

THE AYATOLLAH'S NUCLEAR GAMBLE

THE HUMAN COST OF MILITARY STRIKES
AGAINST IRAN'S NUCLEAR FACILITIES

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Many scholars, soldiers, scientists, and statesmen in Iran, the United States of America, Israel, and the Arab world have worked tirelessly to prevent and protect future generations from the scourge of another war. It is to those generations that I dedicate this study.

Khosrow B. Semnani

FOREWORD

As the director of the Hinckley Institute of Politics, I am pleased to present you with this special report, *The Ayatollah's Nuclear Gamble*. Over the past year, Mr. Khosrow Semnani and his colleagues have put together this important document critically examining the potentially horrific impacts of military strikes against Iran's nuclear facilities. Mr. Semnani—whom I deeply respect and admire for his philanthropic work and his expertise and intellectual curiosity in matters regarding Iran—originally approached me about publishing this document through an acclaimed think tank or public policy center and an abridged version in our noteworthy Hinckley Journal of Politics. I was immediately impressed with the quality and depth of the document and agreed to support him in these efforts, but world events and timing issues made working with these other publications impractical.

With constant reports of the conflict heating up regarding Iran's nuclear program and Israeli and American rhetoric about an attack on Iran becoming more frequent, we realized that time was of the essence. Mr. Semnani and other experts (including Israelis, Americans, and Arabs) with whom I shared this document expressed their desire to make this document available to the international community as soon as possible. I agreed. Because of the circumstances of the world right now, we have decided to publish this special edition. The information and data presented in this publication provide a needed perspective at a time when the issue is at a boiling point.

As with all of the Hinckley Institute's forums and publications, we seek to follow our founder Robert H. Hinckley's admonition of political participation—but in order to truly participate, you need to understand the issues. The Hinckley Institute's various publications seek to capture the diverse conversations surrounding the most pressing issues facing the United States and the world.

The Hinckley Institute has become more internationally engaged since its inception in 1965. Now we have student interns in more than 35 countries around the world, including in the Middle East. As such, we feel more acutely that these international tensions should be thoroughly examined and considered if our leaders are to work toward peaceful solutions.

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PREFACE



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Pre-emptive military strikes to disable the emerging nuclear threat from Iran are under consideration by the U.S., Israel, and other countries. Such strikes, whether using nuclear or conventional means, would result in devastating human, political, and environmental consequences upon both Iran and the region.

To quantify these consequences, Khosrow Semnani, a prominent Iranian-American industrialist with extensive experience in the industrial management of nuclear waste and chemicals, examines consequences of pre-emptive strikes against the Iranian nuclear infrastructure in an accurate and carefully documented monograph. Of great concern and focus by Semnani are the deaths and injuries that pre-emptive attacks would impose on the Iranian people, and the irreversible impacts upon their land and environment, as well as on Iran's neighbors in the Persian Gulf.

Since the dawn of the nuclear era, history has shown the profound and long-lasting consequences of human exposures to radiation and to agents associated with nuclear technologies. The mention of impacted cities and location evokes disturbing images: Hiroshima, Nagasaki, Chernobyl, Three-Mile Island, and Fukushima-Daiichi. The effects of radiation on humans, the land, and the environment have wrought a tremendous toll on the physical, emotional, social, and economic health of innocent people.

Semnani has accurately and realistically described the human consequences of exposures to toxic chemicals and radiation sources that the Iranian people would encounter if military strikes occur against Iran. Harrowing, but accurate scenarios are presented for the affected regions and the frightening consequences upon impacted residents are identified. Most notable is the case study on the potential impact of the release of toxic plumes on Isfahan, one of the world's most beautiful cities.

Semnani is joined by many others who issue a call to world leaders to carefully consider the human and long-term political consequences of military strikes to disable Iran's nuclear capability. As Semnani clearly demonstrates, there is an alternative to military strikes that expose innocent civilians to radiation. It is the replacement of the current leadership in Iran with an accountable, democratically elected government that promotes peace and safeguards the welfare of the Iranian people.

Dr. Miller is an internationally recognized authority on radiation effects in humans, particularly from materials associated with nuclear weapons, their constitutive materials, and from the nuclear fuel cycle.

Dr. Miller directed studies at Chernobyl and at other heavily contaminated nuclear facilities in Russia and states of the former Soviet Union. He has also been involved with contamination events at U.S. uranium production sites, populations exposed from the Nevada Test Site, and radiation exposures at former U.S. nuclear test sites in the Pacific. Dr. Miller has assisted in the development of medical countermeasures for radiation exposures under the U.S. Project BioShield Program.

EXECUTIVE SUMMARY

On May 31, 2012, the United States House of Representatives proposed an amendment to the 2013 Intelligence Authorization Bill that would require the director of National Intelligence to submit to the congressional intelligence committees “a report containing an assessment of the consequences of a military strike against Iran” within 60 days of the amendment’s passage.¹

With the failure of diplomatic talks in Moscow to bridge the “gulf of mistrust” between Iran and the world powers—Britain, China, France, Russia, the United States and Germany—the **possibility of military strikes against the Islamic Republic of Iran’s nuclear program in 2012 cannot be ignored.**²

With three high level talks—in Istanbul, Baghdad and now Moscow—led by European Union Foreign Policy Chief Catherine Ashton and the Supreme Leader’s personal representative and chief negotiator, Saeed Jalili, failing to build confidence in the Islamic Republic’s claims about the peaceful nature of its nuclear program, the hopes for a diplomatic breakthrough are diminishing. **Time is short, the stakes immense.**

As one of the leading advocates of military strikes against Iran, Israeli Prime Minister Benjamin Netanyahu has repeatedly warned of the existential threat to Israel of Iran’s nuclear program. Speaking before the American Israel Public Affairs Committee (AIPAC) in early March 2012, Netanyahu made it clear that time for a peaceful diplomatic resolution to the nuclear dispute was running out. As he put it: “We waited for diplomacy to work; we’ve waited for sanctions to work; none of us can afford to wait much longer.”³ Speaking in Prague in May of 2012, Netanyahu poured cold water on prospects for diplomacy, comparing Iran’s nuclear agenda to North Korea’s: “It looks as though they [the Islamic Republic] see these talks as another opportunity to deceive and delay, just like North Korea did for years.”⁴

While there has been considerable debate about the timing and targets of military strikes against Iran’s nuclear program, the costs and consequences of such strikes have not received sufficient attention. Military planners at the Pentagon do provide policymakers with estimates of civilian casualties; these estimates are typically for

operational purposes and not made available to the general public. Virtually no one has presented a scientific assessment of the consequences of military strikes on operational nuclear facilities. What is certain is the gravity of the risk to civilians: **The IAEA has verified an inventory of at least 371 metric tons of highly toxic uranium hexafluoride stored at Iran’s nuclear facilities.**⁵ The release of this material at sites that are only a few miles from major population centers such as Isfahan warrants a thorough and comprehensive assessment of the potential risks to thousands of civilians living in the vicinity of Iran’s nuclear sites.

