabilities that Iran could plausibly possess in the next decade. If Iran had China's entire 2010 conventional TBM inventory, the threat to air bases would certainly grow but would still remain significantly less than the current missile threat in East Asia. As figure 6 shows, in this excursion, Iran could fire a salvo at every runway and parking aim point within 600 km of its border. Outside that range, however, the number of aim points increases dramatically while Iran's ability to attack them decreases because it has significantly fewer missiles able to range longer than 600 km. In short, inside 600 km, air bases would face a heavy threat, but those beyond that range would face a more limited number of potent salvos. If US Air Force aircraft were concentrated at a small number of bases outside 600 km but within 2,500 km, then Iran could mass multiple salvos against those bases. If, however, US forces could disperse across a number of bases outside 600 km and augment the resilience of these bases with active defenses and combat engineering capabilities, then it might still be possible to weather the limited number of salvos of Iran's expanded TBM arsenal. Although political access is always a contingent decision and difficult to predict, it is noteworthy that 314 airfields with runways of 7,500 feet or longer exist outside the most dangerous 600 km threat zone, representing a wide set of bases to which aircraft could disperse and thus dilute this threat. East Asian geography offers significantly fewer such dispersal air bases. The interaction between geography and TBM capability creates far more potential operating areas in SWA than in East Asia.

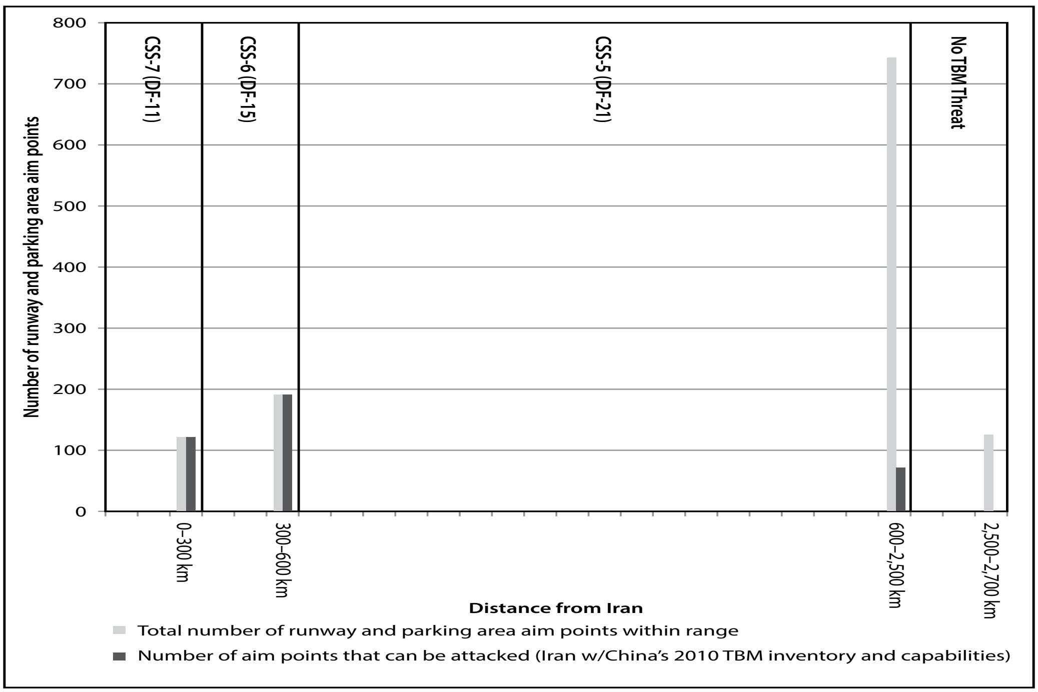

Figure 6. Iran's ability to attack runways and parked aircraft as a function of range if it had China's 2010 TBM inventory. (From author's analysis using Chinese TBM capabilities reported in table 2 and airfield locations from the Department of Defense's Automated Air Facility Information File.)

