

Closing Time

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Assessing the Iranian Threat to the Strait of Hormuz

Iranian closure of the Strait of Hormuz tops the list of global energy security nightmares.¹ Roughly 90 percent of all Persian Gulf oil leaves the region on tankers that must pass through this narrow waterway opposite the Iranian coast, and land pipelines do not provide sufficient alternative export routes.² Extended closure of the strait would remove roughly a quarter of the world's oil from the market, causing a supply shock of the type not seen since the glory days of OPEC. Even if the strait were not closed in the sense of being physically barricaded, military conflict in the area could cause prices to skyrocket in anticipation of a supply disruption—and to remain high until markets could be assured that the flow of commerce had been restored. Consider that when Iraq invaded

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1. See John Deutch and James R. Schlesinger, *National Security Consequences of U.S. Oil Dependency*, Independent Task Force Report, No. 58 (Washington, D.C.: Council on Foreign Relations, 2006), pp. 23, 68; and Eric V. Larson, Derek Eaton, Paul Elrick, Theodore Karasik, Robert Klein, Sherril Lingel, Brian Nichiporuk, Robert Uy, and John Zavadil, *Assuring Access in Key Strategic Regions: Toward a Long-Term Strategy* (Santa Monica, Calif.: Arroyo Center, RAND, 2004), p. xvii.

2. In 2006 approximately 17 million barrels per day (bbl/d) of oil transited the Strait of Hormuz. There is only one pipeline alternative, which runs east to west across Saudi Arabia to the Red Sea port of Yanbu. Its capacity is only about 5 million bbl/d, and about a quarter of that is in use, leaving slightly fewer than 4 million bbl/d of slack—hardly enough to compensate for closure of the strait. The United Arab Emirates is planning to build a pipeline carrying its oil to a port in the Gulf of Oman, but this pipeline would carry only 1.5 million bbl/d. Other Persian Gulf countries periodically express interest in building a larger 5 million bbl/d pipeline that would enable them to bypass the strait and offload oil at Oman. Details on its potential route remain unresolved, and building it would take more than a decade. Plans for such pipelines have fallen through in the past. “Gulf Governments Plan Oil Pipelines That Could Lessen Possible Iranian Threats,” Associated Press Financial Wire, March 20, 2007; “News in Brief,” *Petroleum Economist*, December 1, 2006, p. 40; and Energy Information Administration, “Persian Gulf Region,” Country Analysis Briefs (Washington, D.C.: U.S. Department of Energy, June 2007), <http://www.eia.doe.gov/emeu/cabs/pgulf.html>.

Kuwait in 1990, temporarily halting the export of oil in both countries, the world price of oil more than doubled merely on the expectation of future shortages. Although excess global supply combined with increased Saudi production helped lower the price within a few months, it did not return to the preinvasion level for nearly a year.³ Blockage of the strait would pose a vastly greater threat to the flow of gulf oil, and at a time when excess global capacity is lower and the price of oil higher.⁴

Yet could Iran close the Strait of Hormuz? What might provoke Iran to take an action so contrary to its own economic interests? Does Iran possess the military assets needed to engage in a campaign in the strait, and what might such a campaign look like? Perhaps more important, what would the U.S. military have to do to defend the strait in the event of Iranian interference there? What would be the likely cost, length, and outcome of such efforts?

Despite consensus on the importance of the strait, no open-source analysis has attempted to answer these questions systematically.⁵ Some analysts take the Iranian ability to block the strait as a given, whereas others are equally confident the United States' military superiority would deter or quickly end any Iranian campaign.⁶ One observer argues that "countering any Iranian blockade might involve only a few days of fighting, with major disruption to shipping lasting only slightly longer."⁷ Another warns that the United States might have to engage in weeks or months of military operations to open and defend the strait.⁸ Anthony Cordesman, a highly respected expert on the Persian Gulf,

3. Francisco Parra, *Oil Politics: A Modern History of Petroleum* (London: I.B. Tauris, 2004), pp. 305–306.

4. On the economic impact of oil prices, see James D. Hamilton, "Oil and the Macroeconomy since World War II," *Journal of Political Economy*, Vol. 91, No. 2 (April 1983), pp. 228–248; and Donald W. Jones, Paul N. Leiby, and Inja K. Paik, "Oil Price Shocks and the Macroeconomy: What Has Been Learned since 1996," *Energy Journal*, Vol. 25, No. 2 (April 2004), pp. 1–32.

5. One exception is Anthony H. Cordesman, "Iran, Oil, and the Strait of Hormuz," CSIS Brief (Washington, D.C.: Center for Strategic and International Studies, March 26, 2007), pp. 1–7.

6. For the former, see Simon Jenkins, "If This Is Ahmadinejad's Bluff, It Is Bluff Worth Calling," *Guardian*, May 10, 2006; and James Jay Carafano, William W. Beach, Ariel Cohen, Lisa Curtis, Tracy L. Foertsch, Alison A. Fraser, Ben Lieberman, and James Phillips, "If Iran Provokes an Energy Crisis: Modeling the Problem in a War Game," Center for Data Analysis Report, No. 07-03 (July 25, 2007), <http://www.heritage.org/Research/EnergyandEnvironment/cda07-03.cfm>. For the latter, see Dennis Blair and Kenneth Lieberthal, "Smooth Sailing: The World's Shipping Lanes Are Safe," *Foreign Affairs*, Vol. 86, No. 3 (May/June 2007), pp. 7–13.

7. Simon Henderson, "Facing Iran's Challenge: Safeguarding Oil Exports from the Persian Gulf," *Policy Watch*, No. 1112 (Washington, D.C.: Washington Institute for Near East Policy, June 7, 2006), <http://www.washingtoninstitute.org/templateC05.php?CID?2477>.

8. Joris Janssen Lok, "Western Navies Eye New Tech to Defeat Mines," *Aviation Week & Space Technology*, April 27, 2007, http://www.aviationweek.com/aw/generic/story_generic.jsp?channel?dti&id?news/dtMINE0407.xml&headline?Western%20Navies%20Eye%20New%20Tech%20to%20Defeat%20Mines.

concludes that “Iran could not ‘close the Gulf’ for more than a few days to two weeks,” although what leads him to this conclusion is unclear.⁹ Meanwhile, the director of the Defense Intelligence Agency, Vice Adm. Lowell Jacoby, testified in 2005 that Iran has some capability to “briefly close” the strait, without defining what “briefly” means.¹⁰ In short, analysts disagree about the potential likelihood, course, and outcome of U.S.-Iranian conflict in the Strait of Hormuz, but the nature of current debate on the subject makes it hard to ascertain the basis of differing assessments, much less determine which might be correct.

This article attempts to remedy these deficits through an open-source analysis of the potential interaction of Iranian and U.S. military forces in the strait. This type of analysis has its limits. It cannot draw on classified information. It cannot say much about intentions, only apparent capabilities. It cannot predict how a particular war will turn out, because such outcomes often depend on a host of nonmilitary factors. What it can do is encourage rigor in the public debates that inevitably occur, by showing how different assumptions and data about military capabilities generate different predictions about the parameters of potential conflict. From these results come different policy implications. Analysts may still disagree, but at least they and those listening to them can ascertain the basis of their differences.

The analysis presented here suggests that the notion that Iran could truly blockade the strait is wrong—but so too is the notion that U.S. operations in response to any Iranian action in the area would be short and simple. The key question is not whether Iran can sink dozens of oil tankers, which would be difficult. Tankers are resilient targets. Their immense size, internal compartmentalization, and thick hull plates allow them to survive hits by mines and missiles that would sink warships. Their crude oil absorbs the impact of an explosion and is difficult to ignite.¹¹ Historically, their captains have proven receptive to the strong financial incentives to sustain shipping.¹²

The question is whether Iran can harass shipping enough to prompt U.S. intervention in defense of the sea-lanes. Given that the United States has staked

9. Anthony H. Cordesman and Martin Kleiber, *Iran's Military Forces and Warfighting Capabilities: The Threat in the Northern Gulf* (Washington, D.C.: CSIS Press, 2007), p. 201.

10. Vice Adm. Lowell E. Jacoby, “Current and Projected National Security Threats to the United States,” testimony before the Senate Select Committee on Intelligence, 109th Cong., 1st sess., February 16, 2005, <http://www.investigativeproject.org/documents/testimony/317.pdf>.

11. Martin S. Navias and E.R. Hooton, *Tanker Wars: The Assault on Merchant Shipping during the Iran-Iraq Crisis, 1980–1988* (New York: I.B. Tauris, 1996), p. 86.

12. *Ibid.*

its credibility on promises to do just that, this is a threshold that Iran's significant and growing littoral warfare capabilities can cross, even with fairly conservative assumptions about Iranian capabilities.¹³ In particular, Iran possesses a larger stockpile of missiles and mines ten times as powerful as those used in the tanker wars of the 1980s, the last period of sustained naval conflict in the gulf. If Iran managed to lay even a relatively small number of these mines in the strait, the United States certainly would act to clear the area. But the experience of past mine-warfare campaigns suggests that it could take many weeks, even months, to restore the full flow of commerce, and more time still for the oil markets to be convinced that stability had returned.

More important, once the United States decided to clear the strait of mines, the potential for further military escalation would be high, especially given U.S. casualty sensitivity. The United States' mine warfare assets are designed to be used only in permissive—that is, nonthreatening—environments. The United States would want to locate and destroy any sources of Iranian fire on its mine countermeasure (MCM) ships. In particular, it would want to eliminate Iran's land-based, antiship cruise missile (ASCM) batteries and targeting radars, which are mobile and likely protected by Iranian air defenses. The aerial hunt for these assets could add days, weeks, or even months to the time needed to clear the strait, and quickly develop into a large and sustained air and naval campaign, depending on Iran's strategy for expending the missiles and its skill in hiding the batteries and radars. The United States might then face the dilemma of continuing this difficult search, or ending it by engaging in an even broader coercion campaign against other targets in Iran or escalating to the use of ground forces. These options would be about as palatable to the United States as they would be comforting to the world oil markets.

This article proceeds in five parts. The first section provides background on the strait's geography and how and why Iran might take advantage of it to conduct an integrated littoral campaign using mines, antiship cruise missiles, and land-based air defense. The next three sections analyze each of these components of a potential Iranian campaign, as well as potential U.S. responses to them. The focus is on current capabilities, although the article notes how plausible future changes would alter the analysis. The concluding section discusses the implications for U.S. policy toward Iran and U.S. force structure more generally.

13. On U.S. promises, see David E. Sanger, "On Carrier in Gulf, Cheney Warns Iran," *New York Times*, May 11, 2007.

Background

The Strait of Hormuz is the sole waterway leading out of the Persian Gulf. All tankers carrying oil must pass through it to deliver or retrieve oil from Persian Gulf ports. Iran controls the strait's northern coast, while Oman and the United Arab Emirates own the southern coast. The entire strait is only 180 kilometers long, and at its narrowest points only about 45 kilometers wide. It contains two shipping lanes used for large vessels. The channels are each 3.2 kilometers wide, with a 3.2-kilometer buffer zone between them. The northern channel is within only a few dozen kilometers of the Iranian coast.

The coast contains few major cities but many small towns connected by paved and gravel road networks. Most of the coastal terrain near the strait consists of flat beaches followed by the beginnings of the Zagros mountains. Its ridges go several hundred kilometers inland and range up to about 2,000 meters in height, with valleys in between. The terrain opposing the easternmost portion of the strait is considerably flatter, although there are still some elevations up to about 1,500 meters.¹⁴ The climate is generally hot, with varying degrees of visibility. Sandstorms are not uncommon inland, and high humidity over the gulf and 1 to 2 miles inland can lead to significant cloud cover.

