BOMBING IRAN'S NUCLEAR ENRICHMENT FACILITIES

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INTRODUCTION

Iran has been enriching critical materials needed to build atomic weapons and has been stockpiling the means to deliver them remotely. Their efforts are long- term, robust, redundant, scientifically based and physically protected. They are also accompanied by a campaign of obfuscation that has confused and misled a significant portion of the international community and provided a rationale for inaction. Confusion arises because Iran's nuclear activities are dual-use; i.e., they have both civilian and military applications. Iran has stressed the "peaceful" applications and denied military intent.

Iranian leadership has publically advocated destruction of the state of Israel on numerous occasions. It is, therefore not unreasonable, as many Israelis have done, to categorize Iranian nuclear activities as an existential threat that may warrant preemptive action to destroy the program. However, the threat to Israel is only one reason for intervention. It is widely believed that Iran's activities are also causing a nuclear arms competition in the Middle East specifically by Saudi Arabia, Jordan, and Turkey. Eventually others like Egypt and Iraq may follow. The perception of the Iranian nuclear threat, real or imagined, is clearly having a detrimental effect.

It is imperative that efforts are undertaken to stop Iran from stockpiling nuclear weapons, but those efforts must be credible. If the Israelis intervene unilaterally, can they succeed? Should or will the United States assist Israel? Would American intervention be more successful then Israeli intervention? These issues are explored in a new analysis that takes a somewhat skeptical outlook.

The overarching conclusion is that military intervention is warranted only if success can be assured with high confidence, and that assurance is currently lacking for Israel and to a significant but lesser extent for the United States. A better course of action would combine cybernetic warfare and scientific leadership sabotage with diplomatic and economic sanctions in the hope that these will constrain Iran's nuclear program and either delay, reverse or render it non-threatening. Unfortunately, those measures, which closely mirror current American policy, also do not guarantee success and may necessitate major-power intervention in the future.

IRANIAN NUCLEAR THREAT

Iranian nuclear facilities of most concern are the uranium enrichment plants at Natanz and at Fordow near the city of Qom. Of additional interest is the heavy water separation unit at Arak and the nearby 40MW research reactor. If an attack is launched, these three complexes are the likely focus. Locations of major Iranian nuclear facilities are displayed in Figure 1. [1]

- **Arak – Heavy Water Plant and 40MW Research Reactor**
- **Qom/Fordow – 20% U-235 Enrichment**
- **Bushehr – VVER Pressurized Water Reactor**
- **Isfahan – Yellow Cake and Zirconium**
- **Tehran – 5MW Research Reactor**
- **Gachin and Saghand – Uranium Mines**
- **Parchin – Suspected Weapons Test Site**

Figure 1 – Iranian Nuclear Facilities
Source: Author Adaptation

According to the International Atomic Energy Agency, there are about 9,000 centrifuges installed at Natanz. As of February 2012, most of these were operating and producing low-enriched 3.5% uranium-235. However, a fraction of the centrifuges are producing 20% uranium-235, and over a 5-year period several hundred pounds have been accumulated. 20% uranium is rationalized by Iran as replacement fuel for the 5MW

[1] Iran currently is operating nuclear reactors at Bushehr and in Tehran. Bombing operating reactors with penetrating explosive munitions is a bad idea because that might spread radioactive fallout and possibly trigger a Chernobyl-scale disaster.

Tehran research reactor. However, the Tehran research reactor requires only 38 pounds per year. Ominously, the Iranians have not only exceeded that amount but are increasing their rate of production. It is noted with trepidation that the 20% level is only a short stepping-stone from weapons grade 90% uranium-235.[2]

The enrichment facility at Fordow (near Qom) is believed to be smaller, but when fully operational will also produce 20%-enriched uranium-235 and at triple the Natanz rate. The Fordow facility is nominally intended to provide fuel for the new research reactor being built at Arak, the 40MW heavy water reactor. Iran has been operating a heavy water separation plant at that site to support the 40MW reactor since 2006. The Arak reactor will presumably replace the much smaller Tehran research reactor that produces radioactive isotopes.

The Natanz and the Fordow sites are both heavily protected structurally and with anti-aircraft weapons. The operating centrifuges at Natanz are housed in two halls, each more than four football fields in area. These structures have a five to ten foot roof of reinforced concrete[3] and are also covered with roughly thirty feet of earth. However, although the dimensions and locations of the buildings at Natanz are known with some confidence as the result of commercial and military satellite observation, they are only about 25% occupied. With all that vacant space, the precise aim points for attacking centrifuge cascades are unavailable and the attack process would be necessarily inefficient.