As for the Islamic Republic, its leaders have had no interest in making the risks of their reckless nuclear policies obvious to its citizens even though the resulting economic toll—inflation, unemployment, and the loss of international credit—has devastated the Iranian people. The Iranian military has not provided the Iranian people with any description of potential casualties resulting from attacks on these nuclear facilities. Nor has the parliament encouraged an open assessment of the grave implications of the government’s policies for Iranian scientists, soldiers and civilians working at or living within the vicinity of Iran’s nuclear facilities. This study seeks to address this deficit.

Ayatollah Khamenei, Iran’s Supreme Leader, is making a deadly nuclear gamble. While no smoking gun has emerged to prove that Iran is pursuing a weapon, questions abound in the international community and among Iran’s neighbors. The International Atomic Energy Agency (IAEA) is asking for access to nuclear facilities that could have had military applications. Whatever the technical reality, the political reality is this: Israel continues to threaten military strikes, should diplomacy fail. In a post-election United States, either a newly re-elected President Barack Obama or an incoming President Mitt Romney will face a ticking clock that will add an element of urgency to their decisions on Iran’s nuclear program. The risks to the Iranian people of military strikes have never been greater. These risks are difficult but important to quantify. The human dimension matters. By quantifying the costs of military strikes, we have sought to make the scale of the Ayatollah’s reckless gamble and the gamble of possible U.S. and/or Israeli strikes apparent not only to the Iranian people but also to the international community, including policymakers in the United States and Israel.

Nuclear gambles can have short- and long-term local, regional,

1 Pete Kasperowicz, “Dems push for report on consequences of military strike on Iran,” *The Hill*, 31 May 2012.

2 <<http://www.nytimes.com/2012/06/20/world/middleeast/tense-iran-nuclear-talks-resume-in-moscow.html>>.

3 Chris McGreal, “Netanyahu on Iran: ‘None of us can afford to wait much longer,’” *The Guardian*, 6 March 2012.

4 Tom Peter, “Netanyahu: Iran won’t take nuclear talks seriously,” *The Christian Science Monitor*, 18 May 2012.

5 “Implementation of NPT Safeguards Agreement and relevant provisions of Security Council resolutions,” IAEA Report to the Board of Governors, 18 February 2010: 6.

and global consequences that are impossible to predict, let alone contain. Conventional strikes involving the systematic bombing of nuclear installations can be far more devastating than nuclear and industrial accidents such as Chernobyl, Fukushima, Three Mile Island or Bhopal. The damage from strategic aerial bombardment is planned to be total and irreversible. It leaves no time for intervention, no chance for evacuation and no possibility for containment.

There are few historic precedents for assessing deaths and injuries from the impact of conventional strikes on operational nuclear processing facilities. We have defined casualties as the sum total of fatalities, as well as the acute and chronic injuries resulting from the thermal, physical, chemical and radiological impact of military strikes. Assessing the casualties and damage to the Iranian people depends mainly on two critical factors: the strategic military intent and capabilities of the United States and Israel, and Iran's logistical civil defense capabilities and preparations. These include variables such as the timing and severity of strikes, the nature and number of targets, as well as on-site conditions, such as the nature and amount of toxic inventories present, population distribution in the vicinity of the target sites, and remediation capabilities. Other important natural and environmental factors such as topography, wind direction and humidity are also critical in determining human casualties and other losses.

Conventional military strikes would almost certainly hit the nuclear sites at Isfahan, Natanz, Arak and Fordow. It is highly unlikely, but not completely impossible that the Bushehr nuclear power plant would be targeted as well. Despite some speculation, most experts also rule out the possible use of tactical nuclear weapons against Isfahan and Natanz as unnecessary, disproportionate and counter to U.S. strategic doctrine and international law. Yet virtually none dismiss the high probability of conventional military strikes against Iran's nuclear facilities near Isfahan, Natanz and Arak. We have not included the deeply buried Fordow site near Qom in our analysis due to the incomplete nature of information about this site. However, it is almost certain that Fordow would be targeted with powerful bunker busters.

For the purposes of this study, we have assumed a conservative strike scenario and analyzed the impact of conventional military strike against four targets: Isfahan, Natanz, Arak and Bushehr.

Beyond the sites, some military planners have suggested that any strike against Iran could extend to more than 400 targets, or "aim points." The goal of the strikes would be to permanently cripple Iran's ability to revive its nuclear program by targeting site personnel as well as the auxiliary and support infrastructure. After taking out Iran's air defense systems, highly probable aim points in any target list include leadership and command, communication structures, missile facilities, centrifuge workshops (some of which are located in urban centers), and any other secret nuclear sites known to western intelligence agencies. Other probable targets would include Revolutionary Guard assets that could be used in retaliation and the Parchin military complex where weaponization activities are suspected to have taken place. Uranium mines and mills could also be targeted. We have restricted our estimates of casualties to those injured or killed as a direct result of strikes at the four nuclear facilities and the immediate vicinities only.

Based on the best information available as well as discussions

with Iranian and Western nuclear experts, we have estimated the total number of people—scientists, workers, soldiers and support staff—at Iran's four nuclear facilities to be between 7,000 and 11,000. **It is highly likely that the casualty rate at the physical sites will be close to 100 percent. Assuming an average two-shift operation, between 3,500 and 5,500 people would be present at the time of the strikes, most of whom would be killed or injured as a result of the physical and thermal impact of the blasts. If one were to include casualties at other targets, one could extrapolate to other facilities, in which case the total number of people killed and injured could exceed 10,000.**

To grasp the political and psychological impact of the strikes, what our estimates suggest is that the potential civilian casualties Iran would suffer as a result of a strike—in the first day—could match, and possibly exceed, the 6,731 Palestinians and 1,083 Israelis reportedly killed in the Israeli-Palestinian conflict over the past decade.⁶ Bashar Assad's ground assaults on civilians in Syrian cities—the massacres in Homs and beyond—have taken a daily toll in the tens and hundreds in over a year. Yet the daily toll from the massacres in Syria would pale before the potential sudden death of thousands of civilians from a massive air assault on targets throughout Iran.

However, unlike traditional targets, the risks to civilians extend well beyond those killed from exposure to thermal and blast injuries at the nuclear sites. **Tens, and quite possibly, hundreds of thousands of civilians could be exposed to highly toxic chemical plumes and, in the case of operational reactors, radioactive fallout.**

An attack on the Uranium Conversion Facility at Isfahan and the Enrichment Plant at Natanz would release existing stocks of fluorine and fluorine compounds which would turn into hydrofluoric acid, a highly reactive agent that, when inhaled, would make people "drown in their lungs," as one scientist put it. As a point of reference, fluorine gases are more corrosive and toxic than the chlorine gas used in World War I. Once airborne, at lethal concentrations, these toxic plumes could kill virtually all life forms in their path. Depending on the volume of chemicals stored at the facilities, population densities around the sites, and prevailing wind and meteorological conditions, tens of thousands of workers and civilians in Isfahan and fewer in Natanz could be exposed to toxic plumes. **These plumes could destroy their lungs, blind them, severely burn their skin, and damage other tissues and vital organs.**

Isfahan will pay a particularly high price for the Ayatollah's gamble and the gamble of Israeli and/or U.S. strikes. The current volume and lethality of the toxic chemicals produced at the Isfahan facility alone makes it impossible to ignore the unacceptable risks to civilians if some, or all, of this material is stored at this location.

