SUMMARY

During the 43-day Gulf War, the U.S. Air Force (USAF) flew nearly 70,000 sorties, attacked over 28,000 targets, shot down 36 Iraqi aircraft, disrupted Iraqi command and control and transportation systems, and directly attacked the Iraqi army in Kuwait, destroying many of its vehicles and damaging its morale before the ground offensive began. All of this damage was achieved at the cost of just 14 aircraft, which were lost to ground-based air defenses; none were lost in air-to-air combat. The USAF plans to build on its success in Operation Desert Storm by deploying increasing numbers of stealthy aircraft and precision-guided munitions (PGMs), supported by a much more capable battle-management system, to fight the next war.

However, the USAF is not the only organization to have drawn lessons from Operation Desert Storm. Potential adversaries are likely to expend considerable time, energy, and resources on ensuring that the USAF does not make such a large contribution to victory at so low a cost in a future conflict. The research reported here confronts this possibility and examines ways of dealing with it.

PURPOSE AND APPROACH

Other RAND research has explored how potential adversaries could use asymmetric strategies, special operations forces, terrorists, information attacks, and weapons of mass destruction to degrade or

eliminate USAF combat capability during a future conflict.[1] This report presents yet another strategy whereby a clever and competent adversary could attempt to interfere with USAF combat operations if the USAF sticks to the operational concepts that served it so well during Operation Desert Storm. It examines the following questions:

- How could potential adversaries use readily available commercial and military technology to modify conventionally armed cruise and ballistic missiles to effectively attack USAF aircraft on the ground, at theater operating bases?
- How technically advanced must an adversary be to successfully suppress USAF operations from theater operating bases?
- What options (new operational concepts, material, equipment, etc.) exist for the USAF to minimize the impact of conventional cruise- and ballistic-missile attacks on theater operating bases, both in the near term and long term?

EMERGING THREAT TECHNOLOGY

Ballistic and cruise missiles must be accurate to be militarily effective. Although many countries around the world deploy ballistic missiles similar to those used by Iraq in 1991, these weapons have limited utility against military targets. Several countries, including Iraq and Iran, have used them in combat—but only as terror weapons.[2] Technological sophistication is required for an accurate and robust (militarily suitable) cruise missile, which means that only a few nations currently possess inventories, and only the United States has used cruise missiles in combat since the end of World War II. Global Positioning System (GPS) guidance devices provide a fairly cheap and effective way of improving both ballistic- and, especially, cruise-missile guidance. This technology could be used to improve the ac-

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[1]See David Shlapak and Alan Vick, *"Check Six begins on the ground": Responding to the Evolving Ground Threat to U.S. Air Force Bases*, Santa Monica, Calif.: RAND, MR-606-AF, 1995; Maurice Eisenstein, "The Use of Weapons of Mass Destruction by Terrorists Against Air Bases," unpublished RAND research; Brian Chow, *Air Force Operations in a Chemical and Biological Environment*, Santa Monica, Calif.: RAND, DB-189/1-AF, 1998.

[2]Terror weapons are weapons designed specifically to cause damage, casualties, and fear within the targeted civilian population.

curacy of existing ballistic missiles to about 100 meters and allow almost all nations to obtain the accurate cruise missiles that, until now, have been reserved for technologically advanced societies.

However, improved missile accuracy is not enough to make ballistic and cruise missiles both militarily effective and affordable weapons against parked aircraft. Submunitions are far more efficient against soft targets susceptible to blast or fragmentation damage than are unitary warheads of the same weight. The lethal area of a cruise missile with a 75-pound payload against aircraft in the open is about three times greater when using a submunition warhead than when using a unitary warhead. This advantage increases with increasing payload. An 1,100-pound M-9 ballistic-missile warhead covers almost eight times the area when using a submunition warhead than when using a unitary warhead.[3] The *combination* of increased accuracy from GPS guidance and increased warhead efficiency is what decreases the number of missiles required to attack USAF airbases from hundreds to dozens.

A potential asymmetric strategy considered in this report is the use of small, slow cruise missiles to "slip under" the current USAF radar umbrella. The term "cruise missile" simply refers to an unmanned aircraft designed to fly a one-way attack mission. The cruise missiles considered here are significantly different from the high-performance fighter-size targets USAF air defense systems were designed to counter during the Cold War. Cruising at about 70 knots, these small aircraft would be difficult for current USAF air defense systems to detect. Surveillance and tracking radars designed during the Cold War (e.g., those on F-15s, F-16s, and Airborne Warning and Control System [AWACS]) took advantage of the high speed of Soviet combat aircraft to simplify the task of sorting attacking aircraft from ground-vehicle clutter merely by ignoring potential targets moving slower than about 80 knots. Some of the systems have the capability to detect and track slower targets, but only in narrow sectors and for short periods of time before the number of potential targets exceeds the system's data-processing and display capabilities.

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[3]These calculations assume a 20-foot lethal radius for a 1-pound submunition and that 75 percent of warhead weight is devoted to submunitions, with the remainder devoted to a frame and dispensing mechanism.

Surface radars are less affected by ground clutter than are airborne radars but suffer from limited line of sight against low-flying targets. Patriot and AEGIS[4] could acquire and track a slow-moving cruise missile, but only above the radar horizon—less than 20 miles for a cruise missile flying at 100 to 130 feet. Unless the United States deploys huge numbers of ground-based radars to a future theater conflict, most cruise missiles will go undetected by current U.S. air defense systems.