The Fordow facility in contrast is built into the side of a mountain. Only the nominal entrance points and the number of centrifuge pads that have been delivered to the site are known with any confidence. Direct attack of Fordow with explosive weapons is problematic not only because precise aim points are unavailable but also because adequate depth penetration for the attacking munitions is improbable and undemonstrated at best.

Note that the targeting situation at Arak is totally different. Aerial attack there is much more feasible. The heavy water distillation unit is visually distinctive and aboveground. It is highly vulnerable to attack with aerial bombs. The 40MW research reactor is definitely targetable as well although the wisdom of doing so may be questionable if it has already been loaded with fuel. It is also expected that Arak will be heavily defended with anti-aircraft weapons.

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[2] Greg Jones has calculated that the 90% enrichment level can be reached with only one additional stage from 20%, albeit at a reduced rate. (Greg Jones, *Facing the Reality of Iran as a De Facto Nuclear State,* Nonproliferation Policy Education Center, Arlington, VA, May 26, 2012.

[3] The compressive strength of this concrete is unknown. Although laboratory samples with concrete strengths of 50,000 psi have been demonstrated, it is unlikely the Natanz concrete exceeds 25,000 psi.

THE DUAL-USE IRANIAN RUSE

Iran has consistently chosen dual-use rationale to justify nuclear activities that have ominous military potential. At Natanz, for example and as noted earlier, Iran has enriched and accumulated hundreds of pounds of 20% uranium-235 that it asserts is for the Tehran research reactor. This constitutes a 10-year supply. The Fordow facility moreover is also slated to enrich uranium-235 to the 20% level and at a greatly increased rate. A more plausible explanation for both the Natanz and Fordow highly enriched materials is that they are starting points for 90% uranium-235 that is at the weapons grade level.

At Arak, the separation and accumulation of heavy water as the coolant and enhanced moderator for the 40MW reactor is also suspect. If Iran requires heavy water for its new reactor, it can buy it on the world market at a small fraction of the cost of a stand-alone heavy water separation plant.

Moreover, the purpose of the 40MW reactor itself can be questioned. Iran has asserted that it will replace the 5MW Tehran reactor that produces radioactive isotopes for medicinal purposes. A 40MW reactor that uses expensive heavy water to replace a 5MW radioactive isotope reactor is clearly overkill. A much more likely explanation is that it will be used to accumulate plutonium, with the intent of eventually building atomic weapons. It is observed that plutonium would be more efficiently produced in a fast breeder reactor most of which employ a moderator/coolant like liquid sodium that does not slow neutrons extensively. Heavy water does slow neutrons but that does not stop the transmutation of the uranium-238 isotope to plutonium completely. Heavy water reactors are therefore dual-use. They make ideal research reactors but can also be used for plutonium production.[4]

Iranian officials have recently extended the dual-use rationale in a totally new direction. They now maintain they are developing nuclear-powered submarines that employ highly enriched uranium (>90%) as fuel.[5] Enriched uranium of that (weapons grade) purity is currently used for ship fuel only in military vessels so the "peaceful" part of the argument has been abandoned completely. Since it is widely believed that nuclear submarine technology is considerably beyond Iran's current capability, uranium-235 enrichment at the 90% level could justifiably be condemned as a hoax.

The dual-use ruse is summarized in Table 1.

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[4] Heavy water reactors permit the use of both natural uranium and depleted uranium as fuel. The inappropriate coupling of 3.5% uranium-235 and especially 20% uranium-235 to heavy water is obvious.

[5] Jay Solomon; *Iran Says it Plans Nuclear Submarines;* Wall Street Journal, p. A10, June 13, 2012.

Table 1 – Dual Use Ruse
Source: Author

Location	Activity	Conflicting Purposes
Natanz	3.5% Enrichment 20 % Enrichment	Research Reactor Fuel Weapons Grade Uranium
Fordow	20 % Enrichment	Research Reactor Fuel Weapons Grade Uranium
Arak	40 MW Reactor Heavy Water Production	Radioactive Isotopes Plutonium Production
Natanz & Fordow	>90% Enrichment	Nuclear Submarines Weapons Grade Uranium

CAN THE ISRAELIS DO THE JOB

Israeli aircraft cannot fly directly from their bases to Iran without overflying other sovereign countries including some combination of Jordan, Syria, Iraq, Saudi Arabia, Turkey, and possibly Lebanon as displayed in Figure 2. The straight-line distances are substantial; the arrows in Figure 2 illustratively scale to 1000 nautical miles. The need to skirt air defenses reduces the attack coverage considerably.