According to the International Atomic Energy Agency, from 2004 to 2009, the Isfahan Uranium Conversion Facility (UCF) has produced in excess of 371 metric tons (409 US) of uranium hexafluoride which is stored at either Isfahan or Natanz.⁷ Based on our calculations, if

6 "B'Tselem: Since 2000, 7,454 Israelis, Palestinians killed," *Jerusalem Post*, 27 September 2010. See also: "27 September '10: 10 years to the second Intifada—summary of data," The Israeli Information Center for Human Rights in the Occupied Territories (B'Tselem), http://www.btselem.org/english/press_releases/20100927.asp

7 "Implementation of NPT Safeguards Agreement and relevant provisions of Security Council resolutions," IAEA Report to the Board of Governors, 18 February 2010: 6.

only 5% of 371 metric tons of uranium hexafluoride produced at the Isfahan facility becomes airborne during or after an attack, the toxic plumes could travel 5 miles with the Immediately Dangerous to Life or Health (IDLH) level of 25 milligrams per cubic liter covering a surface area of 13 square miles. With prevailing wind directions and speeds at 9.4 miles/hour moving towards the city, in about one hour, this plume could expose some of the 240,000 residents in Isfahan municipality's eastern districts, particularly districts 4 and 6. At a 20% release, the IDLH plume will travel 9 miles covering 41 square miles and could expose some of the 352,000 residents, mainly in districts 13, 4, and 6, as well as residents in the region north of district 4. **If we assume a conservative casualty rate of 5 to 20 percent among these populations, we can expect casualties in the range of 12,000-70,000 people.**

It is thus highly likely that the people of Isfahan would experience a tragedy similar in magnitude to the Bhopal accident at the Union Carbide plant in India in 1984. Additionally, the environmental degradation due to the spread of airborne uranium compounds, and their entry into water, soil and the food chain would introduce long-term, chronic health risks such as a spike in cancer rates and birth defects. Isfahan, an important cultural and economic hub comparable in terms of its history, architecture, and beauty to Florence and Kyoto, would be devastated. If, however, these materials have been moved from the Isfahan UFC, or are being stored elsewhere, the number of casualties will be reduced correspondingly.

In the case of Natanz Fuel Enrichment Plant and Pilot Fuel Enrichment Plant, the strikes will be particularly heavy because the target is buried. The on-site casualties will be significant, effectively turning the underground nuclear site into a mass grave. The threat from toxic plumes will not be as severe. The facility is not in close proximity to a major urban center, the surrounding area is sparsely populated and the prevailing winds blow away from the cities of Natanz and Kashan. We estimate casualties from exposure to toxic plumes in the Natanz rural region at between 800-7,000 people. Given Natanz's reputation as a fruit and agricultural center, the environmental consequences of strikes on the local economy would be significant.

Strikes on operational nuclear sites also pose grave radiological threats. A military strike on the Bushehr nuclear power plant, which is operating at 75 percent capacity, and Arak's Heavy Water Reactor, once it becomes operational, would pose an even more serious threat to the Iranian people than strikes on Isfahan and Natanz.

The port city of Bushehr is less than seven miles from the Bushehr nuclear facility. Prevailing wind directions blow towards the city, which has a population of 240,000. Although a less likely target, the city would suffer a fate similar to Pripjat, the Soviet city abandoned after Chernobyl, and hundreds of thousands of people in the region would be exposed to dangerous levels of radiation if military planners include the facility on their target list. **If only 1 to 5 percent of the population is exposed to significant radiation levels, 2,400 to 12,000 people could suffer from severe health effects such as those witnessed in the aftermath of Chernobyl.** Moreover, the damage would extend beyond Iran. An attack on the Bushehr nuclear power plant would pose a grave environmental and economic threat to civilians in Kuwait, the United Arab Emirates, Iraq and Saudi Arabia. It would not only devastate the important business centers and fishing communities of the Persian Gulf, but also contaminate desalination

plants, port facilities and oil fields. To gain an approximate idea of the economic consequences of a strike on Bushehr, one should consider that the government of Belarus has estimated the economic cost of Chernobyl to exceed \$200 billion.

The facilities at Arak would also be a definite target. Its 40-mega-watt reactor could be used for the production of Plutonium-239, ideal weapon-production material. The IAEA claims that, based on satellite imagery, the heavy water production plant at Arak is already operational. And the Islamic Republic claims that the Arak heavy water reactor is scheduled to come on line in the third quarter of 2013. An attack before the reactor becomes operational would kill most of the 500 employees at the site but it would not pose significant risks to the population centers around the site. However, once the reactor becomes operational, an attack would expose Khondab, a city of 72,000 residents two miles from the facility, to large quantities of radioactive material. **We estimate that if only 1 to 5 percent of the population is exposed, between 720 and 3,600 people could suffer from chronic effects.**

Beyond the strike force, the next crucial factor in determining casualty levels in the aftermath of military strikes is Iran's disaster management and emergency preparation capacities. In the event strikes lead to the exposure of large populations in Isfahan and elsewhere to toxic plumes, the historical record suggests poor disaster management and inadequate emergency preparation could magnify casualties by a factor of ten. For example, the fatalities in Iran in the aftermath of the Bam Earthquake were ten times those from a more powerful earthquake that hit a more densely populated region of Turkey. As far as exposure to radiation is concerned, it is important to note that the Islamic Republic of Iran lacks a substantial capacity to handle a threat of such a nature and scale. As far as radiation exposure, in the only case documented by the IAEA, the now infamous Gilan case, the Islamic Republic had no choice but to send a worker exposed to radiation to the Institut Curie in France for specialized treatment. In the event of a large scale disaster at an operational nuclear reactor, it would be extremely difficult for exposed civilians to receive appropriate medical attention or compensation from the Iranian government.

In evaluating the military option, some analysts have suggested that a military strike against Iran's nuclear sites could be as simple and effective as the strike on the Iraqi nuclear site at Osirak, Saddam Hussein's half-constructed, French-built reactor destroyed by Israel in 1981. Such an analogy is false. Iran's nuclear plants cannot be compared to Osirak. They are widespread, operational, heavily manned, and contain hundreds of tons of highly toxic chemicals and radioactive substances. Most recently, the former director of the Shin Bet, Yuval Diskin, warned that strikes could even speed up Iran's nuclear program: "What the Iranians prefer to do today slowly and quietly, they will do ... quickly and in much less time."⁸

Rather than dismiss them as collateral damage, it is time to factor the Iranian people into any equation involving military strikes. There is a strong moral, strategic, political and military argument for counting the Iranian people's interests as a key factor in the nuclear dispute. At a minimum, the Iranian people, particularly the people

⁸ Yaakov Lappin, "Former Shin Bet chief slams 'messianic' PM, Barak," *The Jerusalem Post*, 29 March 2012.

of Isfahan, should be warned about the consequences of military strikes. After all, it is they who would pay the price of a military strike, one that would implicate Israeli and American advocates of strikes in a strategic and moral quagmire as perpetrators of man-made nuclear disaster.