Potential basing options are much more constrained in East Asia, where China's highly capable TBM force can hold airfields at risk out to roughly 2,000 km.[59] As table

3 indicates, one needs only one reliable CSS-5 MRBM to attack a single runway or parking apron aim point with high confidence. That is, China could strike a single large air base (such as Kadena) or multiple small air bases with its estimated 2010 arsenal of 36 CSS-5s. In a Taiwan contingency, US airpower would play an important role.[60] Within 2,800 km of the center of the Taiwan Strait lie 112 airfields that have runways longer than 7,500 feet. As depicted in figure 7, only 4 of these 112 airfields are outside CSS-5 MRBM range.[61]

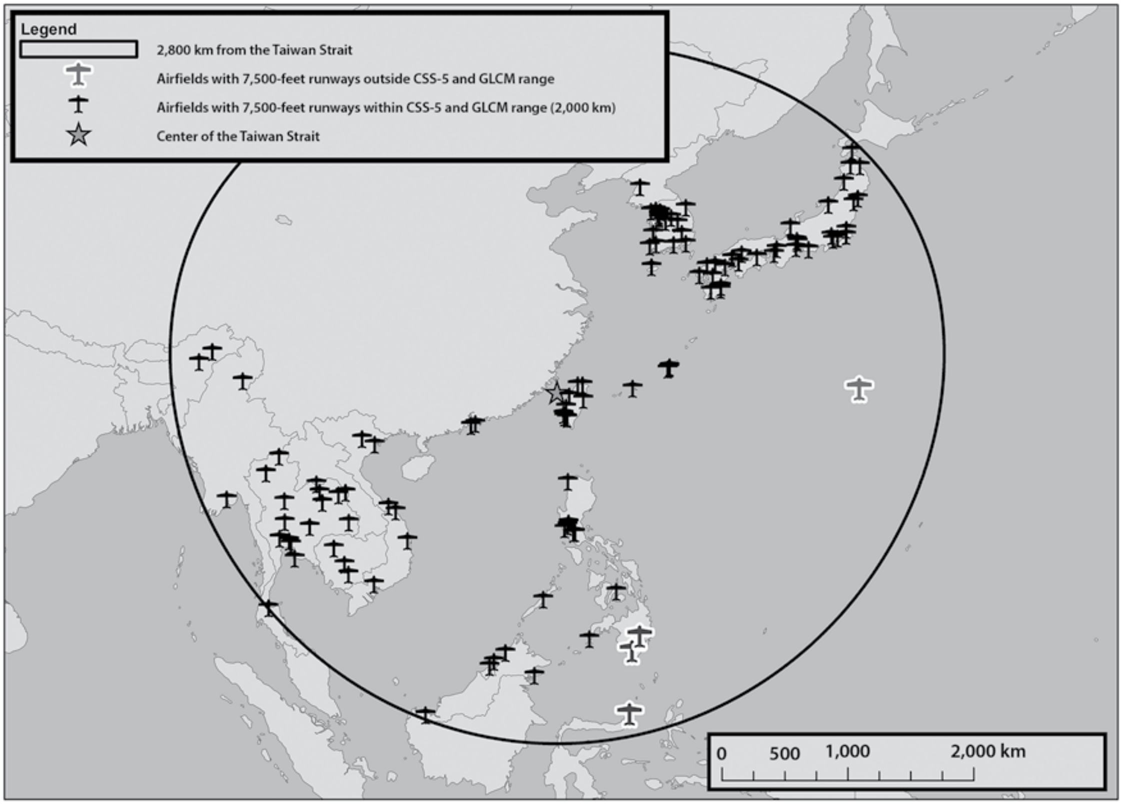

Figure 7. Airfields with 7,500-feet runways within 1,500 nautical miles of the Taiwan Strait. (TBM ranges from table 2 and airfield locations from the Department of Defense's Automated Air Facility Information File.)

Conclusion

A detailed analysis of the capabilities of Iran's existing ballistic missile force clearly indicates the size of the gulf between Iran's threat to US bases in SWA and China's in East Asia. Iranian claims to be able to "obliterate all . . . (US) bases" in SWA are bluster and bluff.[62] It would be prudent to avoid basing unsheltered aircraft within 500 km of Iran in the event of a conflict, but numerous US bases exist outside the 500 km range, beyond which Iran cannot mount an effective attack to shut down air operations. Consequently, military planners still have numerous options for basing fighters outside the effective TBM threat ring in SWA—an option that they do not have in East Asia. This fact also has implications for US force structure because the basing options in SWA mean that legacy short-range fighters can still contribute a great deal of combat power from comparative sanctuary. If every possible scenario were as contested as the one in East Asia in a US-China contingency, then the ability of short-range land-based fighters to contribute becomes more questionable.