THE IRANIAN NAVY

Iran's regular navy includes 18,000 active-duty sailors, as well as another 20,000 in the Islamic Revolutionary Guard Corps Navy (IRGCN).¹⁵ Iran is not lacking in locations from which to initiate naval combat in the gulf, especially the Strait of Hormuz. The navy has bases all along the coast, including a large naval air station and operational headquarters at Bandar Abbas directly north of the strait. Iran also has nearly a dozen domestic ports facing the strait, and the IRGCN has military outposts on islands close to the strait: Abu Musa, Larak, and Sirri. Iran uses these islands as forward bases for in-shore patrol craft. Presurveyed missile and air defense sites are also visible in satellite imagery of the southern coast of Larak, facing the strait. Iran claims two other is-

14. Information taken from *IRAN 2004*, road map of Iran by Gitashenasi Geographical and Cartographic Institute, available from author; Google Earth; Michael Eisenstadt, "Iranian Military Power: Capabilities and Intentions," Policy Paper, No. 42 (Washington, D.C.: Washington Institute for Near East Policy, 1996), pp. 61–62; and "Southwest Asia I: Iran, Iraq, Kuwait, and Saudi Arabia," edition C, Interschool Subcourse IS 3008 (Fort Huachuca, Ariz.: U.S. Army Intelligence Center, March 1999), <http://www.globalsecurity.org/military/library/policy/army/accp/is3008/index.html>.

15. International Institute for Strategic Studies (IISS), "The Middle East and North Africa," *The Military Balance, 2008* (London: IISS, 2008), p. 243.

lands, the Greater and Lesser Tunbs, which sit between the channels in the west. Additionally, Iran controls Qeshm, a large populated island about a dozen kilometers off its coast, directly adjacent to the strait.¹⁶

MOTIVES FOR ACTION IN THE STRAIT

Historically, Iran has recognized that closing the strait would be the military equivalent of cutting off its nose to spite its face. Not only would such a move deprive Iran of vital oil revenue, but it also would invite international intervention. Even during the 1980–88 Iran-Iraq War, when Iran sought to block the passage of oil tankers to and from the Arab states, it exercised restraint. It attacked shipping primarily in the western gulf, closer to the Shatt al-Arab. Only there and in United Arab Emirate waters did Iran lay mines, and not in large numbers. Its activities in and around the strait were confined to intrusive ship boardings and inspections of cargo bound for Iraq. The IRGCN often followed this activity with night-time small arms fire at ships encountered the previous day. Late in the war, Iran installed ASCM batteries at several locations facing the strait, but it never fired them at traffic in the area—even after the U.S.S. *Vincennes* accidentally shot down an Iranian passenger airline in 1988.¹⁷

Many events catastrophic enough to drive Iran to block the strait—say, a U.S. nuclear attack on the Iranian homeland—also would destroy many of the Iranian military capabilities needed to undertake the campaign. Recent media leaks indicate that even a conventional U.S. attack on Iranian nuclear facilities would be designed in such a way as to preemptively destroy the majority of the assets needed to lash out in the strait.¹⁸ That said, a more limited U.S. attack or an Israeli attack might produce a vengeful Iran whose nuclear program was decimated but whose other military assets remained intact.¹⁹ Indeed, there is little evidence that a 2007 U.S. National Intelligence Estimate allayed Israeli fears about the Iranian nuclear program, and it may even have made an Israeli attack more likely by taking the political wind out of U.S. involvement in such an operation.²⁰ Moreover, a vocal minority in the United States contin-

16. Information on base names and which organization controls them is from *ibid*; physical location of bases is from *IRAN 2004*; and measurements and other observations are taken from Google Earth.

17. Navias and Hooton, *Tanker Wars*, pp. 37–38, 58, 81, 109–112, 122–123, 174.

18. Seymour M. Hersh, “The Iran Plans,” *New Yorker*, April 17, 2006, p. 30.

19. The feasibility of an Israeli attack of this type is discussed in Whitney Raas and Austin Long, “Osirak Redux? Assessing Israeli Capabilities to Destroy Iranian Nuclear Facilities,” *International Security*, Vol. 31, No. 4 (Spring 2007), pp. 7–33.

20. National Intelligence Council, “Iran: Nuclear Intentions and Capabilities,” National Intelligence Estimate, November 2007, http://www.dni.gov/press_releases/20071203_release.pdf; and

ues to insist on the need for military attacks on Iran's program, and as the reality of attempted Iranian proliferation eventually reregisters with the U.S. public, political support for attacks may regain steam.²¹

If the United States or Israel attacked Iran, the restraint that previously characterized Iranian behavior in the strait might evaporate. Indeed, in 2006 Iran's supreme leader, Ayatollah Ali Khamenei, cautioned that although Iran would not be "the initiator of war," if the United States punished or attacked Iran, then "definitely the shipment of energy from this region will be seriously jeopardized."²² The Iranian oil minister made similar comments, hinting that "if the country's interests are attacked, we will use all our capabilities, and oil is one of them."²³ One can imagine other events that could bring Iran to the same point of desperation—for example, if it were losing a conventional war with any of its neighbors and wanted to open another front as a punitive measure or a distraction. Short of the extreme case in which the United States preemptively destroys much of Iran's military, there is an intermediate range of scenarios in which Iran is deeply threatened yet parts of its military are still intact and functioning. It is in this context that threats to block the strait could become reality.

A SCENARIO FOR CLOSURE

How might Iran take advantage of existing military installations and assets and the strait's geography to attempt to block the flow of oil? Such a campaign would depend on Iran's ability to coordinate the use of mines, ASCM, and air defense to create a littoral trap for the United States. It would seek to do to the United States in the strait what the Turkish and Germans did to the British in the Dardenelles in 1915: mine a narrow passageway, then, from well-defended coastal positions, attack those trying to clear the mines.²⁴ Specifically, Iran would want to begin by laying minefields in and around the strait's shipping channels, as well as using antiship cruise missiles against merchant traffic and any U.S. MCM and convoy vessels.

Facing this trap, the United States could employ two assets in the strait that

Rory McCarthy, "Unilateral Military Strike Still an Option, Senior Ministers Insist," *Guardian*, December 8, 2007.

21. Norman Podhoretz, "The Case for Bombing Iran," *Commentary*, Vol. 123, No. 6 (June 2007), pp. 17–23.

22. Quoted in Ali Akbar Dareini, "Ayatollah Warns West against Action," Associated Press, June 5, 2006.

23. Quoted in Ariel Cohen, James Phillips, and William Schirano, "Countering Iran's Oil Weapon," Background, No. 1982 (Washington, D.C.: Heritage Foundation, November 13, 2006), http://www.heritage.org/Research/Iran/bg1982.cfm#_ftnref4.

24. James A. Meacham, "Four Mining Campaigns: An Historical Analysis of the Decisions of the Commanders," *Naval War College Review*, Vol. 19, No. 10 (June 1967), p. 78.

the British lacked in the Dardanelles: sophisticated surface defenses and offensive airpower against enemy fire positions ashore.²⁵ An air campaign could work in concert with surface action groups to destroy Iran's ASCM capability while suppressing or destroying Iranian air defenses. The United States' goal would be to clear the mines, a reasonably straightforward technical task, while Iran's goal would be to make success in that endeavor contingent on much more complicated tasks, such as fleet defense and the hunt for mobile targets inland. The potential collision between these goals is the subject of the next three sections of the article.

Mine Warfare in the Strait of Hormuz

Iran possesses an adequate inventory of mines and multiple platforms for delivering them. The key variable is not the number of mines Iran possesses, however—mines are relatively cheap to procure—but rather how many it can lay before being detected. Projections based on past instances of U.S. MCM operations indicate that it could take a month or more to reopen the Strait of Hormuz if Iran were allowed to initiate even a small mine-laying campaign.

IRANIAN MINE WARFARE PLATFORMS

Iran could lay mines from any of its 3 frigates, 2 corvettes, and 10 fast missile boats.²⁶ Iran also has 3 ships in the Persian Gulf that appear to have dedicated mine-laying capabilities, plus 3 still-functioning RH-53D Sea Stallion mine-laying helicopters.²⁷ Additionally, Iran possesses more than 200 smaller patrol and coastal combatants suitable for mine laying. These are faster, harder to detect with radar, and useful mainly for rocket, recoilless rifle, and small arms attacks. Iran used small craft of this type to lay mines during the tanker wars.

Iran has 3 relatively modern type-877 Kilo-class diesel-electric submarines from Russia. Each Kilo has six 533-millimeter torpedo tubes. The submarines can carry 18 torpedoes or 24 mines.²⁸ Iran is also said to have at least 1 midget submarine capable of laying mines, although few other details are known.²⁹ In general, the Iranian operational record with submarines has been spotty, and they are also overdue for refits.³⁰

25. *Ibid.*, p. 81; and Michael E. Golda, "The Dardanelles Campaign: A Historical Analogy for Littoral Mine Warfare," *Naval War College Review*, Vol. 51, No. 3 (Summer 1998), pp. 82–96.

26. IISS, *The Military Balance*, 2008, pp. 242–244.

27. Cordesman and Kleiber, *Iran's Military Forces and Warfighting Capabilities*, pp. 119–120.

28. IISS, *The Military Balance*, 2008, pp. 242–244.

29. *Jane's Underwater Warfare Systems, 2006–2007*, 18th ed. (Surrey, U.K.: Jane's Information Group, 2006), p. 11.

30. *Jane's Fighting Ships, 2006–2007* (Surrey, U.K.: Jane's Information Group, 2006), p. 355.

It would be challenging, though not impossible, for Iran to use its submarines for mine laying in the strait, due to several factors. First, the underwater geography of the strait neutralizes many of the characteristic advantages of submarines. Kilos require a minimum operating depth of 45 meters, and only in a few places is the water in the strait more than 80 meters deep, limiting the use of tactics such as diving for concealment or protection. Additionally, the high salt content of gulf waters and other factors create heat currents that disturb sonar. As a result, it is harder for submarines to use passive sonar to detect ships without revealing their own location. Submarines become hidden but irrelevant platforms, or useful platforms that are easier to find. Either way, antisubmarine warfare forces gain an advantage, and U.S. ASW patrols in the gulf would be likely to detect mine-laying activity by Iranian submarines.³¹ There is evidence Iran may have realized these problems and is planning to relocate its submarines to the Gulf of Oman.³²

IRANIAN MINES

Iran is believed to possess at least 2,000 mines.³³ By historical standards, this is not a large stockpile. For example, the British and Americans laid more than 70,000 mines in an effort to seal the North Sea against German U-boats in World War I, and the United States and the Soviet Union each stockpiled hundreds of thousands of mines during the Cold War.³⁴ Nevertheless, even small numbers of mines have been able to halt surface traffic when their presence was known. In 1972 the United States immediately stopped all traffic in and out of North Vietnam's Haiphong Harbor with an initial drop of only 36 acoustic-magnetic mines.³⁵ In 1991 the Iraqis were able to discourage a U.S. amphibious invasion by laying only 1,000 mines off the Kuwaiti coast, 2 of which later hit but did not sink U.S. warships.³⁶ In 1950 the North Koreans delayed the U.S. landing at Wonsan by laying only 3,000 mines across 50 square miles.³⁷ As these examples show, mines derive much of their power from the

31. Anthony H. Cordesman, *Iran's Developing Military Capabilities* (London: Sampson Low, Marsten, May 2005), pp. 62–63.

32. *Jane's Fighting Ships*, p. 355.