A key preventive step for mitigating the exposure of civilians is verifying the location and quantity of Iran's stockpile of highly toxic chemical and radioactive agents, making sure that they are not stored at sites near major population centers, and encouraging local officials to educate the public and adopt the necessary civil defense plans to ensure rapid evacuation and treatment of populations at risk of exposure to highly toxic chemical plumes, and, in some cases, radiation. It is incumbent on the United Nations Security Council, International Atomic Energy Agency, the Red Crescent, and other international organizations to address the humanitarian consequences of the bombing of Iran's nuclear facilities before, rather than after, the event. Beyond Iran, the bombing of nuclear sites establishes a dangerous precedent with profound ramifications not only for the nuclear industry, but also for all nations facing potential conflicts centered on their nuclear programs.

In the long run, neither a nuclear deal with Iran, nor military strikes would generate a satisfactory long-term solution to the nuclear impasse. Ayatollah Khamenei—the most powerful man in Iran today—can always renege on a nuclear deal and strikes might even strengthen his grip on power. **The best long-term strategy would be a democratic, transparent, and accountable government in Iran.** In such a scenario, political leaders would quickly understand that their people want jobs, dignity, opportunity, and political freedoms, not the false promise of nuclear weapons bought at a heavy, even existential, cost. A military strike would not only kill thousands of civilians and expose tens and possibly hundreds of thousands to highly toxic chemicals, it would also have a devastating effect on those who dream of democracy in Iran. Ayatollah Khamenei has proven that he cares little for the Iranian people. It is up to us in the international community, including the Iranian-American diaspora to demonstrate that we do.

I. INTRODUCTION

“The goal of this study is to protect the Iranian people and to educate policymakers by providing an objective basis for evaluating the impact of military strikes on Iranian civilians and soldiers. Nevertheless, we do not defend a policy of engagement premised on building confidence in the peaceful intentions of a theocracy whose Supreme Leader is responsible for the death of thousands of Iranians and whose president dismisses the people as ‘dust and dirt.’ ”

For more than a decade, powerful politicians in the United States and Israel have warned about the threat of an Iranian nuclear weapon and made sanctions and the threat of strikes against Iran’s nuclear plants the cornerstone of their Iran policies. Despite important dissenting voices that have warned about the consequences of attacks on Iran’s nuclear plants, the idea of military strikes against Iran’s nuclear plants has gained considerable currency in the West. Support for pre-emptive military strikes against Iran’s nuclear program has made its way into presidential debates, congressional resolutions, media circuits, and public opinion polls. Indeed, for some, the Iranian nuclear threat has replaced Iraq’s Weapons of Mass Destruction (WMD) scare as the main strategic threat facing the United States, Israel, and the Arab world. With the failure of the recent round of diplomatic talks in Moscow, the pressure for harsher sanctions and military strikes can only grow stronger.



Figure 1: Ayatollah Ali Khamenei (Photo: Associated Press)

Advocates of military strikes outside Iran fail to appreciate the deadly and deceptive nature of Ayatollah Ali Khamenei’s nuclear gamble or assess the unintended consequences of a military strike by the United States or Israel. At the heart of this misconception is a failure to recognize that Iran’s leaders have no interest in protecting

the life or defending the interests of the Iranian people. Rather, it is the martyrdom of the Iranian citizenry in yet another “holy war” that allows the Ayatollah to tap into an ideology of victimhood and sacrifice that the Islamic Republic will cravenly seek to exploit to their advantage. For the Ayatollah to hold the Iranian people hostage as the exclusive religious guardian of the Iranian state depends on resurrecting the Great Satan: a fundamentalist anti-American narrative blended with anti-imperial Marxist and xenophobic nationalist discourse. While most Iranians have long lost trust in this way of thinking, this revolutionary narrative allows Khamenei to deflect from the repression, corruption and mismanagement at home by blaming foreign powers for the calamities that have befallen Iran since the establishment of the Islamic Republic. With the 2009 Iranian presidential elections forcefully disrupting this narrative by exposing the Ayatollah’s rule as one based on fraud, fear, and force, military strikes might give a bankrupted regime and a bankrupted ruler a reprieve.

The conversion of Iran’s nuclear program into a religious stage would allow the Ayatollah to use the corpse of Iran’s martyred children to act as the bereaved Holy Father, promising to exact a price for the harm inflicted against the body of Iran and Islam by “The Great Satan.” A catastrophe unleashed by military strikes, particularly one that would guarantee the death of thousands of Iranians, would allow the Ayatollah to win his gamble. The Iranian people would pay the price of the strikes provoked by his belligerent policies. He would reap the benefits.

In terms of power and precision, military strikes against nuclear plants could result in damage similar, if not worse than, the damage caused by nuclear accidents, whether the result of human error, design flaws, or natural disasters. In the case of the Japanese nuclear facility Fukushima, the impact of the earthquake, tsunami, and aftershocks on the plant did not fully eliminate the possibility of containing the radiation. Military strikes will destroy all the physical barriers between a nuclear plant and the environment. A deliberate strategic air assault

with powerful conventional weapons—earth-penetrating bunker busters contemplated for use against Iran’s nuclear facilities—is designed to destroy Iran’s nuclear plants. The force of the explosions alone guarantees the massive dispersal of highly toxic chemical and radioactive material. No matter what safety and defensive measures are in place, there would be no time for intervention or evacuation: no way to shut down the plants, cool down the reactors in Bushehr, reinforce containment structures, save plant personnel, evacuate local residents, or bring in rescue workers. The subsequent contamination of air, water, and soil from the chemical and thermal impact of strikes on nuclear plants would be immediate, vast and, for the most part, irreversible.

Amid the nuclear brinkmanship and bravado, there is virtually no public debate in the United States, Israel, or Iran about who would pay for the nuclear gamble. There is no discussion of the human, economic, or environmental costs of an attack on nuclear facilities. Few leaders appear to represent the interest of those constituents who would pay the price of military strikes, and fewer still appear willing to acknowledge responsibility or accept accountability for playing a game whose price would be paid by tens of thousands of innocent civilians and soldiers. The lack of serious discussion about the casualties from military strikes against nuclear installations has not only kept the public in the dark, it has prevented an objective evaluation of unintended consequences of the use of military force.

Without any estimates of the potential body count, the Ayatollah can treat the victims of a military strike as dust and dirt in much the same way he has treated the millions of Iranians who opposed Mahmoud Ahmadinejad’s re-election in 2009. Since Khamenei considers himself accountable only to God, and not to the Iranian people, he feels no need to assume personally the costs of his gamble with the fate and future of millions of Iranians. Yet, it is almost certain that an attack on Iran’s nuclear installation will unleash a genie far more monstrous than Fukushima. Indeed, the opening salvo of this war—the Stuxnet computer worm’s successful cyber-attack on the command and control systems at the Bushehr nuclear plant—was sufficient to prompt Russia’s NATO ambassador to warn of a new Chernobyl.⁹

Ehud Barak, Israel’s defense minister, is one of the few statesmen who appear to have considered the impact of military strikes on innocent civilians. According to secret diplomatic cables released by Wikileaks, the American ambassador to Israel, James B. Cunningham, reported that in May 2009 Barak shared his concerns about civilian casualties with a visiting congressional delegation. According to Barak, the world at that time had 6 to 18 months to stop Iran from acquiring nuclear weapons, after which “any military solution would result in unacceptable collateral damage.”¹⁰ That threshold was crossed in 2010, but that has not stopped Barak from continuing to warn of Israeli strikes.