Iran has previously made false claims about its military capabilities, but those concerning the ability of its TBMs to destroy regional air bases are particularly important to counter.[63] Pointing out the severe war-fighting limitations of its force undermines some of the coercive benefits that Iran seeks to reap from its investments in TBMs. If American partners believed Iran's bluff, then they could be intimidated into denying US access. Iran can still threaten TBM strikes on major cities as punishment for any country that does so, but it currently lacks a credible capability to deny US air operations. If Iran developed a nuclear warhead and integrated it onto an SRBM or MRBM, then this new capability would hold at risk unsheltered aircraft much further afield and would constitute a more potent punishment threat.[64]

Understanding the limited ability of Iran's TBMs to deny US air operations in SWA provides important context for the Department of Defense's investment decisions. Since the majority of SWA basing options exist outside the Iranian TBM threat ring, scarce funds to harden air bases should be allocated first to the Western Pacific, where China's growing TBM force presents a much greater concern.

Recognizing the limits of Iran's TBM force also illustrates a broader point about the variability of A2/AD threats around the world. Numerous studies and American defense policy documents list a host of countries developing A2/AD capabilities that challenge the ability of US military forces to operate.[65] Although there are serious concerns about the proliferation of precision to both nation-states and terrorists, significant differences remain between the capabilities that each challenger to American power could bring to bear.[66] The proliferation of advanced weaponry has broad consequences—such as increasing the number of scenarios during which the US Navy could expect to confront some form of antiship cruise missiles—but defense analysts should be careful to not overgeneralize. Overly broad definitions of the A2/AD issue can impede diagnosis. For example, without the quantitative analysis presented here, it would be difficult to recognize that the United States has far better prospects for simply operating outside the threat of TBMs in SWA than it does in East Asia.[67] Recognizing the regional variation in A2/AD can also counter an exaggerated sense of American decline. Although the United States confronts impediments to its projection of force in East Asia, this article's analysis illustrates that the prospects for safely basing fighters in SWA are much better than in East Asia.

To clearly understand the broader military challenge posed by Iran, American national security planners must recognize that Iranian claims about its TBM force's current ability to deny US air operations are a bluff. Prudence demands that defense analysts continue to closely monitor Iran's ongoing efforts to modernize its TBM force, but neither the American public nor the Iranian leadership should mistake this attention for intimidation. ✪

Notes

1. Secretary of Defense Chuck Hagel, "Reagan National Defense Forum Keynote," US Department of Defense, 15 November 2014, http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1903.

2. Department of Defense, *Quadrennial Defense Review Report* (Washington, DC: Department of Defense, February 2010), 9, http://www.defense.gov/QDR/QDR%20as%20of%2029JAN10%201600.pdf. The term *antiaccess* emerged in American defense circles in the early 1990s to describe a manner in which weaker adversaries might seek to blunt the advantage of US forces. See Roger Cliff et al., *Entering the Dragon's Lair: Chinese Antiaccess Strategies and Their Implications for the United States* (Santa Monica, CA: RAND Corporation, 2007), 3–6, http://www.rand.org/content/dam/rand/pubs/monographs/2007/RAND_MG524.pdf. By 2001 the broader category of antiaccess/area-denial (A2/AD) capabilities had gained currency within the Department of Defense. See Department of Defense, *Quadrennial Defense Review Report* (Washington, DC: Department of Defense, 30 September 2001), 30–32, 43–44, http://www.defense.gov/pubs/qdr2001.pdf. The A2/AD concept helped to focus research into potential future challenges for US forces. See, for example, Christopher J. Bowie, *The Anti-access Threat and Theater Air Bases* (Washington, DC: Center for Strategic and Budgetary Assessments, 2002); Andrew Krepinevich, Barry Watts, and Robert Work, *Meeting the Anti-access and Area-Denial Challenge* (Washington, DC: Center for Strategic and Budgetary Assessments, 2003). See also Air-Sea Battle Office, *Air-Sea Battle: Service Collaboration to Address Anti-access and Area Denial Challenges* (Washington, DC: Air-Sea Battle Office, May 2013), 2, http://www.defense.gov/pubs/ASB-Concept Implementation-Summary-May-2013.pdf.