33. This is the figure reported in most sources. *Jane's Fighting Ships* claims that Iran may have "up to 3,000 mines." *Ibid.*, p. 354.

34. Meacham, "Four Mining Campaigns," p. 91.

35. Tamara Moser Melia, "Damn the Torpedoes": *A Short History of U.S. Naval Mine Countermeasures, 1777–1991* (Washington, D.C.: Naval Historical Center, 1991), p. 101.

36. Michael R. Gordon and Bernard E. Trainor, *The Generals' War: The Inside Story of the Conflict in the Gulf* (New York: Little, Brown, 1995).

37. Meacham, "Four Mining Campaigns," p. 105.

fear they induce, which is often based more on the psychological effect of a lucky initial explosion than on rational calculations of risk.³⁸

Of Iran's 2,000 mines, about half were purchased from Russia when Iran acquired its 3 Kilo submarines.³⁹ It is hard to do more than guess at Iran's specific stocks of different kinds of mines and which type(s) it would use in the strait.⁴⁰ The strait is relatively shallow, and the currents are strong, meaning that drifting mines could be flushed easily from the shipping lanes and/or come to pose a danger to Iran's own forces. Indeed, Iranian mines found in the western gulf during the 1980s apparently began their lives as moored mines farther east but broke free of their chains in the rough waters. It is a reasonable assumption that Iran would have sought to acquire moored or bottom mines to use in the strait if at all possible.⁴¹

In the past Iran has used the North Korean-manufactured M-08 moored contact mine, which is based on a 1908 design. The U.S. Navy caught the IRGCN red-handed laying such mines north of Qatar in 1987.⁴² One blew a hole in the Kuwaiti supertanker the *Bridgeton* in 1987, another in the hull of the U.S.S. *Samuel Roberts* frigate in 1988. (Neither sank, though they required extensive repairs.) The M-08 has a 115-kilogram charge, is meant for use against surface ships, and can operate in depths of 6 to 110 meters, making it feasible for use in the strait.⁴³

The Soviet Navy produced large quantities of the M-08 and the similar M-26 mine, so it is plausible that Russia could have sold Iran some of each with the recent submarine sale. Neither the M-08 nor the M-26 can be laid from torpedo tubes, however, so at least some of the 1,000 mines Russia sold Iran were likely of a different sort—probably from Russia's MDM/UDM series of seabed influence mines.

Versatile and powerful, the MDM-6 is a likely candidate. It can be laid either from 533-millimeter torpedo tubes (the tube width found on Iran's Kilos) or

38. *Ibid.*, p. 113.

39. Cordesman, *Iran's Developing Military Capabilities*, chap. 4.

40. *Ibid.*; and *Jane's Underwater Warfare Systems*, p. 365.

41. For background on mines, see Thomas R. Bernitt and Sam J. Tangredi, "Mine Warfare and Globalization: Low-Tech Warfare in a High-Tech World," in Tangredi, ed., *Globalization and Maritime Power* (Washington, D.C.: National Defense University Press, 2002), pp. 391–397; and Gary K. Hartmann, *Weapons That Wait: Mine Warfare in the U.S. Navy* (Annapolis: Naval Institute Press, 1979).

42. Melia, "Damn the Torpedoes," p. 126.

43. *Jane's Underwater Warfare Systems*, pp. 362–364. Iran also possesses an unknown quantity of the M-26 moored contact mine and the smaller MYaM moored contact mine. *Jane's Underwater Warfare Systems*, pp. 362, 364; and Eisenstadt, "Iranian Military Power," p. 55. Reports persist that Iran has tried to acquire or indigenously produce the EM-52 or MN-52 rocket-propelled mine as well.

from surface ships with rail and stern ramps. Its charge is an order of magnitude greater than the M-08's, around 1,100 kilograms, and it has a similar operating depth, 12 to 120 meters, appropriate to the strait. Far more sophisticated in design than the contact mines discussed above, the MDM-6 detonates in response to acoustic, magnetic, or pressure influences within a radius of 50 to 60 meters. It also has a timing device and ship counter, endowing its user with more control.⁴⁴

A SCENARIO FOR IRANIAN MINING OF THE STRAIT

Based on the above information, it is hard to predict exactly how many mines Iran could lay undetected. A scenario with some straightforward, though not especially creative assumptions about Iranian readiness, capabilities, coordination, and stealthiness might read as follows:

- If 2 of Iran's 3 Kilos were operational, they could together lay 4 minefields, each containing 48 MDM-6 mines, for a total of 192 mines. This would require 8 total mine-laying sorties, meaning that each Kilo was able to reload its torpedo tubes 3 times at Bandar Abbas without arousing suspicion, and that the timers on the mines in the initial minefields did not malfunction and go off before the later minefields were seeded.
- Iran could lay these 4 minefields at the mouth of the strait, the narrowest portion, east of the Tunb Islands, directly south of Larak Island. The mines would be laid not only in the two shipping channels but across the buffer zone and the areas immediately outside the channels.
- Iran could use its 167 smaller surface craft (its 36 fast patrol craft inshore, 37 patrol boats, 40 patrol boats inshore, 14 Hovercraft, and 40 Boghammars) to lay mines at night in the channels to the west.⁴⁵
- If each of the 167 small craft were able to lay 3 mines on average, a total of 501 additional mines could be laid. These craft would lay the older variety of moored contact mines, such as M-08 mines.

This is a stylized scenario. For example, it is questionable whether Iran could coordinate all these activities in a single major operation without risking fratricide. It is unlikely Iran could ensure that all of its smaller vessels were simultaneously seaworthy. On the other hand, it is also unlikely Iran would rely

44. The MDM-1, a slight variant of the MDM-6, is also a possible candidate. *Jane's Underwater Warfare Systems*, p. 364.

45. IISS, *The Military Balance*, 2008, pp. 242–244; and Cordesman, *Iran's Developing Military Capabilities*, chap. 4.

solely on such military vessels to lay mines. Fishing dhows and other civilian craft could easily participate in such a campaign. Because estimates of the quantity and availability of these alternative vessels are lacking, it is more conservative simply to ask how many mines Iran might be able to lay based on its order of battle data. Additionally, this scenario does not factor in the possibility that Iran could use its dedicated mine-laying ships and helicopters to lay significant quantities of additional contact mines. If Iran were willing to risk almost certain detection and destruction of these assets, it could sow additional minefields.

The general point is that it does not require great imagination to think Iran could lay several hundred mines in the gulf. If the above conditions prevailed, for example, Iran could lay a total of 693 mines. This is not an especially large number, but in such a confined area with such heavy commercial traffic, it would not take long for a tanker to encounter a mine. The effects of the MDM-6 mine on a tanker are unknown, but given that these mines have both more sophisticated detonation mechanisms and ten times the charge of the mines that hobbled tankers in the 1980s, the threat to tanker traffic cannot be dismissed easily. If shipping companies—and their insurers—believed that large swaths of the channels and surrounding areas were definitely mined, and in some places with mines ten times as powerful as what was seen in the tanker wars, they likely would halt or reduce shipping.⁴⁶

Most important, however, an Iranian mine warfare campaign against shipping would guarantee U.S. intervention, fulfilling Iran's basic goal. The common assertion that 2,000 to 3,000 mines would be needed to close the strait may not take this potential Iranian objective into account.⁴⁷

COUNTERING THE MINE THREAT IN THE STRAIT

Putting aside any other potential Iranian threats, what would the United States have to do to clear the mines, and how long would it take? The goal in such operations is usually to clear a Q-route—an initial passage through a minefield in which the chance of hitting a mine is believed to be reduced to 10 percent or less and through which essential traffic can flow, including the MCM vessels themselves. The number of mines that must be removed to form a Q-route depends on the density of the minefield. Michael Glosny reports that creating a

46. Navias and Hooton, *Tanker Wars*, pp. 3, 4, 96–98, 127–128, 181–183.

47. Anthony H. Cordesman and Abraham R. Wagner, *The Lessons of Modern War: Vol. 2, The Iran-Iraq War* (Boulder, Colo.: Westview, 1990), p. 558; and Capt. John Moore, "The Gulf: Hazardous but Still Navigable," *Jane's Naval Review*, Vol. 4 (1985), p. 53. Both simply assert the 2,000 to 3,000 figure without explaining why it should be accepted.

Q-route at Wonsan required clearing only 225 of 3,000 mines—less than 10 percent.⁴⁸ If Wonsan is any guide, clearing Q-routes in the strait would require clearing fewer than 70 mines out of a total of about 700 laid.

The only problem with the Q-route metric of U.S. success in the strait is that a Q-route might not be enough space for full traffic to resume or the oil markets to relax. It would be a success in terms of minimizing the risk of further mine damage to commercial ships and allowing the initiation of slow convoy operations, similar to Operation Earnest Will in 1987. But it would not restore the full flow of oil. A more relevant standard of success would be to clear all or nearly all 693 mines. It is difficult, however, to extrapolate based on past cases of mine clearing how long such an operation would take.

First, the difficulty of clearing mines varies considerably with the type of mine involved. Moored contact mines can be swept relatively easily once their location is known. Larger influence mines take more time to identify and more skill to neutralize, often because MCM ships must carefully mimic the influences that will cause detonation. This explains why MCM ships at Wonsan were each able to clear an impressive 0.67 contact mines per day, whereas a British minesweeper took six days to identify and neutralize a single 680-kilogram influence mine in the Red Sea in 1982.⁴⁹ Second, countermine assets vary considerably. The number of ship-hours the United States took to clear a mine at Wonsan may bear little resemblance to the number it would take today. In fact, the clearing might be done with unmanned vehicles, advanced helicopters, or other technology that scarcely existed fifty years ago. Third, environmental conditions affect the ease and speed with which mines can be cleared. Torrential rain was a major impediment to the attempted British sweeps at Gallipoli. The Persian Gulf is unlikely to pose similar obstacles.

That said, two cases in the relatively recent past mimic some important features of likely mine-clearing operations in the strait: Operation Candid Hammer to clear Iraqi mines off the coast of Kuwait in 1991, and operations to clear Iraqi mines in the Khor Abd Allah waterway near the port of Umm Qasr in 2003. Both operations involved U.S. forces in the Persian Gulf, and both required clearing moored contact mines, of the type the Iranians likely would use for at least part of their operations. Despite imperfections in the data about

48. Michael A. Glosny, "Strangulation from the Sea? A PRC Submarine Blockade of Taiwan," *International Security*, Vol. 28, No. 4 (Spring 2004), pp. 143–145.

49. The Wonsan calculation appears in *ibid.* The Red Sea figure appears in Cordesman and Wagner, *The Lessons of Modern War*, p. 565.

these two operations, significant differences in the technology and concepts of operation used, and the fact that the cases involved minefields of different sizes, the two campaigns generate roughly similar estimates of how long the United States would need to clear 693 mines from the strait.

PROJECTIONS FROM 1991

In 1991 Iraq laid 1,157 moored contact mines across several minefields. In response, Operation Candid Hammer took more than a dozen U.S., British, French, and Belgian MCM ships from approximately March 1 until April 20 to clear 907 Iraqi mines off the coast of Kuwait.⁵⁰ Of the 1,157 mines, 3 detonated under the U.S.S. *Princeton* and the U.S.S. *Tripoli*, leaving 1,154 mines. Operation Candid Hammer apparently cleared only 907, or 78.6 percent, of the original mines. The 31 days of March plus the 20 days of April mean that Candid Hammer took about 51 days. I was unable to determine the exact number of ships involved in the operation, but a conservative estimate of each ship's capabilities would take the reported "more than a dozen" to mean at least 15. If 907 mines were cleared by 15 ships in 51 days, then 17.8 mines were cleared per day in total, with each ship on average clearing 60.46 mines over the course of the operation and each ship on average clearing 1.18 mines in a single day.