There is no clear quantitative study of the collateral damage from strikes. Few proponents of military force have considered the stra-

tegic impact of the collateral damage from military strikes or—how the death of tens of thousands of Iranians would give the regime a reprieve, resurrect the ideology and expand the authority of the belligerent ideologues and militant forces the strikes seek to eliminate. And fewer still have considered the long-term strategic and political consequences of a military decision that is guaranteed to pull generations of American, Iranian, and Israeli youths into a cycle of war as destructive as the decade-long Arab-Israeli wars. At a time when millions across the Middle East, from Iran to Syria, Egypt to Yemen, are breaking out of decades of military rule, war can once again freeze civil society for decades to come.

The goal of this study is to provide an objective basis for evaluating the impact that military strikes would have on Iranian civilians and soldiers. Our hope is that policymakers will consider civilian casualties and take the necessary measures to protect the Iranian people against the consequences of the nuclear gamble. Nevertheless, we do not defend a policy of engagement with a theocracy whose Supreme Leader is responsible for the death of thousands of Iranians and whose president dismisses the people as “dust and dirt” as Ahmadinejad did during the post-2009 election uprising. The premise of diplomacy with the Islamic Republic of Iran requires a willful act of self-deception. It means ignoring irrefutable facts: sacrificing the promise of Iranian democracy on the altars of a theocracy founded on fraud and sustained by force.

Rather than feed and fuel this negativity by focusing on Iran’s nuclear programs and policies, our goal is to avert a catastrophe by quantifying its dimensions, and to propose a different approach that would restore the bonds of friendship and respect between the people of Iran, the United States, Israel, and the Arab world. Tackling the root causes rather than the symptoms of the Iran problem begins by disrupting the Ayatollah’s divisive and destructive fiction, one that equates Islam with tyranny and violence against the Iranian people and enmity and hatred for the United States and Israel. Instead of threatening the Iranian people with military strikes and sanctions in retaliation for Ayatollah Khamenei’s policies and Ahmadinejad’s threats, we support an Iran policy that breaks the nuclear impasse by targeting the ideological, political, economic, and military foundations of the Ayatollah’s rule.

A strategic shift in Iran policy means taking aim at Ayatollah Khamenei and the military that supports him, not the Iranian people. It is telling that Saeed Jalali, Iran’s top nuclear negotiator, derives his authority as the Ayatollah’s personal representative, not the Iranian people’s representative. Such a strategy is already coming into focus with UN Resolution 1747, which was passed by the Security Council on March 24, 2007. That resolution, among other things, targeted “persons involved in nuclear or ballistic missile activities,” as well as Iranian Revolutionary Guard Corps “key persons,” including virtually all its senior commanders.¹¹ What the resolution did not take into account is that, under the Iranian constitution, the Ayatollah’s role as religious leader of the Iranian state places him at the head of Iran’s Revolutionary Guards as well as the country’s nuclear program. In the end, the only way to build confidence in Iran’s nuclear program

9 “Russian’s Nato envoy: Iran-bound Stuxnet worm could have caused Chernobyl,” Reuters, 26 January 2011 <<http://www.haaretz.com/news/international/russia-s-nato-envoy-iran-bound-stuxnet-worm-could-have-caused-new-chernobyl-1.339376>>.

10 Jo Becker, James Glanz and David E. Sanger, “Around the World, Distress over Iran,” *The New York Times*, 28 November 2010.

11 United Nations Security Council Resolution No. 1747 (2007). <<http://image.guardian.co.uk/sys-files/Guardian/documents/2010/11/29/UNSCR1747.pdf>>.

is to take it out of the hands of a broken government that operates under the shadow of a preacher of enmity and put it in the hands of a transparent, accountable, and competent democratic government, one whose political, religious, and scientific leaders place the peace and prosperity of the Iranian people and the security of their nuclear program above that of Ayatollah Khamenei.

The road to Iranian democracy will be rife with obstacles, but it is a well-traveled road, one that Iranians know well through more than 100 years of effort, dating back to the Constitutional Revolution of 1906-11. Freedom, democracy, and economic dignity are organic, indigenous Iranian aspirations. By devising a strategy that would support a democratic, transparent, accountable Iranian government, we would be helping a proud nation fulfill a century long quest, while making the world safe from the Ayatollah's nuclear gamble—and the gamble of others who seek to strike at Iran's facilities. It is not only sound strategic policy, but also sound moral policy befitting the best traditions of a great, democratic nation like the United States.

II. METHODOLOGY AND ASSUMPTIONS

“This study focuses on the projected devastating impact of military strikes on only four critical nuclear sites near the Iranian cities of Isfahan, Natanz, Arak and Bushehr. We have based our projections on the most credible figures and intelligence from reliable sources, taking into account the highly sensitive nature of the information available about Iran’s nuclear program and military and civil defense capabilities, as well as U.S. and Israeli military plans and strike targets.”

This study focuses on the projected impact of military strikes on only four critical nuclear sites near the Iranian cities of Isfahan, Natanz, Arak, and Bushehr. We have based our projections on the most credible figures and intelligence from reliable sources, taking into account the highly sensitive nature of the information available about Iran’s nuclear program, its military and civil defense capabilities, as well as U.S. and Israeli military plans and strike targets. To calculate the physical, chemical, and radiological consequences of strikes, we have relied extensively on the International Atomic Energy Agency’s reports for information about Iran’s nuclear program, as well as studies by the Center for Strategic and International Studies (CSIS) for information about possible strike scenarios.

To establish brackets for assessing the human costs of military strikes, we have also drawn on theoretical studies based on computer modeling of different strike scenarios. This study also draws on scientific studies based on historical experience with comparable nuclear and industrial accidents, terrorist strikes, and natural disasters. These include studies on the human, health, environmental, and economic toll of Chernobyl, Fukushima, Bhopal, the attack on the World Trade Center, and the Bam earthquake. Where data have been limited, we have used the most scientifically dependable models for our extrapolations and estimates. Where possible, we have also ventured estimates about the broader damage to the economy and environment of Iran.

Measuring the extent of the damage to the Iranian people resulting from strikes on the Isfahan and Natanz facilities depends on using a dispersion model that would take into account the interaction of a number of variables including:

A. Strategic and tactical intentions of the U.S. and Israel for attacking Iran’s nuclear installation.

1. The facilities targeted
2. The timing and duration of the strike
3. The number, type and accuracy of weapons used
4. The quality of intelligence for targeting
5. The amount of advance warning before the strikes

6. Topography, construction, and defense of the targets
7. Nature, amount, and composition of toxic materials released
8. Distribution and absorption of toxins and radioactive materials
9. Topography of the vicinity around sites and prevailing climate conditions at the time of the strike, including wind patterns, humidity, and rainfall
10. Population densities and concentrations at and around targets within the radius of strikes

B. The Iranian government’s plans, preparedness and defense systems designed to respond to attacks.

1. Quality of intelligence in anticipating timing and nature of attacks
2. Access and ability to implement defensive measures against attacks
3. Civil defense and emergency response capabilities
4. Public education and awareness

For the purpose of this study, we have defined casualties as the sum total of fatalities and injuries resulting from exposure to the physical, thermal, chemical and radiological consequences of military strikes on Iran’s nuclear installations.