OPERATIONAL IMPACT

We posit a simple illustrative scenario to explore the impact GPS-guided cruise and ballistic missiles equipped with submunition payloads might have on current USAF theater air operations. In our scenario, Iran uses an Iraqi succession crisis turned civil war as an opportunity to invade southern Iraq. The United States responds in a variety of ways, including deploying USAF combat aircraft to the following bases on the Arabian peninsula: Dhahran, Doha, Riyadh Military, and Al Kharj.

These bases have a total of 14 potential parking areas ranging in size from 600 × 300 feet to 9,000 × 900 feet. The total area of the parking ramps at these bases is over 44 million square feet—the equivalent of almost 1,000 football fields. These bases can accommodate a huge number of combat aircraft and an intense aerial-port operation. However, the number of GPS-guided, submunition warhead cruise missiles and ballistic missiles required to attack this huge area is surprisingly small, assuming a 20-foot lethal radius for the 1-pound submunitions employed and standard USAF aircraft-parking procedures. A 0.9 Pk (probability of kill) against all aircraft on the parking ramps of these four bases could be achieved with 30 GPS-guided M-9 and 30 M-18 ballistic missiles, and 38 small GPS-guided cruise missiles, at an estimated cost of about $101 million.

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[4]AEGIS is a totally integrated shipboard weapon system that combines computers, radars, and missiles to provide a defense umbrella for surface shipping. The system is capable of automatically detecting, tracking, and destroying airborne, seaborne, and land-launched weapons. Joint Chiefs of Staff, Department of Defense *Dictionary of Military Terms,* Washington, D.C.: Joint-Pub 1-02, March 23, 1994, pp. 6–7.

Attacking the tent cities at all four bases and a Patriot or theater high-altitude air defense (THAAD) radar at each requires an additional 40 ballistic missiles and 8 cruise missiles, raising the total cost to about $163 million—about the cost of four Russian Su-27 export-version fighters. The effect on USAF sortie generation of destroying a large number of aircraft, living quarters, most personal equipment, and some work centers while creating widespread foreign-object damage would be devastating.

POSSIBLE USAF RESPONSES

To reduce the vulnerability of deployed forces, the USAF could take a variety of actions over the next few years. These actions fall into three basic categories: passive defenses, active defenses, and dispersal.

Passive defenses include constructing hardened aircraft shelters and living facilities at likely deployment bases; acquiring deployable shelters, for both aircraft and personnel, capable of withstanding submunition impact; and constructing additional parking-ramp space to allow increased dispersal. These measures would complicate an adversary's targeting problem and increase the number of weapons required to achieve a given level of damage.

All of these measures could be effective against GPS-guided cruise- and ballistic-missile attacks, but have potentially serious drawbacks. Hardened shelters and additional parking ramps are expensive, time-consuming construction projects that require the USAF to correctly anticipate—years in advance—where it will fight the next war. Deployable shelters allow more-flexible operations, but significantly increase the wing's airlift requirements.

Short-term active defenses against the small, slow cruise-missile threat could include relatively low-tech, simple measures such as putting machine-gun teams with night-vision goggles in towers surrounding USAF operating bases or deploying radar-guided guns.

Another relatively short-term alternative available to the USAF is to disperse its operations to a large number of highway landing strips to complicate an adversary's targeting problem. This option has the potential to defeat the missile threat but, again, carries significant potential costs, especially for sortie-generation activities. Sortie rate

would not necessarily be reduced by dispersed operations, given the economies-of-scale considerations in maintenance and force protection, but would require more personnel to achieve the same number of sorties (all other things being equal—range to target, availability of munitions, etc.). In addition, an adversary with access to effective human intelligence (HUMINT) or satellite capability could locate and attack USAF units at these dispersed locations.

The Expeditionary Air Force (EAF) concept also must be considered when formulating basing operations and vulnerability to missile attack. This concept emphasizes the ability to rapidly deploy anywhere in the world, which raises two issues for defense planning: First, little support will exist to build additional infrastructure (shelters, additional ramp space, etc.) at potential deployment bases that could reduce the impact of airbase attack. Second, since the EAF must travel light to deploy a warfighting package quickly anywhere in the world, little flexibility will exist to transport items that would provide protection or facilitate recovery from such attacks.

POTENTIAL LONG-TERM SOLUTIONS

If the USAF could conduct its theater air campaigns from a few secure bases with assured access,[5] many of the issues discussed in this report could be avoided. Hardened facilities and advanced missile defenses could be constructed prior to the start of hostilities. Although a detailed cost analysis was beyond the scope of this work, building a robust passive and active defense system at only a few selected bases should limit the total expense.

To achieve the goal of operating anywhere in the world from a few secure, hardened, fixed bases with guaranteed access, the USAF would need to develop operational concepts for longer ranges. Crew-fatigue considerations limit aircraft with 500-knot cruise speeds to ranges of about 2,000 nautical miles (nmi) for sustained operations. An aircraft with a 1,000-knot cruise speed could cover virtually the entire inhabited land surface of the Earth, except for the southern tips

[5] *Assured access* means basing in the United States or on the territory of very close allies, such as the United Kingdom, who typically support U.S. actions.

of Africa and South America, by operating from four secure hardened bases: Guam, near Anchorage, Miami, and London.

A total inventory of approximately 80 to 105 Mach 2 bombers with the following specifications could deliver enough PGMs (about 560 tons per day) to replicate the USAF Desert Storm effort:

- a weight of 290,000 to 350,000 pounds
- an unrefueled range of 3,250 nmi
- a payload of 15,000 to 20,000 pounds.

This force could attack targets almost anywhere in the world while operating from well-protected, permanent bases in the United States and the United Kingdom.