This is an impressive rate of clearance, perhaps attributable to unusual circumstances. First, the MCM teams already had a good sense of where the mines were. Coalition forces had encountered mines starting in December 1990 and therefore had had time to do at least some initial surveillance and mine hunting in the area. Second, Iraqi generals agreed to provide maps of the minefields at cease-fire negotiations with Gen. Norman Schwarzkopf, commander of the coalition forces, in early March.⁵¹ Third, the coalition did not have to worry about protecting the MCM ships from air attack or shore-based attack. Candid Hammer took place in a totally undefended area in which MCM ships could roam at will. Fourth, as mentioned, the Iraqis used moored contact mines that are relatively easy to sweep by breaking the moorings.

Counterbalancing these favorable circumstances, however, was a major limitation on the coalition effort: U.S. mine-clearing helicopters were taken out of the operation when the *Tripoli*, the MCM helicopter carrier, was damaged. As a result, despite some of the coalition advantages mentioned above, Candid Hammer provides neither an overly rosy nor an overly conservative basis for

50. It is unclear what happened to the remainder of the Iraqi mines. Navias and Hooton, *Tanker Wars*, pp. 196–197.

51. Gordon and Trainor, *The Generals' War*, p. 444.

projecting the length of future MCM operations. For example, if the United States (and/or its allies) could bring only 15 MCM ships of early 1990s' quality to bear on 693 mines in the strait, and other circumstances were the same as in *Candid Hammer*, it would take 38.9 days to clear all the mines. If the United States needed to clear only about 80 percent of the mines, as was apparently the case in *Candid Hammer*, then the operation would take 31.2 days. Even so, under this scenario it would take at least a month to fully reopen the strait. Clearing a Q-route, assumed here to be 10 percent of the mines, would take much less time, of course—approximately 3.9 days.

U.S. MCM capabilities have changed considerably since 1991, however. In *Candid Hammer* the United States was relying on a combination of allied ships of varying vintages, its own MCM ships from the immediate post-Vietnam era, and perhaps 2 or 3 of the Avenger-class MCM-1 minesweepers, then in the process of being procured. It had no helicopters available. Today the United States has 14 of the Avenger-class ships, as well 8 Osprey-class coastal mine hunters.⁵² Two Ospreys and 2 Avengers are based permanently in Bahrain, where the United States has also forward deployed 4 of its MH-53E Sea Dragon airborne mine countermeasures (AMCM) helicopters.⁵³ Amphibious assault ships are also forward deployed in the area and are capable of supporting AMCM operations. The countermine operations of Operation Iraqi Freedom provide some insight into how these newer assets might work together in the strait.⁵⁴

PROJECTIONS FROM 2003

In 2003, in an effort to secure the Khor Abd Allah waterway leading to the port of Umm Qasr, the United States deployed its 4 in-region mine warfare ships and 1 squadron of Sea Dragons. It also relied on 4 British minesweepers and a British mine warfare command ship.⁵⁵ Over the course of approximately 4 days, this combined force neutralized 78 mines.⁵⁶

Here it is not appropriate to calculate the number of mines neutralized per ship per day, because the ships could not have done their work without the airborne guidance and protection. (Indeed, this was part of why *Candid Hammer* resulted in damage to 2 major warships, and the 2003 operation did

52. *Jane's Fighting Ships*, pp. 890, 902–903.

53. Paul J. Ryan, "Iraqi Freedom: Mine Countermeasures a Success," *Proceedings*, Vol. 129, No. 5 (May 2003), p. 52.

54. Cmdr. Michael P. Tillotson, "CTF 56: Operation Iraqi Freedom," PowerPoint presentation, plenary session, Sixth International Symposium on Technology and the Mine Problem, Naval Postgraduate School, Monterey, California, April 21–23, 2004, available on CD-ROM from author.

55. Ryan, "Iraqi Freedom," p. 52.

56. Tillotson, "CTF 56."

not.) Rather, the important calculation is that the combined force cleared approximately 19.5 mines per day—a figure not too different from the 17.8 mines per day that Candid Hammer achieved. If U.S. (and possibly allied) forces cleared mines in the strait at the same rate as they did in the Khor Abd Allah waterway, it would take at least 3.6 days to clear a Q-route. It would take 35.5 days to clear all the mines. Clearing only 80 percent of the mines would require approximately 28.4 days.

APPLICATION TO THE STRAIT

Despite differences in the details, the 1991 and 2003 cases both suggest that reopening the strait could take the better part of a month. Additionally, the United States had three advantages in the 1991 and 2003 operations that it would not enjoy in the strait scenario outlined above. First, both operations occurred in areas smaller than the strait. Second, the Iranians probably can use influence mines that are much more difficult to clear than those used by the Iraqis. In the scenario posited earlier, 192 of the 693 mines were MDM-6 influence mines. Depending on how much longer these take to clear, the United States could be facing additional weeks of MCM operations. For example, if it takes twice as long to clear influence mines, then the 192 influence mines would add 8.66 days to the time it would take to clear 80 percent of the mines based on projections from the 1991 case, and 7.9 days to the time it would take to clear 80 percent of the mines based on projections from the 2003 case, for totals of 39.7 days and 36.3 days, respectively. It could easily add days to the time it would take to establish a Q-route. Third, in both 1991 and 2003, the United States and its allies had the relevant assets in theater at the time that the mine-clearance clock started ticking. Whether in the future the United States would have allied support, much less actual allied assets in the region, remains open to question. In both 1991 and 2003, allies probably provided roughly half the relevant assets. Presumably they would have an interest in doing so in the future as well. But if the United States had to go it alone, operations could take significantly longer.⁵⁷

Looking toward the future, the United States plans to develop and deploy

57. Additional MCM vessels from the United States would take weeks to reach the Persian Gulf from their home ports. Committee for Mine Warfare Assessment, Naval Studies Board, and Division on Engineering and Physical Sciences, National Research Council, *Naval Mine Warfare: Operational and Technical Challenges for Naval Forces* (Washington, D.C.: National Academy Press, 2001), p. 44; "Navy Acquisitions: Improved Littoral War-Fighting Capabilities Needed," Report to Chairman and Ranking Minority Member, Subcommittee on Military Research and Development, Armed Services Committee, U.S. House of Representatives, GAO-01-493 (Washington, D.C.: Government Accountability Office, May 2001), p. 6; and Frank Colucci, "Navy Upgrading Sea-Mine Sweeper Helicopters," *National Defense*, Vol. 88, No. 602 (January 2004), pp. 38–39.

organic airborne mine countermeasures: the ability to find, classify, and neutralize mines from aerial platforms located with carrier strike groups and surface action groups rather than on dedicated MCM ships. These capabilities are supposed to become operational during the next five or so years, but mine warfare historically has not been a priority for the U.S. Navy, so delays seem possible.⁵⁸ The United States is already phasing out its dedicated MCM ships. Ultimately, whether the shift to dedicated MCM assets will produce a net improvement in actual MCM capabilities is unclear; rather, the key change is that MCM assets will be in theater at the start of future conflicts. The projections from the 1991 and 2003 cases began the MCM “clock” when all assets were in the region, so the estimates of how long MCM operations might take in the future should not be dismissed just because the concept of operations might differ. Moreover, some have cautioned that although organic assets may help in establishing Q-routes quickly, they cannot match the dedicated assets’ capability to conduct sustained, large-area operations.⁵⁹

The best defense against mine laying, of course, is prevention. To the extent that the United States and its allies could catch the Iranians in the act of initiating the scenario described above, particularly any activities by Iranian submarines, they could reduce dramatically the damage caused by attempts to close the strait.⁶⁰ Additionally, MCM operations can occur much faster if the defenders have updated hydrographic maps of the areas in which the mines have been laid. Precise bottom contour charts showing the seabed and all objects embedded in it are crucial, helping the mine hunters immediately identify new objects that might be mines.⁶¹ U.S. MCM teams reportedly spend much of their time between combat missions engaged in such mapping.

Finally, the calculations in the scenario above assumed that MCM operations were occurring in isolation. In reality, other events would be transpiring as well. The United States would be attempting to prevent Iran from laying additional mines, or at least to catch the Iranians in the act, as it did in 1987.⁶² The United States probably would issue a *démarche* declaring that if Iranian ships or submarines left their harbors during U.S. MCM operations, it would be con-

58. *Naval Mine Warfare*, pp. 82–85; Thom Shanker, “U.S. and Britain to Add Ships to Persian Gulf in Signal to Iran,” *New York Times*, December 21, 2006; *GlobalSecurity.org*, “Airborne Mine Countermeasures (AMCM),” <http://www.globalsecurity.org/military/systems/aircraft/systems/amcm.htm>; and *Jane’s Underwater Warfare Systems, 2006–2007*, p. 531.

59. Robert J. Natter, “Access Is Not Assured,” *Proceedings*, Vol. 129, No. 1 (January 2003), p. 39.

60. Continuous shore-based surveillance of the Iranians was common during the tanker wars. Moore, “The Gulf,” pp. 53–54.

61. *Jane’s Underwater Warfare Systems, 2006–2007*, pp. 431, 445.

62. Melia, “*Damn the Torpedoes*,” p. 126.

sidered an act of war. To be sure, Iran disregarded this sort of warning in 1988 when the United States launched Operation Praying Mantis to destroy 2 Iranian oil and gas platforms in retaliation for Iranian mining. Several Iranian vessels confronted 3 U.S. surface action groups in and around the strait, and the United States responded by sinking 2 Iranian warships and severely damaging one of Iran's 3 frigates in barely a day of combat.⁶³

Iran could also attempt to attack the surface and aviation assets engaged in MCM operations—indeed, this could be the real point of the mine laying. These assets are much more vulnerable to shore-based fire than are tankers. The United States might want to neutralize this threat almost entirely before proceeding with MCM operations. It probably considers its MCM assets too vulnerable, expensive, and scarce to operate in the face of a credible offensive threat from the Iranian shore. An assessment of what Iran could do in this regard, how the United States could defend against it, and the time it might add to the overall length of the conflict is the subject of the next section.

Antiship Cruise Missiles in the Strait of Hormuz

Iran would have two primary means of attacking U.S. or other traffic in the Strait of Hormuz. The first would be U.S.S. *Cole*-style naval terrorism—small boats relying on their speed and near invisibility to conduct attacks on U.S. capital ships at close ranges, perhaps in groups.⁶⁴ This threat is serious given Iran's large inventory of such vessels, control of the islands in the shipping channels, stock of motivated IRGCN fighters, and general proclivity toward tactical creativity at sea.

The *Cole* was attacked in port, however, not on the open ocean. Coordinating small-boat attacks far from shore would likely be difficult, especially in any kind of sea state. Iranian command and control of large numbers of vessels dispersed across multiple locations would also likely be a problem once hostilities had begun.⁶⁵ There is also an inherent trade-off between small boats' visibility and their firepower. Cruise missiles have the most ability to damage U.S. ships, but they can be carried only on Iran's larger vessels (frigates and fast at-

63. Craig L. Symonds, *Decision at Sea: Five Naval Battles That Shaped American History* (New York: Oxford University Press, 2005), pt. 5.