3. Air-Sea Battle Office, *Air-Sea Battle: Service Collaboration*, 2.

4. Department of Defense, *Joint Operational Access Concept*, version 1.0 (Washington, DC: Department of Defense, 17 January 2012), 9–10, http://www.defense.gov/pubs/pdfs/JOAC_Jan%202012_Signed.pdf; Department of Defense, *Quadrennial Defense Review Report* (2010), 31–32; and Air-Sea Battle Office, *Air-Sea Battle: Service Collaboration*, 2.

5. See, for example, Department of Defense, *Quadrennial Defense Review Report* (2010), 31; Andrew F. Krepinevich, *Why AirSea Battle?* (Washington, DC: Center for Strategic and Budgetary Assessments, February 2010); Nathan Freier, "The Emerging Anti-access/Area-Denial Challenge," Center for Strategic and International Studies, 17 May 2012, http://csis.org/publication/emerging-anti-accessarea-denial-challenge; and John A. Tirpak, "Fighting for Access," *Air Force Magazine* 96, no. 7 (July 2013): 22–27. For a rare discussion that cited only Iran and not China, see Adm Jonathan W. Greenert and Gen Norton A. Schwartz, "Air-Sea Battle: Promoting Stability in an Era of Uncertainty," *American Interest*, 20 February 2012, http://www.the-american-interest.com/2012/02/20/air-sea-battle/.

6. A similar comparative methodology could be used to assess the cross-theater variation in other A2/AD threats, including surface-to-air missile capabilities, submarines, and mining capabilities.

7. Of course, this conclusion depends upon the open-source assessments used to evaluate the capabilities of Iranian missiles.

8. This conclusion follows directly from the limited accuracy, payloads, and ranges of Iran's missiles and does not factor in any American active missile defenses such as Terminal High Altitude Area Defense (THAAD) batteries, Patriot batteries, or sea-based SM-3 interceptors. Given that the United States and its partners possess these capabilities, it implies that air operations in the face of Iranian missile attack would be even *more* feasible than the analysis presented here would imply. Regarding US partners bolstering missile defenses, see David E. Sanger and Eric Schmitt, "U.S. Speeding Up Missile Defenses in Persian Gulf," *New York Times*, 30 January 2010, http://www.nytimes.com/2010/01/31/world/middleeast/31missile.html.

9. This analysis does not explore the potential coercive effect that Iran's threatened or actual attacks on Gulf Cooperation Council members or Israeli cities would have on whether regional states decide to grant the United States access to air bases.

10. Some investments that improve air base resilience, such as rapid runway repair kits, could be deployed to different regions. Others, such as permanent hardened aircraft shelters, are tied to specific locations.

11. "DoD News Briefing with Secretary Gates and Gen. Cartwright from the Pentagon," US Department of Defense, 17 September 2009, http://www.defense.gov/transcripts/transcript.aspx?transcriptid=4479.

12. Media coverage of tensions in SWA frequently cite the Iranian ballistic missile threat. See, for example, "Iran Missiles Can Hit All US Bases in Region: Cmdr.," Press TV, 4 July 2012, http://www.presstv.ir/detail/2012/07/04/249305/iran-missiles-can-easily-hit-us-bases/; Oren Dorell, "Experts Say Iran's Missile Arsenal Poses Threat to U.S.," *USA Today*, 25 September 2012, 8; and Anthony Capaccio, "Iran's Ballistic Missiles Improving, Pentagon Finds," Bloomberg, 10 July 2012, http://www.bloomberg.com/news/2012-07-10/iran-improves-ballistics-missiles-to-target-ships.html.

13. Department of Defense, *Quadrennial Defense Review Report* (2010), 31.

14. In its 2012 report to Congress on Iranian military power, the Department of Defense assessed that "Iran has boosted the lethality and effectiveness of existing [ballistic missile] systems" and concluded that "short-range ballistic missiles provide Tehran with an effective mobile capability to strike partner forces in the region." Department of Defense, "Annual Report on Military Power of Iran" (Washington, DC: Department of Defense, April 2012), 1, 4, https://fas.org/man/eprint/dod-iran.pdf.

15. See Alan Vick, "Challenges to the American Way of War" (presentation at Global Warfare Symposium, Los Angeles, CA, 17 November 2011).