One can categorize the casualties from military strikes against Iran’s nuclear facilities into three groups of victims. The first group would be those exposed to the physical and thermal impact of the blasts. This would largely impact scientists, engineers, workers, and soldiers at the facilities, as well as residents living very near the sites. The second group would be those exposed to the chemical consequences of the military strikes, primarily due to release of lethal chemical compounds, toxic plumes, and dusts. This group would consist of people living in close proximity to the sites or along the path of prevailing winds, as well as rescue and recovery workers dispatched to the sites. A third group would be those exposed to the radiological consequences. If Bushehr is attacked, this group would

be the largest and would range from those living alongside the sites to those tens and even hundreds of miles away. They would suffer from both acute and chronic health effects related to radiation exposure. The acute, or immediate radiological health effects are caused by the release of iodine, cesium and strontium as fission-produced materials, mainly resulting from attacks on Bushehr and Arak (once its reactor is operational). The chronic, or long-term radiological exposures come from radioactive materials such as depleted uranium or uranyl fluoride,¹² which could result in significant birth defects and exposure related cancers (Figure 2).



Figure 2: 18-month-old Iraqi child suffering from birth defects from radiological effects of depleted uranium (Photo: URUKNET)

While we define the total casualties from military strikes as the sum total of deaths, injuries and sicknesses in each of the first three categories, it is important to point out that a much larger fourth group would suffer from the psychological consequences of exposure to the shock and trauma of military strikes.

We have assumed that the ultimate goal of military strikes would be not only to destroy the physical facilities, but also to deliver maximum damage and fatalities to the personnel and other support infrastructure to ensure the long-term, if not permanent, inability of Iran’s government to revive its nuclear program. As Paul Rogers notes in his study, “Iran: Consequences of a War,” the killing of those with technical expertise would have substantial impact on any efforts to reboot Iran nuclear program.¹³ It is conceivable that the military planners would seek to minimize damage to civilians with precision attacks. Assuming such a surgical attack option meets the strategic goals, hundreds, if not thousands, would still be killed or severely injured and Iran would have to retaliate. Most military analysts assume that conventional attacks will be extensive and rely on heavy, bunker-busting bombs.

When considering the potential on-site fatalities, we have assumed a 1-to-1 scientist to support staff ratio. According to Dr. Ghanna-

di-Maragheh, a ranking Iranian nuclear official, 800 to 1,000 experts are employed at the Isfahan UCF,¹⁴ which brings the total number of employees, including soldiers, administration, maintenance to somewhere between 1,600 and 2,000. At Bushehr, other sources estimate 3,000 specialists, or 6,000 total workers at the facility. We also assume 1,000 scientist and engineers work at Natanz with an additional 1,000 supporting staff members. At Arak, we estimate a total staff of 1,000 and additional construction workers due to expansion of the facility. We have assumed a two-shift work cycle wherein at least half of the facilities’ total workers would be present during an attack.

Assessing casualties resulting from chemical and radiological exposure to those who live in the vicinity of these facilities is considerably more challenging than estimating on-site casualty figures. We have based our calculations and estimates of casualties at Isfahan and Natanz on the assumptions listed below:

CHEMICAL ASSUMPTIONS

The primary threat from strikes against the facilities near Isfahan and Natanz is associated with the release of vast quantities of uranium hexafluoride and its byproducts. Uranium hexafluoride (UF₆) is a volatile solid or liquid, depending upon ambient pressure and temperature. For active processing in centrifuges, the UF₆ must exist as a gas. If UF₆ is released to the atmosphere it undergoes exothermic chemical reactions with water vapor, producing hydrogen fluoride (HF), uranyl fluoride (UO₂F₂) and other fluoride derivatives. The UF₆ undergoes further polymerization, depolymerization, and hydrolysis in a complex set of interactive chemical reactions and phase changes depending upon local environmental conditions. (Figure 3)

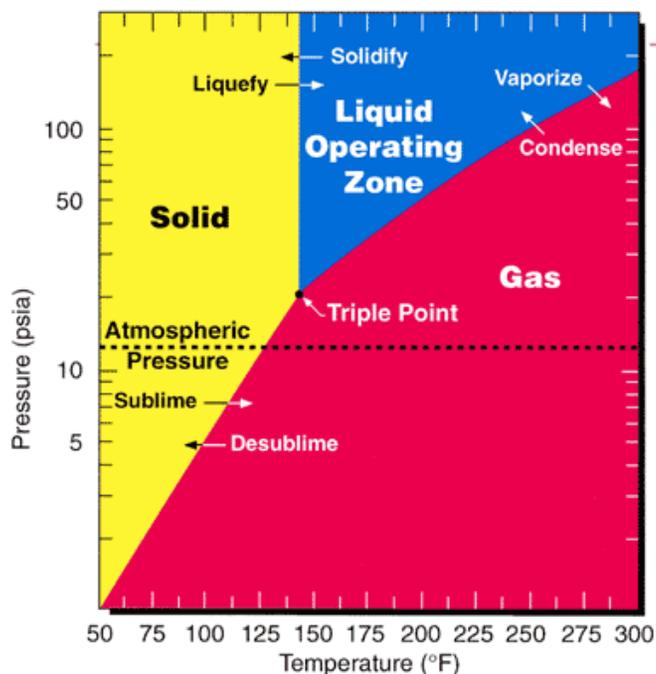


Figure 3: UF₆ Phase Diagram (Source: U.S. Dept. of Energy)

12 “Radiological and Chemical Fact Sheets to Support Health Risk Analyses for Contaminated Areas”, Argonne National Laboratory Environmental Science Division, March 2007.

13 Paul Rogers, “Iran: Consequences of A War,” The Oxford Research Group, February 2006.

14 M. Ghannadi-Maragheh, “Iranian Nuclear Fuel Cycle Experience,” presented at the World Nuclear Association Annual Symposium, 3-5 September 2003

A. Inventories, Storage and Location

We have based our calculations of inventory on the IAEA's February 2010 report which states that the stock of uranium hexafluoride produced at the Isfahan conversion facility amounts to 371 metric tons (409 US).¹⁵ This facility has not produced any uranium hexafluoride since February of 2009. We have discounted the possible presence of quantities of toxic primary reagents needed for the production of uranium hexafluoride, such as hydrogen fluoride and fluorine gas as well as other operational byproducts whose stock cannot be determined at this time. On several occasions, Iranian officials have made statements which suggest that the overall stock of uranium compounds at the Isfahan facility is much greater.¹⁶

Uranium hexafluoride is believed to be stored in 12,000 kg Y-45 cylinders at the Isfahan and/or Natanz facilities. The exact location, and the corresponding distribution volumes of this material, is not available from any reliable source. However, it would make sense for the bulk of this stock to be stored at Natanz.

B. Release

In the case of military strikes, some if not all of the pressurized cylinders of uranium hexafluoride would be subjected to thermal and explosive destructive forces and subsequent release of their contents to the environment. Since the exact volumes at each location are unknown, and given that the severity and accuracy of the strikes as well as the preparedness of Iranian installations cannot be determined beforehand, we have assumed a range of releases from 1-50% at each site. (See Gaussian Plume Calculations Table [Table 9] in Appendix 1.)