64. Thom Shanker, "Iran Encounter Grimly Echoes '02 War Game," *New York Times*, January 12, 2008.

65. Owen L. Sirrs, "Operational Art Can Neutralize the Asymmetric Small Boat Threat in Major Operations," paper submitted to the Joint Military Operations Department, Naval War College (Newport, R.I.: Naval War College, February 2, 2002), pp. 8, 15, <http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier?ADA401088>.

tack boats) visible to radar. Iran's smaller vessels, however stealthy and numerous, are more likely to carry only rockets and guns.

The U.S. Navy is well aware of potential small-boat tactics and conducts exercises accordingly.⁶⁶ Crews are trained to detect attackers visually and to counter them through layered defenses and direct fire. Naval helicopters armed with Hellfire missiles would be particularly useful in this regard. The U.S. Navy is also adding high-definition thermal imagers to its Aegis cruisers and destroyers to help detect small approaching craft.⁶⁷

In short, Iran's small boats cannot be ignored and likely would enhance the other capabilities discussed here. This threat merits additional research. Nevertheless, it alone is unlikely to be decisive in the strait. As a result, this section focuses on the second means through which Iran could threaten surface ships: antiship cruise missiles. After outlining the Iranian order of battle and sketching a scenario for missile attacks, this section discusses the offensive and defensive aspects of a potential U.S. response.

IRANIAN ANTISHIP MISSILE CAPABILITIES

Like its mine warfare capabilities, Iran's ASCM capabilities have improved since the 1980s. The open-source literature provides varying estimates of these capabilities, however. Significant uncertainties exist regarding the types, number, and performance characteristics of missiles in Iran's inventory; how many batteries Iran has from which to launch these missiles; and how it has allocated the batteries and missiles across naval versus land-based or air-based platforms. The sheer variety of the Iranian inventory, comprising old Western models, Chinese and other imports, and indigenous copies and modifications of foreign missiles, complicates attempts at estimation. Many open-source materials are imprecise in their terminology for describing these missiles, and sources contradict one another. Iran also has incentives to obfuscate and exaggerate. These data limitations must be kept in mind in evaluating any potential scenario for Iranian ASCM attacks in the strait.

That said, even the most conservative estimates indicate that Iran probably possesses at least several hundred antiship cruise missiles with at least a few dozen batteries.⁶⁸ Most Iranian missiles are from China or are based on Chi-

66. Mark Logico, "U.S. Navy Ships Conduct FAC/FIAC Exercises," press release, No. 128-07, U.S. Naval Forces Central Command, U.S. Fifth Fleet, June 6, 2007, <http://www.cusnc.navy.mil/articles/2007/128.html>.

67. *Jane's Fighting Ships*, pp. 887, 890.

68. Shlomo Brom and Yiftah Shapir, *The Middle East Military Balance, 2001–2002* (Cambridge, Mass.: MIT Press, 2002), p. 160.

nese designs. These include the C-802 Saccade, a sea-skimming, subsonic missile whose turbojet engine gives it a range of at least 120 kilometers.⁶⁹ The C-802 is the successor to the C-801 Sardine, a similar missile Iran also possesses with rocket propulsion and a shorter range of 8 to 42 kilometers.

Iran is capable of launching these missiles from surface vessels, aircraft, and trucks. Iran's primary naval platforms for delivering antiship missiles are its 10 French-made Kaman fast missile boats and its 10 Chinese-made Houdong fast missile boats. At least half of the Kaman boats are believed to carry the C-801, and the Houdong vessels are thought to carry the C-802. Iran also has 3 guided missile frigates, of British origin and early 1970s' vintage. Previously fitted to carry C-801 missiles, they may have been upgraded to carry the C-802 and have improved fire control radars.⁷⁰ Additionally, Iran has an air-launched version of the C-801, the C-801K, believed to be installed on up to six F-4E aircraft—probably part of the Phantom squadron located at Bandar Abbas.⁷¹

Nevertheless, Iran may have put most of its Saccade missiles not on ships or aircraft, which are relatively vulnerable platforms, but on inland truck-mounted batteries.⁷² Such batteries would be highly mobile and much harder to find, like the Scud missiles Iraq launched in 1991. For example, one report indicates that Iran has stationed at least 60 of its 75 Saccade missiles on the island of Qeshm.⁷³

Iran has a larger but aging arsenal of other Chinese-made, land-based antiship missiles: the CSS-N-2 Silkworm and the CSS-N-3 Seersucker. These weapons have a range of at least 95 kilometers. Like the C-801 series, the Silkworm and Seersucker are sea-skimming subsonic cruise missiles that can pose a serious hazard to undefended surface ships. One source indicates that Iran has deployed at least 12 batteries and 300 missiles of this type in and around Bandar Abbas, directly across from the strait.⁷⁴ Iran is also said to have shorter-range antiship cruise missiles for use by fast attack boats.⁷⁵

Reports have circulated for years that Iran has acquired the extended-range SS-N-22 Sunburn ship-launched cruise missile from Ukraine, but no reliable

69. China itself has an improved version of this missile, the C-802A, with a range extended to 180 kilometers. It is reasonable to think that Iran possesses or could acquire the C-802A. Robert Hewson, "Dragon's Teeth: Chinese Missiles Raise Their Game," *Jane's Navy International*, Vol. 112, No. 1 (January 1, 2007), pp. 19–23.

70. Cordesman, *Iran's Developing Military Capabilities*, p. 56.

71. IISS, *The Military Balance*, 2008, pp. 242–244; and *Jane's Fighting Ships*, p. 357.

72. *Jane's Fighting Ships*, p. 354.

73. Cordesman and Kleiber, *Iran's Military Forces and Warfighting Capabilities*, p. 117.

74. *Jane's Sentinel: The Gulf States* (Surrey, U.K.: Jane's Information Group, 1997), sec. 2.13.5.

75. Cordesman, *Iran's Developing Military Capabilities*, pp. 117–118.

sources have confirmed this claim.⁷⁶ There are also more recent reports to suggest that Iran possesses an extended-range version of the Seersucker known as the Raad.⁷⁷ Supposedly Iran has acquired several hundred of these missiles, which can be ship- or shore-based, and apparently reach targets 150 kilometers or more away.⁷⁸ To be conservative, the analysis here excludes the Sunburst and the Raad, but it could be amended easily to include them.

Crucially, missile ranges refer only to the distance that the missile's motor and fuel can carry it; they say nothing about the distances at which the missile's radar can find targets. Iran's C-801 and C-802 missiles were designed to rely on line-of-sight (LOS) targeting using type 254 radar, a Chinese copy of the Russian Square Tie radar.⁷⁹ LOS targeting is distinct from over-the-horizon (OTH) targeting. When using LOS targeting, the shooter can hit only what he can "see." Because radio waves move in nearly straight lines, they bend very little in comparison to the curvature of the Earth, preventing them from finding targets much past the horizon.⁸⁰ Hence the missile's true range is what is within the horizon. This method stands in contrast to OTH targeting in which a missile can be programmed to travel to a point in space even if it lies beyond a direct line of sight from the location at which it is fired.

The shooter's line of sight depends on both his height and the target's height. For example, a shooter at sea level can see a 10-meter-tall target only if it is 12 kilometers or closer.⁸¹ The shooter's prospects improve a bit if he can reach higher ground—when he is 30 meters high, he can see that same target from 35 kilometers. But the shooter would have to be nearly 400 meters above the ground to find the 10-meter-tall target from 95 kilometers away.⁸²

To be sure, Iranian missiles using even normal LOS targeting still could be menacing at close distances against undefended ships. In July 2006 Iran reportedly assisted Hezbollah in missile attacks against a Cambodian merchant ship

76. *Jane's Sentinel*, sec. 2.13.5; and Cordesman, *Iran's Developing Military Capabilities*, p. 56.

77. *Jane's Fighting Ships*, p. 354.

78. "Dragon's Teeth"; and *Jane's Navy International*.

79. E.R. Hooton, ed., *Jane's Naval Weapon Systems*, No. 45 (Surrey, U.K.: Jane's Information Group, April 2005), pp. 286–291.

80. On over-the-horizon targeting, see Norman Friedman, *Seapower and Space: From the Dawn of the Missile Age to Net-Centric Warfare* (Annapolis: Naval Institute Press, 2000), pp. 7–8.

81. Radar horizons are calculated from the equations provided in the online version of George W. Stimson, *Introduction to Airborne Radar*, 2d ed. (Mendham, N.J.: SciTech, 1998), <http://radarproblems.com/calculators/horizon.htm>.

82. Still, atmospheric conditions in the gulf, including high levels of dust and humidity, seem to cause radio waves to behave unpredictably. Those with operational experience in the region report that on some days lines of sight are greatly restricted, whereas on other days a phenomenon known as "ducting" greatly extends the range of radio waves beyond what normal LOS calculations would predict.

and an Israeli missile corvette that were 60 and 16 kilometers off the Lebanese coast, respectively. The 2 missiles Hezbollah used were copies of the Saccade.⁸³ The Cambodian ship sank, and the *Hanit* sustained severe damage, killing four sailors, when it failed to deploy its Barak antimissile system.⁸⁴

Nevertheless, the epilogue to this incident shows that close engagement ranges help the defender as well as the attacker. If the attacker has to rely on LOS targeting, the defender can make good guesses about the launch locations or at least the locations of the targeting radars. Within days of the Hezbollah attack, Israel reportedly destroyed all of Lebanon's coastal radar stations, and no subsequent naval missile attacks occurred during the war.⁸⁵ The United States likely would have similar success destroying the targeting radars or batteries if Iran launched missiles at the strait from its islands or low coastal areas. Iran could shoot from these locations, raising the probability of hitting a U.S. ship, but it probably would have to trade a radar or battery for every attempt.

Iran could compensate for the limitations of LOS targeting if it used sensors or spotters mounted on other platforms to locate targets and communicate that information to missile crews. Hypothetically, Iranian submarines, aircraft, and any of its surface vessels could perform these tasks, if they were in a position to survey U.S. positions in the strait. So could Iranian fishermen with satellite phones. These spotters would have to know their own position precisely; acquire the bearing, range, and speed of a target; and transfer this information to a shooter. Most important, the missile being fired would have to be able to accept a fire control solution from some source other than a colocated radar. These tasks are not easy, and it is unknown if Iran's missiles have been modified to use this sort of information.

One source does claim that the C-802 can be targeted using an over-the-horizon radar.⁸⁶ If true, this would enlarge the inland areas from which Iran could target traffic in the strait. Even so, Iran's cruise missiles would still face the problem of "clobber" over long distances—terrain elevations that would obstruct the flight path of the low-flying missile. The U.S. Navy avoids this problem with its Tomahawk missiles only through the use of extensive geospatial information and the ability to carefully program flight paths. There is no evidence Iran has such data or this programming ability, meaning longer-range targeting using these missiles is still likely to be difficult.