16. For example, in July 2012, Iran conducted a military drill that included ballistic missile strikes on a mock air base target. The commander of its Islamic Revolution Guards Corps Aerospace Force detailed contingency plans for Iran to strike US bases in the opening minutes of a conflict, going so far as to claim that Iran could "obliterate" all US bases in SWA. See "Iran Missiles Can Hit"; and Jeremy Binnie, "Iran Demonstrates Accuracy of Ballistic Missiles," *Jane's Defense Weekly*, 4 July 2012.

17. Qualitative discussions of the Iranian TBM threat to air bases generally conclude that although Iranian missiles cannot hit point targets due to their poor accuracies, they do threaten soft targets such as unsheltered aircraft and area targets. See, for example, William D. O'Malley, *Evaluating Possible Airfield Deployment Options: Middle East Contingencies* (Santa Monica, CA: RAND Corporation, 2001), 27–29; Jeffrey White, "What Would War with Iran Look Like?," *American Interest*, July/August 2011, http://www.the-american-interest.com/article-bd.cfm?piece=982; Anthony H. Cordesman and Alexander Wilner, "Iran and the Gulf Military Balance—II: The Missile and Nuclear Dimensions," working draft (Washington, DC: Center for Strategic and International Studies working draft, 16 July 2012); Krepinevich, *Why AirSea Battle?*, 34; and Mark Gunzinger with Chris Dougherty, *Outside-In: Operating from Range to Defeat Iran's Anti-access and Area Denial Threats* (Washington, DC: Center for Strategic and Budgetary Assessments, 2011), 38. There have been few operational tests of the claim that US bases are vulnerable to Iranian TBM attack, the major exception being an International Institute for Strategic Studies (IISS) net assessment which concluded that Iran's TBMs would probably not be capable of shutting down critical military activities at large military targets like airfields and seaports. See IISS, *Iran's Ballistic Missile Capabilities: A Net Assessment* (London: IISS, 10 May 2010), 139. However, even this highly technical analysis did not explicitly calculate how much damage Iran could do to key elements of an air base (such as runways and parking ramps) at varying distances from Iran. Furthermore, quantitative studies have focused on the TBM threat to energy infrastructure. See, for example, Joshua R. Itzkowitz Shifrinson and Miranda Priebe, "A Crude Threat: The Limits of an Iranian Missile Campaign against Saudi Arabian Oil," *International Security* 36, no. 1 (Summer 2011): 167–201. Moreover, some analyses have narrowly examined the threat that generic TBMs could pose to unsheltered aircraft. See John Stillion and David T. Orletsky, *Airbase Vulnerability to Conventional Cruise-Missile and Ballistic-Missile Attacks: Technology, Scenarios, and U.S. Air Force Reponses* (Santa Monica, CA: RAND Corporation, 1999).

18. A common measure of accuracy is circle error probable (CEP). A weapon's CEP describes a radius within which a weapon lands 50 percent of the time. For example, on average, a missile with a CEP of 100 m will land within 100 m of its aim point 50 percent of the time. Iran's Scuds have CEPs in the hundreds of meters. See Jane's Defense International, "Shahab 1 (R-17 (SS-1C 'Scud B') Variant)," *Jane's Strategic Weapons Systems*, 11 December 2013.

19. Standard nomenclature categorizes missiles with a range of less than 1,000 km as SRBMs, 1,000–3,000 km as MRBMs, 3,000–5,500 km as IRBMs, and in excess of 5,500 km as ICBMs.

20. The Shahab design shares essential characteristics with the North Korean No Dong and the Pakistani Ghauri. See Jane's Defense International, "Hatf 5 (Ghauri)," *Jane's Strategic Weapons Systems*, 24 August 2011; and Jane's Defense International, "Shahab 3/4 (Ghadr-1)," *Jane's Strategic Weapons Systems*, 12 February 2012.

21. See note 18 for an explanation of CEP.

22. Scud/Shahab designs use kerosene as a propellant and inhibited red fuming nitric acid (IRFNA) as an oxidizer, but the BM-25 reportedly uses unsymmetrical dimethalhydrazine (UDMH) as a propellant and hydrogen oxide (H2O4) as an oxidizer. Although hydrazine is more energetic than kerosene (a fuel tank full of UDMH can propel a missile further than one full of kerosene), it is extremely toxic and requires extensive safety precautions during fueling. For this reason, it has been used for applications (such as space launch) where launch sites are fixed and timelines can accommodate appropriate safety precautions or in cases in which the missile can be fueled and then stored (e.g., in a sealed launch tube on a submarine). For more on the strengths and weaknesses of various rocket propellants, see John Clark, *Ignition! An Informal History of Liquid Rocket Propellants* (New Brunswick, NJ: Rutgers University Press, 1972). Ballistic missile analysts actively debate whether the BM-25 is an actual missile or some form of deception. See Markus Schiller, *Characterizing the North Korean Nuclear Missile Threat* (Santa Monica, CA: RAND Corporation, 2012).