C. Vaporization

Depending on the intent and effectiveness of the strike, the conventional bombing of Isfahan or Natanz results in the destruction of the majority if not all of the stock of UF₆ cylinders at temperatures exceeding several hundred degrees Fahrenheit—well above the 135°F vaporization temperature of uranium hexafluoride at 14.7 psia (Phase Diagram Figure 3). Therefore, we expect a significant portion of the uranium hexafluoride stockpile to become airborne and dispersed in the atmosphere. An empirical example of vaporization was demonstrated in January of 1986 at an industrial accident at Sequoia Fuels Corporation facility in Gore, Oklahoma. In this accident, although at ambient temperatures 50% of the pressurized liquid uranium

hexafluoride was vaporized when a 13,400kg cylinder was ruptured.¹⁷

D. Reactivity

When uranium hexafluoride is released at atmospheric pressure and temperature it reacts with water vapor producing highly toxic and reactive hydrogen fluoride, fluorine gas and uranyl fluoride. These lethal gases can escape the source of the explosion depending on wind speeds and can travel significant distances before they react with other substances. A Princeton study on the detectability of UO₂F₂ aerosols produced by UF₆ Released from Uranium Conversion plants indicates that fine and ultrafine aerosols of UO₂F₂ can persist on a time scale of 4 to 40 days with a lifetime determined in part by their solubility in water. In a dry climate such as that found in Iran, absorption of these byproducts would be less likely to be as immediate as in humid conditions. They can last for a long time and spread across a vast area.¹⁸

E. Lethality

Even at very small concentrations, these fluorine compounds can be highly corrosive. Because they are highly water soluble, mild exposure irritates the mucous membranes and eyes. Exposure at 25 ppm causes lung inflammation, vomiting and pulmonary edema. As with chlorine, exposure to higher concentrations of these gases can cause immediate death. As a point of reference, unlike other mineral acids, including hydrochloric acid, hydrogen fluoride, because of its corrosive nature, is the only acid that cannot be stored in glass containers.

To assess the health and safety impact of these byproducts, we have used the U.S. National Institute for Occupational Safety and Health (NIOSH) limits for exposure to toxic chemicals. This agency has established the Immediately Dangerous to Life and Health (IDLH) values for fluorine at 25 ppm. The primary, acute hazard from UF₆ and its related compounds is tissue exposure to fluorine and various fluoride compounds. The HF and other fluorine components produce severe pulmonary complication and edema, respiratory spasms, and general skin tissue and eye damage. The uranium component in these compounds can produce chronic kidney damage.

The IDLH or toxicity values for UF₆, UO₂F₂, HF, F₂, and other fluoride compounds are very similar within a narrow range of values. So a combined, mean IDLH value is assumed as 25 ppm since a more accurate estimation of the various mass components of the fluoride products is not possible due to unknown conditions during a military strike.¹⁹

F. Range

The airborne dispersion of the chemical materials that could be released from an attack upon an Iranian nuclear site with UF₆, HF,

15 "Implementation of NPT Safeguards Agreement and relevant provisions of Security Council resolutions," IAEA Report to the Board of Governors, 18 February 2010: 6.

16 For example, in a paper on the Iranian Nuclear Fuel Cycle delivered at the World Nuclear Association's Annual Symposium on 3-5 September 2003, Dr. M. Ghannadi-Maragheh, then vice president of the Atomic Energy Organization of Iran for nuclear fuel production, claimed that "265 t/a of UF₆ will be converted to 285 t/a of UF₆ which is maintained in a special drum for future application." If we add the onsite inventory of HF and F₂ to the UCF stockpile, the maximum inventory of toxic fluorine compounds at the site would exceed 300 tons/year (360 U.S. tons/year). Given the difficulty of verifying such claims, we have based our calculations on the IAEA's statements about the stock of uranium hexafluoride only.

17 Edward Shum, "Accidental Release of UF₆ at the Sequoyah Fuels Corp. Facility at Gore, Ok," Office of Nuclear Material Safety and Safeguards at the US Nuclear Regulatory Commission, <http://www.irpa.net/irpa7/cdrom/VOL.2/S2_70.PDF>.

18 R. Scott Kemp, "Initial Analysis of the Detectability of UO₂F₂ Aerosols Produced by UF₆ Released From Uranium Conversion Plants," Program on Science and Global Security, Princeton University, 23 August 2006.

19 See Appendix 1, Toxic Plume Calculations, Dr. Gary Sandquist.

or F_2 can be modeled using the standard Gaussian plume atmospheric dispersion and transport model. Since the lethal gas plume is heavier than air, it will remain close to the ground until eventually dissipated by the atmosphere. Although the Gaussian plume model has its limitations and does not work for the release of massive amounts of chemicals across long distances, it does provide a framework for quantifying and assessing the risks to Isfahan from smaller releases.

Three experimental releases of UF₆ to the atmosphere were conducted at Bordeaux, France, between 1986 and 1989. Also many accidental releases of UF₆ have occurred including one at Gore, Oklahoma, and the Comurhex Plant in France. Some information gathered from the above releases has been used to confirm the accuracy of dispersion modeling and chemical interactions with the environment. Generalized conclusions indicate that close to these releases, source-specific and environmental media were dominant factors, while at longer distances from the release point, current weather, and atmospheric conditions determined dispersion patterns. (See Gaussian Plume Calculations for Military Strikes on Iranian Nuclear Infrastructure [Table 9] in Appendix 1.)

G. Casualty rates

It is harder to predict the exact number of casualties resulting from exposure to toxic chemicals. We have evaluated a range for releases of 1- 50% of the potential inventory of uranium hexafluoride produced at Isfahan. We have also factored in population densities and distributions in the areas surrounding the sites. We have assumed conservative casualty rates at between 5-20% of exposed individuals in the areas impacted by the toxic plumes.

RADIOLOGICAL ASSUMPTIONS

The adverse radiological consequences resulting from military attacks on Iran's four facilities can be divided into two main categories: Acute Radiation Exposure (immediate) and Chronic Radiation Exposure (long-term). Given that there is very little fissile materials at Isfahan and Nantanz, the primary radiological hazard would come from the release of uranium hexafluoride and uranium oxides left over from processing at Isfahan. Uranium compounds released to the atmosphere and environment do not pose acute or immediate negative health effects. However, if they contaminate the food supply or urban habitat such that they are inhaled or ingested they can increase risks of cancer, kidney failure, and birth defects.

The stock of uranium hexafluoride produced at the Isfahan conversion facility amounts to 371 metric tons (409 US). One can also expect a significant amount of uranium oxides as primary reagent held at this facility; however, we do not have any accurate figures about this secondary inventory. We have based our calculations on the uranium hexafluoride stock only.

III. THE MILITARY OPTION

“Our goal is neither to confirm nor contradict perceptions and prejudices about the nature of Iran’s nuclear policies, program, or rights, nor to debate the morality, legality, or practicality of the strikes. It is to provide policymakers, the media, and the public, especially the American, Israeli, and Iranian people, with an objective estimate of the risks and costs of military strikes against Iran’s nuclear sites.”