83. Alon Ben-David, "Hizbullah Hits Israeli Corvette," *Jane's Defense Weekly*, July 26, 2006, p. 18.

84. Yaakov Katz and Sam Ser, "IDF Report Card," *Jerusalem Post*, August 25, 2006.

85. Yaakov Katz, "50 Miles from Beirut 'We Are in Charge of the Sea,'" *Jerusalem Post*, July 19, 2006.

86. Cordesman and Kleiber, *Iran's Military Forces and Warfighting Capabilities*, p. 117.

A SCENARIO FOR IRANIAN CRUISE MISSILE ATTACKS IN THE STRAIT

Temporarily putting aside the limitations of LOS targeting, and assuming Iran could take full advantage of its missiles' ranges, from how far inland could Iran launch cruise missiles and hit targets in the strait? Usually analysts draw "missile fans" from a known missile location outward, to determine what targets it could hit. In this case, the target is known—the strait—so by "flipping" the missile fan over and drawing it radiating outward from the strait, one can determine the universe of locations from which a missile hitting that target could have been fired. Geographic Information Services (GIS) software enables calculation of the size of this area: about 33,000 square kilometers of Iranian territory, on the conservative assumption that Iran's longest-range missile is the C-802, with a reach of 120 kilometers.⁸⁷ If the open-source order of battle is correct, Iran could have 15 to 25 Sardine or Saccade batteries scattered across this area. (The Saccade's range is much longer than the Sardine's, however.) Additionally, Iran could have up to 12 shorter-range Silkworm or Seersucker batteries hidden in the 20,000 square kilometers of this area that are within 95 kilometers of the coast.

In reality, it seems unlikely that Iran would concentrate all its cruise missile batteries on land, much less on this one portion of the coast, but it is possible. In total, the United States could face several dozen batteries and several hundred antiship cruise missiles spread across an area roughly three times the size of Kosovo.⁸⁸

How might Iran choose to expend its missiles? Given its small arsenal, its goal might be to launch missiles only occasionally—perhaps once or twice per day, or every other day—to pose a continuing threat to MCM or commercial vessels attempting to traverse the strait. (This was roughly the average rate of launch of Iraqi Scud missiles during the 1991 Gulf War.⁸⁹) In so doing, Iran

87. These measurements were derived using ArcView software to combine and manipulate Russian maps taken from *Global Planner: International Datasets* (Dallas, Tex.: Tobin International, 2004); and a map of the Hormuz shipping lanes from the University of Texas library, http://www.lib.utexas.edu/maps/middle_east_and_asia/hormuz_80.jpg. The map created shows how far inland Iranian launchers could be while still potentially targeting traffic in the strait—but not how far out into the Persian Gulf such missiles potentially could travel. Map available from the author.

88. This challenge becomes harder for the United States if Iran has longer-range missiles, which would expand the search area. It becomes easier if alternate shipping routes are available farther from the Iranian shore. Bathymetry charts reveal that the water may be deep enough to accommodate large vessels south of the official shipping lanes. Still, if U.S. MCM vessels were operating to clear the shipping lanes, they would remain vulnerable to Iranian fire. The bathymetry can be examined using a map from the University of Texas library, http://www.lib.utexas.edu/maps/middle_east_and_asia/iran_strait_of_hormuz_2004.jpg.

89. Iraq launched an average of 14.7 Scuds per week during Desert Storm. Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey Summary Report* (Washington, D.C.: Office of the Secretary of the Air Force, 1993), p. 83.

could force the United States to invest considerable effort searching for mobile missile batteries inland and create doubt about whether all had been found or not, forcing the United States either to delay MCM operations or to risk missile attacks on the MCM ships.

OFFENSIVE MEASURES AGAINST RADARS AND BATTERIES

Presuming Iran's lack of OTH targeting capability, the task of destroying its land-based mobile missile capability depends on determining where within the 33,000 square kilometers of territory there are elevations that would provide unobstructed lines of sight between Iranian missile radars and traffic in the strait. In fact, much of the real estate does not meet these conditions.⁹⁰

GIS software enables detailed examination of topographical features of the search area. Simple visual inspection reveals that roughly one-third of this territory—the immediate coastal area—is at sea level or elevated only a few dozen meters. Even assuming no obstructions, an Iranian targeting radar at a height of, say, 50 meters would have to be within approximately 45 kilometers of a U.S. ship to target it.⁹¹ Only a few spots in Iran would meet this requirement, notably on the island of Qeshm and in the area near Bandar Lengeh. Iranian islands in the shipping channels would also be well within range.

The southernmost ridges of the Zagros mountains also provide some significant coastal elevations between 500 and 1,000 meters directly facing the strait, particularly toward the western end—prime spots for radar. Yet these same ridges create a natural barrier to radar and LOS communications links from most of the areas to the north. There are some gaps between the ridges wherein a carefully angled radar could track a slice of the strait, but generally the landscape is not amenable to such operations. Easily another third of the 33,000-square-kilometer area consists of valleys, including much of the extra “band” of territory from which the longer-range Saccade missiles could be launched. (This fact also negates the potential effect of Iran's possible acquisition of longer-range missiles, if they do not have OTH targeting and the ability to solve the “clobber” problem.)

90. This topographic map was created using ArcView software to combine and manipulate the Russian maps, the University of Texas shipping lanes map, and topographic data from the GTOPO30 series produced by the U.S. Geological Survey. Map available from the author.

91. If one averages the heights of four potential targets—a U.S. MCM ship, a U.S. frigate, an Aegis cruiser, and an Aegis destroyer—it is possible to generate a rough estimate of how close an Iranian shooter at a particular height would have to be to reach these targets. On average, a shooter at a height of 0 meters would have to be within 16 kilometers to conduct LOS targeting; at 125 meters, within 62 kilometers; at 250 meters, within 81 kilometers; at 500 meters, within 108 kilometers; and at 1,000 meters, within 147 kilometers. Ship heights taken from the entry on the U.S. Navy in *Jane's Fighting Ships*.

Consequently, if Iran wanted to launch missiles from farther inland, it would have to move to progressively higher elevations to find an unobstructed line of sight to the target. Higher ground creates a different set of challenges, however. First, there is not a lot of it. No more than 10 percent of the entire search area is above 1,000 meters, and only twice that is above 500 meters—in total, perhaps 30 percent of the 33,000 square kilometers, or 9,900 kilometers. Still, from these heights it is possible to target even relatively small targets in the strait from ranges of more than 100 kilometers.

Second, these elevated areas are not conducive to mobility. Unsurprisingly, Iran has not built a lot of roads on the tops of mountains—not even gravel or dirt roads, according to one reliable atlas.⁹² Iran could forge off-road paths, and the truck-mounted missiles and radar are probably sturdy enough to travel in such areas, but off-road speeds are slower, especially going up and down steep mountains. Of course, the Serbs managed to conduct effective mobile operations even in the mountainous terrain of Kosovo, using the valleys as hiding places, so this is not inconceivable. But the Serbs also had the benefit of greater foliage than Iran possesses. Additionally, they were using surface-to-air missiles, whose radars get around the “clobber” problem by pointing nearly straight up at the sky. Cruise missile radars would operate at a much lower angle.

Finally, there are not as many paths down a mountain as there are directions to drive on flat terrain. The routes of escape following a launch are more limited, further narrowing the areas the United States has to search, especially if it studies reconnaissance satellite imagery of areas surrounding potentially favorable launch sites before the conflict to determine paths in and out.

In sum, about half of the 33,000 square kilometers constitutes suitable terrain from which to target mobile missiles against traffic in the strait: the 10 percent of terrain above 1,000 meters, the 15 percent between 500 and 1,000 meters, plus sections of the coast and a few carefully angled spots farther inland. Even within these areas, the Iranians would have to have remarkable tactical skill to coordinate the campaign. Still, assuming the above, the United States would need a concept of operations for finding and destroying mobile missile batteries and targeting radars across approximately 16,500 square kilometers—an area about 50 percent larger than Kosovo.

As a first priority, the United States would want to destroy the Iranian radars needed to find targets for the missiles, without which the problem of mis-

92. *IRAN* 2004.

sile targeting becomes much harder for the Iranians. Radars are by their nature cooperative targets: whenever they are used to search for targets, they emit signals that give away their locations. The United States could deploy RC-135 Rivet Joint aircraft off the Iranian coast to gather this sort of signals intelligence and then feed estimates of Iranian radar locations to JSTARS (Joint Surveillance Target and Attack Radar System) aircraft. JSTARS could then use its SAR (synthetic aperture radar) to generate maps of likely radar locations and feed that information to tactical aircraft patrolling the area.⁹³

Additionally, the United States would want to be able to detect any ASCM launches as quickly and accurately as possible. The U.S. Defense Support Program (DSP) satellites are well suited to this task.⁹⁴ Operational since 1970, these geosynchronous satellites were designed to provide warning of Soviet ballistic missile launches and are now capable of detecting and characterizing a large variety of infrared events on or near the Earth's surface.⁹⁵ The United States is also able to reposition satellites to improve the launch point estimate, suggesting the detection method would be highly accurate.⁹⁶ In the Gulf War, for example, field commanders employing the Patriot missile batteries were able to obtain information from DSP satellites about Iraqi ballistic missile launches within two minutes of the launch, with a target field identification of 6 kilometers.⁹⁷ On a clear day, DSP satellites almost certainly would detect the infrared signatures of Iranian cruise missile rocket boosters. They could then

93. The United States eventually might be able to link three or more platforms (some combination of tactical aircraft, Rivet Joint, JSTARS, AWACS, Global Hawk, and others) to triangulate the location of ground radars using three or more different sensors and time delay of arrival techniques. This approach would cut the time needed to locate such targets. David A. Fulghum, "Taming Airborne Networks," *Aviation Week & Space Technology*, Vol. 163, No. 7 (August 15, 2005), p. 46; and "Mistaken Identity?" *Aviation Week & Space Technology*, Vol. 160, No. 27 (July 5, 2004), p. 19.

94. *Jane's Space Directory* (Surrey, U.K.: Jane's Information Group, 2006–07), p. 604; and Louis J. Rodrigues, "Defense Support Program: Ground Station Upgrades Not Based on Validated Requirements," GAO/NSIAD-93-148 (Washington, D.C.: General Accounting Office, May 1993).

95. *Jane's Space Directory*, p. 605. Recently declassified documents reveal that DSP satellites have proven their ability to detect and characterize events other than ballistic missile launches. During the Cold War they also detected pipeline fires, surface-to-air missile launches, aircraft crashes, and the afterburners on Soviet Backfire bombers. This sort of capability will only improve as the United States completes the transition to its new Space-Based Infrared System (SBIRS) of satellites. See the following documents available in Jeffrey Richelson, ed., "Space-Based Early Warning: From MIDAS to DPS to SBIRS," *National Security Archive Electronic Briefing Book*, No. 235, November 9, 2007, <http://www.gwu.edu/?nsarchiv/NSAEBB/NSAEBB235/index.htm>; Air Force Space Command, SBIRS Overview Brief, Combat Air Force Commander's Conference, November 16–17, 1998, pp. 3, 7; memo from William G. Hyland to Helmut Sonnenfeldt, December 13, 1975; and Ellis E. Lapin, "Surveillance by Satellite," *Journal of Defense Research*, Vol. 8, No. 2 (Summer 1976), pp. 169–186. See also Friedman, *Seapower and Space*, chap. 10.

96. *Jane's Space Directory*, pp. 604–605; and Friedman, *Seapower and Space*, p. 358 n. 15.