23. For forecasts of increased accuracy for Iran's TBMs, see Frederic Wehrey et al., *Dangerous but Not Omnipotent: Exploring the Reach and Limitations of Iranian Power in the Middle East* (Santa Monica, CA: RAND Corporation, 2009), 66; Krepinevich, *Why AirSea Battle?*, 35; and Gunzinger and Dougherty, *Outside-In*, 94.

24. Another conventional variant, the DF-21D, has an antiship mission. See Andrew S. Erickson and David D. Yang, "Using the Land to Control the Sea? Chinese Analysts Consider the Antiship Ballistic Missile," *Naval War College Review* 62, no. 4 (Autumn 2009): 53–86.

25. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China, 2010* (Washington, DC: Department of Defense, 2010), 44, http://www.defense.gov/pubs/pdfs/2010_CMPR_Final.pdf.

26. China does currently possess the nuclear-armed, liquid fueled DF-3/CSS-2 IRBM. See Jane's Defense International, "DF-3 (CSS-2)," *Jane's Strategic Weapons Systems*, 26 June 2009. Regarding planned IRBMs, see Doug Richardson, "China Plans 4,000 km-Range Conventional Ballistic Missile," *Jane's Missiles & Rockets*, 1 March 2011.

27. Office of the Secretary of Defense, *Annual Report to Congress: Military Power of the People's Republic of China, 2009* (Washington, DC: Office of the Secretary of Defense, 2009), http://www.defense.gov/pubs/pdfs/China_Military_Power_Report_2009.pdf; and Department of Defense, *Annual Report to Congress* (see note 25).

28. These calculations assume perfect missile reliability, no target location error, and equal variance in x and y error. In short, only the missile's inaccuracy would cause it to miss the target. These assumptions are biased in Iran's favor. The single-shot probability of hit (SSPh) is calculated using a standard formula: SSPh = 1- 0.5^(R^2/CEP^2) where R is the radius of the target and CEP is the missile accuracy. Cumulative probability Ph = 1-(1-SSPh)^N where N is the number of missiles fired. See J. S. Przemieniecki, *Mathematical Methods in Defense Analyses* (Reston, VA: American Institute of Aeronautics and Astronautics, 2000), 38.

29. If the Iranians were to adopt a concept of operations (CONOPS) for air base attack similar to that of the PLA, they might focus on first damaging runways to prevent aircraft from taking off and then stage a follow-on attack to destroy the aircraft that have been pinned at the base. For details on Chinese air base attack CONOPS, see Cliff et al., *Entering the Dragon's Lair*, 81.

30. The precise MOS for an aircraft depends upon a host of factors, including its munitions and fuel loads, the weather, and the altitude of the air base. See Air Force Pamphlet 10-219, vol. 4, *Rapid Runway Repair Operations*, 28 May 2008, http://static.e-publishing.af.mil/production/1/af_a4_7/publication/afpam10-219v4/afpam10-219v4.pdf.

31. This is based upon the US Air Force's BLU-67 antirunway bomb, a 4.5 kilogram (kg) penetrating submunition carrying 2.75 kg of high explosives. See Jane's Defense International, "Penetrating and Area Denial Bombs," *Jane's Air-Launched Weapons*, 18 March 2005.

32. This analysis assumes only a single runway at the airfield—one that it is short enough (say, 7,000 feet) that if a single section is damaged in its center (i.e., 3,500 feet from each end of the runway), then there will be no 5,000-feet-long fighter MOS left. In other words, the attacker has only a single aim point. Later we discuss the case involving multiple runway aim points at a base.

33. In fact, the challenge is even greater because the cumulative probability of all four attacks succeeding is 0.75^4 = 0.32. In order for the probability of shutting down all of the MOSs on Al Dhafra to be 75 percent, the salvo fired at each of the four cut points would have to have an individual probability

of success of 0.93. This would require firing a salvo of 25 Shahab 1s at each cut point, for a total raid size of 100 TBMs.