It is probable that aerial refueling will be required for multiple bombing passes and a round-trip. However, although over-flight and aerial refueling are both hindrances, they are not "show stoppers". Israel might opt to negotiate *sub-rosa* over-flight permissions or simply ignore such infractions since world reaction would be hostile in any case. Although, Israeli refueling capabilities may in fact be marginally adequate, they would come at the expense of an extended campaign requiring many repeat tanker sorties.[6]

[6] According to several Global Security websites, non-refueled combat ranges for F15I and F16I Israeli aircraft are 1250 nautical miles. Israel would undoubtedly seek refueling help from the United States but in the current climate that would likely be declined.

Figure 2 – Middle East Proximities
Source: Author Adaptation

However, major difficulties arise from the likelihood of inefficient aim point selections and from inadequate explosive munitions earth penetration. On the basis of the occupied space in the underground buildings, aim point efficiency would be only about 25% at Natanz and substantially less at Fordow. This obviously necessitates many more bombing sorties than desired.

Single aerial bombs lack the penetrating capability necessary to engage Iranian underground target structures. Adequate penetration through the roof requires impacting the same spot with multiple bombs. It is estimated that about 3 bombs per aim point will be required at Natanz and a larger number at Fordow.[7] In principle, this is feasible if GPS technology is used but the capability has not been demonstrated

[7] The best penetrating munition, the GBU-28, would consistently pass through the earth overburden and reach the concrete roof from 40,000 ft. Defeating the roof would take another 2 bombs in the same hole.

systematically with guided bombs. In any case, substantially larger numbers of sorties are required for sufficient penetration. The more difficult target, Fordow, might require a hundred sorties alone considering both the aim-point uncertainties and the multiple impacts necessary. In contrast, the targets at Arak can be bombed very efficiently requiring no more than five to ten 2000-lb guided bombs.

In summation, short of a commando raid using air-inserted ground forces, Israel cannot realize reliable destruction of the more troublesome Iranian targets. An air-inserted commando raid would require at least 2 battalions of Special Forces and more if the operations were contested by Iran on the ground.

CONSEQUENCES AND ALTERNATIVES

If Israel attacks Iran, it can expect only partial success at best. Undoubtedly, the heavy water facility and 40MW reactor at Arak can be set back for many years, perhaps permanently.[8] However, Natanz and particularly the Fordow facility are both much better protected. Israeli success in these cases is problematic and will probably be inconclusive. The likely outcome will be uncertainty and controversy.

The consequences of an unsuccessful Israeli attack could be severe. There would be adverse reaction domestically within Israel threatening support for the government in power. The bulk of the international response would also be negative including the likely reaction of the United States government. The reaction of Middle Eastern countries like Saudi Arabia and Jordan would have further negative consequences; it would undoubtedly stimulate activities to develop their own individual nuclear deterrents. *A failed Israeli attack is not an option.*

A successful Israeli attack would fare much better but it would have to be proven. The durability of even a proven success would be suspect.

A successful Israeli attack would be valued in terms of the number of years in which the Iranian program has been delayed. The bomb damage assessment process would require ground forces and/or ground sensors to be credible.

A troubling attack consequence would be the potential unleashing of a retaliatory missile barrage by Iran against Israel. Israel has defenses against that possibility, specifically the Arrow 3 anti-ballistic missile system. However, Arrow is unproven in combat and therefore of uncertain effectiveness. Israel could attempt preemptive bombing strikes against Iranian missile sites, but that would greatly increase the required number of aerial sorties, already in the hundreds. Israel also has a non-nuclear

[8] The two known Israeli attacks on nuclear facilities are the 1981 destruction of the 40MW Osirak reactor in Iraq, and the September 2007 destruction of a suspected Syrian site. Both were believed intended for plutonium production, and both actions are considered highly successful.

missile deterrent that could be unleashed against Iranian cities as punishment. Neither of these is an attractive alternative.[9]

Those outcomes must of course be weighed against the consequences of no military action. Alternatives to military action include intensified diplomatic and economic sanctions both of which have not proven effective in the past. Obstacles to effective economic sanctions arise principally from reluctance on the part of China and Russia to participate noting that both have substantial business activities in Iran. Other alternatives to military action include support of Iranian dissidents with the hope of major policy changes and possibly regime change.[10] These alternatives closely mirror current American and Israeli policy but have not previously gained significant traction despite substantial effort.