97. *Jane's Space Directory*, p. 605.

relay location information, missile type, and azimuth to a network of fixed and mobile ground stations. Those ground stations, in turn, could use Link-16 to communicate the information to ships and tactical aircraft.⁹⁸

DSP satellites can also cue the Airborne Warning and Control System (AWACS), which would be able to provide further information on Iranian launches. Unlike the DSP satellites, AWACS would detect not the infrared signature coming from the point of launch but rather the altitude and direction of the missile as it traveled toward a target in the strait. AWACS could then trace back from the flight path to estimate a set of potential launch points. If DSP satellites could identify the launch point within a 6-kilometer radius of accuracy, as in the Gulf War, the missile battery would have to be located within a circle of approximately 113 square kilometers. Overlaying the AWACS-generated target field onto the DSP-generated target field as in a Venn diagram would produce a shared target field of less than 113 square kilometers. Some of the inevitable error in the AWACS calculation could be reduced further by using data from Aegis ships and naval aircraft to triangulate the target. Terrain information would make it possible to narrow the target field even more.⁹⁹

The United States would then want to get a SAR image of the reduced area and task a moving target indicator (MTI) radar with tracking any movement therein. In other words, it would use one radar mode to produce a detailed still map of the terrain in question, then use a second mode to detect mobile targets within that map. The Global Hawk unmanned aerial vehicle would be ideally suited to this purpose, given that it carries a dual-mode radar, flies at such high altitudes that it could likely avoid detection, and by flying more directly over Iran would be better able to see into potential radar shadows. JSTARS also carries a dual-mode radar and could locate mobile targets. This information could then be passed to Predators or, more likely, tactical aircraft such as the F-15E, F-16, and F-18, which could race to the identified target field and search visually for the mobile battery.

How many tactical aircraft would it take to cover the 16,500 square kilometers from which Iran might launch antiship cruise missiles? It is possible to generate estimates from a few assumptions, which, even if they are not perfectly accurate, do give a sense of the rough scope of likely operations. For example, assume it takes two minutes for DSP satellites to transmit information about an Iranian launch to in-theater commanders, and one additional minute

98. Friedman, *Seapower and Space*, p. 358 n. 18.

99. *Jane's C4I Systems, 2006-07* (Alexandria, Va.: Jane's Information Group, 2006), p. 318; *Jane's Fighting Ships*, p. 877; and Friedman, *Seapower and Space*, p. 244.

for AWACS to track the missile, for Global Hawk to generate its SAR-MTI map, and for this information to reach an attack aircraft.¹⁰⁰ Meanwhile, assume that it takes Iranian missile operators five minutes to pack up their transporter-erector launcher (TEL) and move it out of the immediate area or hide.

These assumptions yield a two-minute window for an attack aircraft to destroy the battery at the launch site, after which the probability of finding the TEL swiftly declines. If an orbiting aircraft is flying at 0.8 Mach, a typical tactical aircraft cruising speed, then it must be no more than 32.6 kilometers away from the launch site to reach it within this window. Under these assumptions, any given aircraft could patrol an area of approximately 3,339 square kilometers. Hence it would take at least 5 aircraft on orbit at all times to cover the 16,500 square kilometers of territory from which Iran could target missiles at traffic in the strait—assuming there was no more than one launch within a given patrol area at any one time and that the orbits were perfectly efficient, which seems unlikely.¹⁰¹

Still, if it took 4 attack aircraft to sustain each orbit—1 on station at any given time, 2 transiting to and from the orbit, and a fourth on the ground for maintenance and crew change—20 aircraft would be needed to perform the attack mission. This sortie generation rate is well within the capability of a typical Nimitz-class carrier, which usually houses 4 Hornet squadrons.¹⁰² For sustained operations, however, the United States likely would want to rely on 2 or more carriers.

How long would it take the United States to destroy all the mobile batteries? The answer would depend on how many batteries Iran actually deployed to the search area, how many launches it chose to conduct each day, and U.S. skill at finding the TELs. Estimates of the campaign length vary greatly depending on alterations in these key assumptions. For example, if Iran had 36 batteries in the 16,500-kilometer area and launched 2 per day, it would take the United States 18 days to destroy them all, even if it had a 100 percent success rate in finding them.¹⁰³ By contrast, if the Iranians chose to deploy only half their bat-

100. This concept of operations comes from Alan Vick, Richard Moore, Bruce Pirnie, and John Stillion, *Aerospace Operations against Elusive Ground Targets* (Arlington, Va.: RAND, 2001), pp. 65–66.

101. These assumptions are favorable to the Iranians. If they take even one extra minute to move the TEL, the patrol radius of each orbiting aircraft is increased to 48.9 kilometers, yielding a much larger single aircraft coverage area of 7,512 square kilometers, and necessitating only 3 orbits.

102. See the entry on the U.S. Navy in *Jane's Fighting Ships*.

103. This estimate comes from the assumption of 25 Sardine/Saccade batteries plus 12 Silkworm/Seersucker batteries, which would make for 37 batteries. I rounded down to 36 batteries to make an even number and easier calculations.

teries to the coast but kept up the same rate of launch and the United States retained a 100 percent success rate in finding batteries after launch, the United States would need only 9 days to destroy all the batteries. Tweaking the assumptions in a direction less favorable to the United States can ratchet up the estimate dramatically, however. For example, if Iran deployed all 36 batteries to the area around the strait, reduced its launch rate to once per day, and the United States was successful at finding batteries only half the time, it could take 72 days to find all the batteries (if it opted to keep searching, a dubious assumption). In general, because U.S. detection capabilities depend significantly on Iranian launches, Iran has some ability to stretch out the hunt.

DEFENSIVE MEASURES AGAINST ANTISHIP CRUISE MISSILES AT SEA

Even if the United States believed it had destroyed most of Iran's ASCM capability, it would want to maintain defensive measures against any residual launches. The concept of defensive operations in the strait would involve U.S. Aegis cruisers and destroyers protecting MCM vessels and aircraft, as well as any commercial shipping. The warships' sensors and defensive capabilities would provide rings of protection within which these other relatively defenseless platforms could operate at reduced risk.¹⁰⁴

The centerpiece of U.S. defensive capabilities is the Aegis weapons system, which enables cruisers and destroyers to track and respond to multiple threats in multiple mediums simultaneously.¹⁰⁵ The outermost Aegis barrier is missile defense using the second generation of U.S. standard missiles, known as SM-2. SM-2 missiles can directly intercept incoming low-altitude cruise missiles. Aegis cruisers can carry up to 122 SM-2 missiles, and the destroyers up to 90, though the usual loadout is more like 40 to 50, with the other slots reserved for Tomahawk missiles and antisubmarine warfare missiles.¹⁰⁶ These loadouts cannot be changed at sea. Depending on how many missiles Iran launched, how many surface action groups were in the Persian Gulf at the outbreak of hostilities, and the U.S. firing philosophy, Aegis destroyers and cruisers could empty their magazines before the conflict was over. It takes 2 to 3 days to reload these magazines in port, meaning the United States probably would want

104. *Naval Mine Warfare*, pp. 49–50.

105. Hooton, *Jane's Naval Weapon Systems*, pp. 237–238.

106. *Jane's Fighting Ships*, pp. 877, 880. Aegis and other ships will soon carry shorter-range radar-guided missiles known as the RIM-7 Evolved Sea Sparrow that might be able to provide more effective defense in the narrow engagement distances of the strait. FAS Military Analysis Network, "RIM-7 Sea Sparrow Missile," updated November 26, 1999, <http://www.fas.org/man/dod-101/sys/missile/rim-7.htm>.

multiple surface action groups in theater to cover any defensive gaps during the reloading process.

If missile defense proved ineffective, Aegis ships would have to rely on other measures, starting with electronic jamming of the guidance capabilities of the incoming missile(s). Additionally, Aegis ships have a close-in weapons system known as the Mk 15 Phalanx, a gun that stops an incoming missile by putting a massive wall of lead in the air at a rate of several thousand rounds per minute. Failing that, Aegis ships can deploy infrared flares and chaff to confuse the missile in its final approach to the ship. In short, U.S. defensive capabilities against antiship cruise missiles are robust, but they may not be perfect, especially at close ranges or if the Iranians decided to expend most of their missile arsenal.

So far the analysis in this section and the previous section has assumed that the United States possesses air superiority. The next section relaxes this assumption and examines Iranian air defense capabilities and what the United States might need to do to suppress them.

Air Defense over Iran

Iran's most survivable and effective means of defending its air space are land-based air defense systems.¹⁰⁷ After briefly reviewing Iran's air-to-air capabilities, this section discusses the land-based defenses in more depth, concluding with an examination of how the United States could achieve air superiority in the event of conflict in the Strait of Hormuz.

IRANIAN AIR-TO-AIR CAPABILITIES

Iran's ability to defend its airspace with fighter aircraft is limited. Iran possesses a hodgepodge of operational fighter-attack aircraft, including two dozen Soviet-made MiG-29 aircraft; 25 F-14 aircraft; and 24 F-7M Chinese fighter aircraft. Only these latter planes have the needed parts and air-to-air missiles, but the F-7M itself is merely an upgraded Chinese copy of the MiG-21, not a fighter that can compete with today's U.S. Air Force and Navy.¹⁰⁸

107. Raas and Long, "Osirak Redux?"

108. Cordesman, *Iran's Developing Military Capabilities*, p. 69; IISS, *The Military Balance*, 2008, pp. 242–244; and Sharon Theimer, "Pentagon's Doorstep Surprise," *Houston Chronicle*, January 17, 2007. Some unconfirmed reports indicate that Russia has sold Iran 250 Su-30 fighter bombers, which would represent a substantial capabilities improvement. These reports originated in the Israeli media. "Russia's Largest Arms Deal in 30 Years: Iran Buys 250 Fighter-Bombers," DEBKA

The bigger problem is that even though Iran possesses some potentially menacing hardware, its pilots do not receive the training needed to use that equipment effectively.¹⁰⁹ The United States likely would be able to eliminate the threat from Iranian interceptors through offensive fighter sweeps early in the conflict. In any event, Iran probably lacks the maintenance capability to sustain these aircraft in combat across a lengthy conflict.¹¹⁰

None of this is to say that Iran could not get planes in the air. It surely could mount sorties on the first day of a war against U.S. aircraft conducting any of the missions described above. It could also use its interceptors or fighter bombers to attack U.S. vessels and helicopters engaged in mine-clearance operations. The question is how quickly the United States could destroy the Iranian aircraft that came up to fight and, more important, convince the Iranians of the futility of mounting further strikes. In 1991 the Iraqis reached this conclusion after barely a week of combat, at a cost of 33 fixed-wing aircraft and 5 helicopters.¹¹¹ Considering that the Iraqi Air Force was in better shape to begin with, this benchmark seems conservative regarding combat against Iran.

LAND-BASED AIR DEFENSE CAPABILITIES

Iranian land-based air defenses could pose a more persistent threat. Iran has devoted considerable resources and attention to its land-based air defenses. Out of a 52,000-man air force, Iran assigns 12,000 to 15,000 personnel to this task.¹¹² In recent years Iran has sought to purchase additional surface-to-air missile systems such as the SA-6 Gainful and SA-10 Grumble, but there have been no confirmed reports of delivery. For example, the Russians periodically note that despite cooperation on the Bushehr nuclear reactor and other military ventures, they have not filled Iran's 1998 order for the more advanced SA-10.¹¹³

Whether Iran possesses the SA-6 is slightly more open to question. Some analysts suggest that Iran could have up to 25 SA-6 batteries.¹¹⁴ So far, however, no evidence has emerged that this system is operational. In this case, the ab-

report, July 27, 2007, <http://patdollar.com/2007/07/russias-largest-arms-deal-in-30-years-iran-buys-250-fighter-bombers/>. For a skeptical perspective, see "Russia Denies Plans to Supply 250 Su-30 Fighter Planes to Iran," BBC Monitoring, August 2, 2007.

109. Extensive and realistic training greatly improves the combat performance of fighter pilots. See Marshall L. Michel, *Clashes: Air Combat over Vietnam, 1965–1972* (Annapolis: Naval Institute Press, 1997).