34. To have more than a 75 percent chance of successfully damaging a runway aim point, Iran must fire 13 Shahab 1 SRBMs at once. If it wished to attack two runway aim points simultaneously, then it would have to launch 26 Shahab 1s simultaneously, requiring 26 launchers. Since it has only 12–18 launchers, it could not attack two runway aim points simultaneously.

35. See Stillion and Orletsky, *Airbase Vulnerability*.

36. This assumes that 75 percent of missile payload is given to submunitions, that each submunition weighs 1 pound, and that they are spaced so that every fighter-sized aircraft, on average, will be within 15 feet of 3 submunitions. For a nominal missile payload of 1,760 pounds (800 kg), this means that the TBM will carry 1,320 1-pound submunitions. If we wish to space these submunitions so that every point inside the submunition dispersal pattern is no more than 15 feet away from a submunition, then we can calculate the TBM's submunition dispersal radius with the following formula: Rd = R*((3*(3^0.5)*N)/(2**pi*))^0.5 where Rd is the TBM's submunition dispersal radius, R is the maximum distance between two submunitions, and N is the number of submunitions. In this case, Rd is about 495 feet—that is, each arriving TBM covers 771,629 square feet with submunitions. Paul Dreyer derived this equation at RAND in 2010.

37. Even firing Iran's entire ballistic missile arsenal at regional cities would probably create less than a few hundred casualties. See IISS, *Iran's Ballistic Missile Capabilities*, 133.

38. Operating procedures and terrain play a large role in the actual difficulty of finding a mobile erector launcher or transporter erector launcher once it is in the field.

39. Anthony Cordesman and Abraham Wagner, *The Lessons of Modern War*, vol. 2, *The Iran-Iraq War* (London: Mansell Publishing, 1990) 499–502.

40. Wehrey et al., *Dangerous but Not Omnipotent*, 65.

41. Ibid., 41.

42. See ibid., 51. Some Gulf Cooperation Council officials have expressed concern over the threat that ballistic missiles pose to their economies and stability. See ibid., 147–48.

43. Ibid., 70.

44. Lionel Beehner and Greg Bruno, "Iran's Involvement in Iraq," Council on Foreign Relations, 3 March 2008, http://www.cfr.org/iran/irans-involvement-iraq/p12521.

45. Fariborz Haghshenass, "Iran's Air Forces: Struggling to Maintain Readiness," policy no. 1066, Washington Institute, 22 December 2005, http://www.washingtoninstitute.org/policy-analysis/view/irans-air-forces-struggling-to-maintain-readiness.

46. Kenneth Allen and Maryanne Kivlehan-Wise, "Implementing PLA Second Artillery Doctrinal Reforms," in *China's Revolution in Doctrinal Affairs: Emerging Trends in the Operational Art of the Chinese People's Liberation Army*, ed. James Mulvenon and David Finkelstein (Alexandria, VA: CNA Corporation, 2005), 159–200.

47. Michael Chase, Andrew Erickson, and Christopher Yeaw, "Chinese Theater and Strategic Missile Force Modernization and Its Implications for the United States," *Journal of Strategic Studies* 32, no. 1 (February 2009): 67–144.

48. Thomas Mahnken, "China's Anti-access Strategy in Historical and Theoretical Perspective," *Journal of Strategic Studies* 34, no. 3 (June 2011): 299–323.

49. Cliff et al., *Entering the Dragon's Lair*, 62–64.

50. Ibid., 64.

51. Cortez A. Cooper, *Testimony: Joint Anti-access Operations; China's 'Systems-of-Systems' Approach* (Santa Monica, CA: RAND Corporation, 2011), http://www.rand.org/content/dam/rand/pubs/testimonies/2011/RAND_CT356.pdf.

52. Michael Chase and Andrew Erickson, "The Conventional Missile Capabilities of China's Second Artillery Force: Cornerstone of Deterrence and Warfighting," *Asian Security* 8, no. 2 (July 2012): 120, 122.

53. David A. Shalapk et al., *A Question of Balance: Political Context and Military Aspects of the China-Taiwan Dispute* (Santa Monica, CA: RAND Corporation, 2009), http://www.rand.org/content/dam/rand/pubs/monographs/2009/RAND_MG888.pdf.