In the absence of military action and without effective diplomatic and economic restraints on Iran's nuclear ambitions, the Middle East arms competition will continue and eventually, as with India and Pakistan, may get out of control. Ultimately, Iran will accumulate a nuclear weapon stockpile and that will force a military response by one or more major powers.

The consensus of intelligence assessments on Iran is that they are not now assembling nuclear weapons. This provides time to contemplate and implement solutions other than a military strike.[11] Unfortunately, the Middle East arms competition will continue during this interim period with undesirable consequences.

The United States should put pressure on Saudi Arabia, Jordan and Turkey to constrain their in-house nuclear activities, and redouble diplomatic and economic sanctions against Iran. Israel should refrain from a unilateral military strike unless it can be done with a high level of assured success.

WILL THE UNITED STATES HELP OR SUBSTITUTE FOR AN ISRAEL ATTACK

The United States is in the process of an intensive counter-terrorist campaign using drone strikes against leadership targets in Pakistan, Afghanistan and Yemen. However,

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[9] An Israeli preemptive strike might also trigger short-range barrages from Hezbollah in Lebanon and Hamas in Gaza. Israel is much better prepared to deal with these using its Iron Dome defensive system. Another concern is the possible closing of the Straight of Hormuz by Iran. That is primarily an international issue and Iran has threatened such action in the past. However, it would expand the scope of the war against Iran and is considered unlikely.

[10] Cyber-warfare employing the so-called Stuxnet worm has reportedly been used against the Natanz centrifuges with partial success. Another cyber-warfare technique uses the FLAME virus that was discussed extensively in the New York Times. Claims have also been made that assassination and abduction of Iranian scientists have impacted their program substantially. All are delaying tactics at best.

[11] Ob. cit., Contrary to consensus opinions of the intelligence community, Greg Jones estimates Iran is only a few months from accumulating the required enriched uranium, and that a bomb could be built shortly thereafter.

it has simultaneously curtailed military action in Iraq, and is reducing forces in and has announced withdrawal from Afghanistan by the end of 2014. The United States participated in the ouster of Qaddafi in Libya but only minimally, letting NATO take the lead. It has thus far refrained from military activities in Syria. The clear intent of United States policy is to reduce military expenditures by hundreds of billions of dollars.

The military budget will undoubtedly be reduced in the next few years and a major component of that reduction will be outlays for Middle East operations. In the ongoing austerity environment, it is unlikely that any administration will encourage an Israeli preemptive strike. Cost-cutting pressures will prevent major outlays for military assistance.

It is observed that a United States pre-emptive strike would encounter many of the same difficulties confronting the Israelis. The United States could launch their attack from nearby coastal waters and from land bases in Afghanistan. However, they would suffer the same inefficiencies of inadequate ordnance and poor aim point selections.

SUMMARY

Although Iran's nuclear activities need to be curtailed, it is judged that Israel does not have a well-assured success level for bombing Iranian nuclear enrichment facilities and should not attempt it unilaterally. This lack of assurance derives from uncertain aim-point locations particularly at Fordow, and from inadequate earth penetration by current explosive ordnance. Additionally, Israel would have to overfly nearby sovereign countries to reach Iranian targets with hundreds of sorties, risk air defense attrition both en route and within Iran, and would probably require aerial refueling assistance. The needed over-flight permissions are unlikely to be granted and refueling help is doubtful.

The consequences to Israel of a failed attack would be significant both domestically and in terms of international reaction. Even a successful attack would have to be substantiated, a difficult undertaking. Controversy would accompany the aftermath of any attack, successful or not. Substantiation of attack results requires definitive on-the-ground verification, and even that would be interpreted in terms of delay time and not program termination. Overall, the judgment rendered here is that Israel should not attempt unilateral destruction of Iranian nuclear facilities by aerial bombing.

However, non-attack also has consequences. Aside from the fact that a rogue nation will probably accumulate a nuclear stockpile, the most significant consequence is that the ongoing nuclear arms competition in the Middle East continues and may get out of control. To mitigate this, the United States should intensify diplomatic efforts to constrain Saudi Arabia, Turkey and Jordan from pursuing in-house nuclear weapons development. Concurrently, it should not take American military action against Iran off

the table. To further dissuade Iran from pursuing its nuclear program, the international community should renew and extend diplomatic efforts, and strengthen economic sanctions. These actions represent current policy. Unfortunately, in the long term, they will probably fail.