110. Cordesman, *Iran's Developing Military Capabilities*, chap. 5.

111. Keaney and Cohen, *Gulf War Air Power Survey*, p. 58.

112. Cordesman, *Iran's Developing Military Capabilities*, p. 71.

113. Yaakov Katz and Herb Keinon, "Israel Warns of Repercussions from Russian Missile Sales to Iran," *Jerusalem Post*, January 17, 2007.

114. Cordesman, *Iran's Developing Military Capabilities*, p. 72.

sence of evidence seems to be evidence of absence: Iran would have a strong incentive to prove its possession of the SA-6 as a way of deterring air attack. It must know that the SA-6 posed a serious suppression challenge for the United States in Kosovo in 1999, for example. That an SA-6 has never been fired in an Iranian military exercise or against any of the unmanned aerial vehicles hovering in the region casts doubt on claims that Iran possesses the system.

By contrast, Iran has advertised its recent acquisition of the Russian SA-15 Gauntlet, also known as the Tor-M1. As of early 2007, Russia had begun delivery of a total of 29 batteries purchased by Iran. The SA-15 is a low-to-medium-altitude system with a maximum engagement range of 12,000 meters. Although the system is undoubtedly one of the better-functioning parts of Iranian air defenses, the SA-15 is unlikely to pose a serious threat to first-class air forces, such as those of the United States and Israel, which can engage targets from outside its range.

Iran also has 150 or more I-HAWK (Improved Homing All the Way Killer) MIM-23B missile batteries, spread across 16 battalions. Capable of all-weather operations at altitudes of up to 20,000 meters, the I-HAWK is not to be underestimated. That said, it was made by Raytheon, so Iran is unlikely to have acquired sufficient spare parts for the system since the 1979 revolution. Additionally, both the United States and Israel have employed the I-HAWK, so Iran's principal adversaries are likely to be familiar with this system and to have devised appropriate countermeasures.¹¹⁵

The rest of Iran's surface-to-air missile systems are obsolete and vulnerable to electronic countermeasures.¹¹⁶ Beyond the deficiencies in particular systems, however, there are two bigger weaknesses in Iranian air defenses. First, the sheer number of batteries is not impressive considering the country's size and the number of sites Iran presumably wants to defend. Iran is slightly bigger than Alaska, covering an area of 1.6 million square kilometers. Another way to think of this is that Iran is eighteen times larger than Serbia, three times larger than Iraq, and twice as large as Afghanistan.¹¹⁷ Its territory includes a dozen major cities, at least half a dozen significant nuclear sites, 5,440 kilometers of land borders in a militarized neighborhood, and 2,440 kilometers of coastline facing the U.S. Navy and Sunni Arab states.¹¹⁸ Its SA-5 are said to cover its major ports, oil facilities, and Tehran, while its SA-2 are said to cover

115. Raas and Long, "Osirak Redux?" pp. 16–17.

116. *Jane's Land-Based Air Defense, 2006–2007* (Surrey, U.K.: Jane's Information Group, 2006), pp. 128–131, 152, 320, 337; and Cordesman, *Iran's Developing Military Capabilities*, p. 72.

117. Entries on Afghanistan, Iran, Iraq, and Serbia in Central Intelligence Agency, *The World Factbook, 2007*, <https://www.cia.gov/cia/publications/factbook/index.html>.

118. See Iran entry in *ibid.*

the major cities and bases, including the coastal areas of Bandar Abbas, Kharg Island, Bushehr, and Bandar-e-Khomeni.¹¹⁹ Reports also indicate that Iran has concentrated some of its better land-based air defense assets around the key nuclear sites of Natanz and Isfahan.¹²⁰ No matter how Iran configures its defenses, they are likely to be spread thin—Iran must defend a much larger area than the United States must suppress.

Second, Iranian air defenses may be less than the sum of their parts. It is one thing to have the hardware needed to conduct point defense, but quite another to have the surveillance and communications infrastructure to link various nodes into an integrated air defense system. This problem may be acute in Iran's case due to its mishmash of foreign-manufactured systems that were not designed to work together. Anthony Cordesman claims that Iran "also lacks the low-altitude radar coverage, overall radar net, command-and-control assets, sensors, resistance to sophisticated jamming and electronic countermeasures, and systems integration capability necessary to create an effective air defense net. . . . Iran lacks the battle management systems and its data links are not fast and effective enough to allow it to take maximum advantage of the overlapping coverage of some of its missile systems."¹²¹

REQUIREMENTS FOR U.S. AIR CONTROL

Iranian air defenses are not impressive, but they nevertheless could pose a threat to U.S. forces, especially to pilots patrolling directly over Iranian air space searching for mobile missile batteries. U.S. operations in Kosovo provide a reasonable basis on which to project how the United States might want to enhance its strike packages to suppress Iranian air defenses. As mentioned, the Iranian territory in question is approximately 50 percent larger than the area of operations in Kosovo, but Iranian air defenses are also of poorer quality and likely to be more dispersed than the Serbs' were.¹²²

The bulk of the suppression mission in Kosovo was accomplished with 48 F-16CJ aircraft and 30 U.S. Navy and Marine Corps EA-6B aircraft, both carrier- and land-based. The Falcons concentrated on the mission of destroying SAM batteries with high-speed antiradiation missiles, while the Prowlers generated electronic countermeasures against the Serbs' early warning radars. The U.S.

119. Cordesman, *Iran's Developing Military Capabilities*, p. 72.

120. Uzi Mahnaimi and Sarah Baxter, "Focus: Mission Iran," *Sunday Times*, January 7, 2007; and "Iran Port Bustles in Shadow of War," *Washington Times*, March 14, 2007.

121. Cordesman, *Iran's Developing Military Capabilities*, pp. 72–73.

122. The Serbs had the SA-6, SA-7, SA-9/13, SA-14, SA-16, and SA-18, in addition to antiaircraft artillery. Benjamin S. Lambeth, "Kosovo and the Continuing SEAD Challenge," Report RP-1018 (Santa Monica, Calif.: RAND, 2002), p. 16.

Table 1. Summary of Estimated Campaign Lengths and Military Commitments

Iranian Threat	Estimated Time (optimistic)	Estimated Time (pessimistic)	Military Commitment
Mines	28 days	40 days	All mine countermeasure capabilities, plus allies' (to clear 80 percent of mines)
Antiship cruise missiles	9 days	72 days	Multiple Aegis ships, port support, AWACS, JSTARS, UAVs, tankers, jammers, at least one carrier battle group
Air defense	—	—	2–3 squadrons F-16CJ, 30+ Prowlers, Compass Call, Rivet Joint
Total	37 days	112 days	

Air Force's EC-130 Compass Call aircraft conducted other electronic warfare against enemy voice communications, while the RC-135 conducted passive electronic intelligence gathering to cue F-16 pilots to the SAM sites.¹²³

To be sure, these requirements are not minor, but these forces largely protected U.S. aircraft in Kosovo. The Serbs, who concentrated their assets much more than the Iranians could, were able to shoot down only 2 U.S. aircraft, an F-117 and an F-16, out of thousands of U.S. sorties.¹²⁴ The main effect of the Serbs' contestation of air control was to place an upper bound on the number of sorties that could be devoted to offensive missions (in the Kosovo case, the strategic bombing campaign; in the Iran case, the search for missiles). Because U.S. air suppression assets were (and are) scarce, the continuing need to add suppression assets to each strike package limited how many strikes could occur each day. The overall length of the conflict increased as a result. Still, this combination of forces was able to conduct the mission successfully in Kosovo, and a similar force package likely could perform the suppression role during conflict in the strait. (For a summary of estimated campaign lengths and military commitments, see table 1.)

Conclusion

The United States' ultimate military superiority vis-à-vis Iran is without question, and eventually the United States would prevail in any confrontation.

123. *Ibid.*

124. *Ibid.*, pp. 12–13.

Nevertheless, mine warfare is within Iran's capabilities, and Iran possesses the antiship cruise missiles and air defense needed to make U.S. MCM operations even more difficult and time-consuming than they normally are. It does not take much imagination to suggest that the traffic in the Strait of Hormuz could be impeded for weeks or longer, with major air and naval operations required to restore the full flow of traffic.

Iran's limitations, such as the command and control and targeting challenges it would face in littoral warfare, are not often appreciated. But its strengths are often overlooked as well, such as the stocks of missiles and much more explosively powerful mines it has acquired since the tanker wars of the 1980s. Likewise, although the United States retains the world's best conventional military, its past experiences hunting mobile targets from the air and conducting MCM operations in the littorals do not inspire confidence that confrontation in the strait would end quickly. The United States' fleet defenses have never been tested in combat against an adversary with large numbers of cruise missiles, and the United States is in the midst of a major transition in its entire concept of MCM operations. Given these realities, sanguine assurances about the course and outcome of military conflict in the strait seem unjustified at best, and dangerous at worst.

Most important, Iran does not have to seal the strait entirely to provoke U.S. intervention, and once that intervention begins, the potential for further military escalation is high. In particular, if the air and naval campaigns appear to be dragging on, the United States might be forced to consider holding hostage other targets in Iran or using ground forces. Either way, a significant and sustained increase in the price of oil would seem likely.

This analysis has significant implications for U.S. force posture and foreign policy. First, as a general matter, the analysis shows that despite a growing bipartisan consensus on the need to expand U.S. ground forces, U.S. air and naval capabilities remain essential to the defense of Persian Gulf oil supplies. More specifically, the U.S. ability to reopen the strait hinges critically on two sets of scarce assets: dedicated MCM capabilities and air defense suppression capabilities. It is precisely because the United States has such a small (and shrinking) MCM fleet that it would have to mount such a serious offensive effort to eliminate Iranian shore-based fire. If MCM assets were greater in number and therefore more expendable, the U.S. Navy would be able to risk operating them in a less permissive environment, thereby shortening the amount of time required to reopen the strait.

Likewise, air defense suppression assets continue to be "high demand, low density," constraining the number of offensive air sorties that can be con-

ducted at any one time. This scarcity places an inherent limit on how fast any aerial hunt for mobile targets can proceed, unless the United States wants to incur an increased risk of shoot-downs. The importance of U.S. air control assets will only grow if Iran has the opportunity to acquire more advanced SAMs and aerial interceptors in the years to come. Greater U.S. investment in the suppression mission would be a boon not only to U.S. prospects in the strait but also against other potential adversaries, such as China and North Korea.

The United States should also encourage the use of more southern routes within the gulf, as water depths allow. The greater the area tankers are comfortable traversing, the harder it will be for Iran to threaten the flow of that traffic with a small number of mines. Additionally, the farther from the Iranian coast that tankers can travel, the smaller the area within Iran from which missiles can be targeted at traffic in the gulf. Shrinking this area would reduce the difficulty of hunting for mobile missile batteries, as well as related air defense requirements, speeding how quickly the United States could conduct MCM operations in a permissive environment.

Above all, the scenario described here points to the critical importance of early detection of any Iranian mine laying in the Persian Gulf and especially the need to keep close tabs on Iranian submarine activity. Such surveillance depends not only on U.S. activities in the region but also on those of Iran's gulf neighbors. If the United States wishes to continue to act as the guarantor of free passage in the strait, it needs to make these monitoring activities a clear part of a broader effort to discourage Iranian attempts at harassment or closure. It also may wish to convey to Iran that, precisely because of the potential length and complexity of the operations outlined in this article, a campaign to clear the Persian Gulf of Iranian mines could quickly become a war to clear the Iranian harbors and coast of most remnants of the country's military.