54. Credit for this point goes to my colleague Alan Vick who generously shared his insight on crisis stability in this context.

55. Iranians' public statements that they plan to attack US air bases do not necessarily invalidate this perspective. A plausible Iranian strategy would be to bluff regarding the capabilities of their missiles in the hopes that doing so might deter the United States from resorting to force or might deter regional states from providing access to the United States for fear of becoming a target.

56. The figure 2,800 km represents a nominal outer boundary at which single-seat fighters could conduct operations. Supported by aerial refueling, fighters can operate at significant distances. Daily flight-duty limits for single-seat aircraft are 12 hours, which include preflight time. Assuming two hours of preflight, a block speed of 500 knots, and 4 hours on station leads to a total time of 12 hours at a radius of 1,500 nautical miles or about 2,800 km. The length of an airfield's runway is only one factor in determining its suitability. Many other factors affect the usefulness of an airfield for military operations, including fuel storage, munitions storage, parking area, and runway strength. The United States also possesses expeditionary capabilities that enable it to rapidly expand the infrastructure of an airfield to enable operations from it. To simplify this illustration, however, this article uses runway length as a filter to estimate the number of useful airfields.

57. Calculation of the number of runway aim points is based upon a simple formula: Ap = Rounddown(RW/5,000) where Ap is number of aim points per runway, RW is the length of the runway in feet, and 5,000 is the length of a nominal fighter MOS in feet. Because of the difficulty of getting high-resolution parking-area data for all of these airfields, we assume that each airfield has only two parking-apron aim points. This underestimate is very conservative because many airfields in the region would require more than two submunition-armed TBMs to cover all of their aircraft parking areas.

58. Of course, it is implausible that the US Air Force would be based at all of the air bases within a given range bin, but it is also implausible that Iran would fire only a single salvo at an air base. For example, runways must be reattacked because combat engineers can repair damaged sections of runway to reopen an MOS.

59. Department of Defense, *Annual Report to Congress*, 32 (see note 25).

60. Shlapak et al., *Question of Balance*.

61. All of these bases in East Asia are within range of Chinese air-launched cruise missiles delivered by medium-range H-6 bombers. See Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China* (Washington, DC: Office of the Secretary of Defense, 2013), 81.

62. "Iran Missiles Can Hit."

63. For example, Iran unveiled a purported stealth fighter in early 2013 that was widely debunked as a fake. See, for example, Jeremy Binnie, "Iran Unveils 'Stealth Fighter'," *Jane's Defense Weekly*, 4 February 2013. It is also important to temper concerns voiced by American defense analysts regarding the potential threat to air bases from Iranian TBMs.

64. If Iran developed a nuclear warhead and integrated it onto an SRBM or MRBM, then this new capability would threaten unsheltered aircraft much further afield, representing a more credible punishment threat. Nuclear-armed ballistic missiles would be less dependent upon precision to destroy their targets, but Iranian leaders would likely have a higher threshold for their use; consequently, threats to use them in minor crises would be less credible.

65. Examples include the 2010 *Quadrennial Defense Review Report*, which cites China, North Korea, Iran, and Hezbollah as A2/AD challenges (pages 31–32); the 2012 Defense Strategic Guidance, which states that China and Iran "will continue to pursue asymmetric means to counter [American] power projection capabilities" (Department of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* [Washington, DC: Department of Defense, January 2012], 4); and a 2012 article coauthored by the chief of naval operations and the Air Force chief of staff that cites China, Iran, and Hezbollah as A2/AD challenges (Greenert and Schwartz, "Air-Sea Battle").

66. Randy Huiss, *Proliferation of Precision Strike: Issues for Congress*, CRS Report R42539 (Washington, DC: Congressional Research Service, 14 May 2102), http://fas.org/sgp/crs/nuke/R42539.pdf; and James Bonomo et al., *Stealing the Sword: Limiting Terrorist Use of Advanced Conventional Weapons* (Santa Monica, CA: RAND Corporation, 2007).

67. For example, a recent study of the Iranian A2/AD issue concluded that in the future, US forces would need to be able to "fight from extended ranges." Gunzinger and Dougherty, *Outside-In*, 94. As this article has shown, however, air bases more than 500 km away from Iran currently enjoy effective

sanctuary from Iranian TBM attack. Therefore, many basing options exist, and although they are further away than some other locations, they remain well within the effective combat radius of US fighters.

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