Ahmadinejad’s alleged threats to annihilate Israel have raised fears about Iran’s nuclear program, policies, and intentions. Israeli Prime Minister Benjamin Netanyahu has made the Iranian threat a cornerstone of Israel’s foreign policy and a test of the United States’ commitment to the security of Israel.

Speaking at AIPAC on March 5th, the Prime Minister warned that responsible leaders cannot base the security of their nations on “the belief that the world’s most dangerous regimes won’t use the world’s most dangerous weapons.” He left no doubt about his perception that the Islamic Republic was a terrorist regime that had to be stopped.

“Iran calls for Israel’s destruction, and they work for its destruction—each day, every day. This is how Iran behaves today, without nuclear weapons. Think of how they will behave tomorrow, with nuclear weapons. Iran will be even more reckless and a lot more dangerous. There’s been plenty of talk recently about the costs of stopping Iran. I think it’s time we started talking about the costs of not stopping Iran.”²⁰



Figure 4: Benjamin Netanyahu (Photo: Associated Press)

On Iran, Netanyahu’s message has been clear and consistent. In a speech before the General Assembly of the Jewish Federations of

North America in New Orleans on November 8, 2010, Netanyahu delivered the same message.

“The simple paradox is this: If the international community, led by the United States, hopes to stop Iran’s nuclear program without resorting to military action, it will have to convince Iran that it is prepared to take such action. Containment will not work against Iran. It won’t work with a brazen and erratic regime that accuses the United States of bombing its own cities on 9/11, that calls for the annihilation of Israel, and is the world’s leading sponsor of terrorism. The bottom line is this: Iran’s nuclear program must be stopped. Iran’s nuclear program is the greatest threat we face.”²¹

Netanyahu is not alone. There is considerable support in some corners of Congress for the use of military force against Iran should no peaceful solution be found. A day before Netanyahu’s May 24 speech, the U.S. House of Representatives referred House Resolution 271 expressing “support for Israel’s right to use all means necessary to confront and eliminate threats posed by Iran, defend Israeli sovereignty, and protect the lives and safety of the Israeli people, including the use of military force if no other peaceful solution can be found within a reasonable time.”²²

The military option also has strong advocates in the U.S. Senate. In a speech on “U.S. Power in the Middle East” delivered at the Council on Foreign Relations, Sen. Joseph Lieberman, chairman of the Homeland Security and Governmental Affairs Committee, warned that “if a nuclear Iran is as unacceptable as we say it is, we must be prepared to do whatever is necessary to prevent the unacceptable.”²³

21 “Prime Minister Netanyahu’s speech at the General Assembly of the Jewish Federations of North America in New Orleans,” press release from the Prime Minister’s Office, 8 November 2010, <<http://www.pmo.gov.il/PMOEng/Communication/PMSpeaks/speechga081110.htm>>.

22 House Resolution 271: Expressing Support for the State of Israel’s Right to Defend Israeli Sovereignty,” <<http://www.govtrack.us/congress/bill.xpd?bill=hr112-271>>.

23 “Sen. Lieberman Addresses U.S. Power in the Middle East,” Council on Foreign Relations, 29 September 2010, <http://www.cfr.org/publication/23056/senLieberman_addresses_us_poweUn_middle_east.html>.

20 “Excerpts from PM’s AIPAC speech,” *The Jerusalem Post* online, 3 July 2012, <<http://www.jpost.com/LandedPages/PrintArticle.aspx?id=260779>>.

As with Iraq, perceptions about the nature of the threat posed by Iran’s nuclear intentions, program, and policies are pivotal to shaping U.S. policy in the Middle East. The specter of an Iranian bomb fuels fears about a shift in the balance of power in the Middle East. In this perspective, an increase in the power of revolutionary Iran poses a grave threat to the stability and security of the region, particularly to Israel, Saudi Arabia, the conservative sheikhdoms of the Persian Gulf, Iraq, and Lebanon. More broadly, Iran is viewed as a strategic threat to a postwar international and regional order dominated by the United States.

With the prospects of Iran filling the vacuum created by American withdrawal from Iraq and Afghanistan, the question of the balance of power between Iran and the United States has assumed greater urgency. The fear of Iran as a hostile power with questionable regional intentions has exacerbated concerns about Iran’s emergence as a nuclear power capable of projecting military power on its weaker neighbors.

Against this background, Senator Lieberman and others said that it was time for the United States to reestablish its credibility by considering a military strike against Iran:

“It is time for us to take steps that make clear that if diplomatic and economic strategies continue to fail to change Iran’s nuclear policies, a military strike is not just a remote possibility in the abstract, but a real and credible alternative policy that we and our allies are ready to exercise if necessary.”

His meaning was clear. The United States had to send a message to its friends and enemies that Iran would not be allowed to cross the nuclear red line:

“We will prevent Iran from acquiring a nuclear weapons capability, period—by peaceful means if we possibly can, but with military force if we absolutely must,” Senator Lieberman said. “A military strike against Iran’s nuclear facilities entails risks and costs—I know that—but I am convinced that the risks and costs of allowing Iran to obtain nuclear weapons capability are far greater.”²⁴

The Obama administration is also inching towards the military option. In his speech before AIPAC, President Obama ruled out containment as an option. “My policy here is not going to be one of containment. My policy is prevention of Iran obtaining nuclear weapons.”²⁵ He added, “When I say all options are on the table, I mean it.”²⁶

Appearing before members of a House Appropriations Subcommittee, February 16, 2012, Defense Secretary Leon E. Panetta, made it clear that the U.S. was keeping all options on the table in case “red lines” are crossed. He added that while intelligence reports indicate that Iran was continuing with enrichment activities, “intelligence does not show they’ve made a decision to proceed with developing a nuclear weapon.”²⁷ On March 8, 2012, Panetta went further. He told the *National Journal* that the Pentagon is preparing an array of military options for striking Iran if sanctions fail to persuade the Iranian regime. Panetta said such planning has been underway “for

a long time,” and added that a U.S. strike would be much more grave than an Israeli one. “If they (Israel) decide to do it, there’s no question that it would have an impact, but I think it’s also clear that if the United States did it, we could have a hell of a bigger impact,” he said.²⁸

SUPPORT FOR MILITARY OPERATION

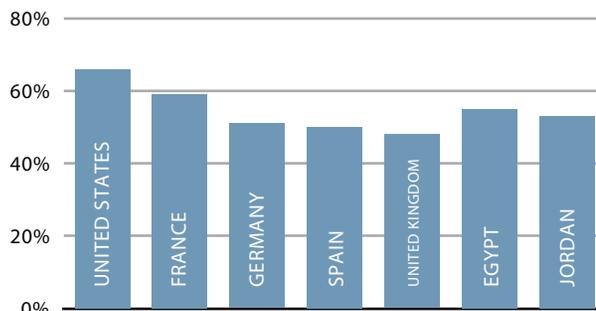


Figure 5: Support for Military Option

A poll by Pew Research Center’s Global Attitudes Project found that “while support for military action against Iran is less widespread than support for tougher economic sanctions, majorities or pluralities of those who oppose a nuclear-armed Iran in 16 out of 22 countries surveyed are willing to consider the use of military force to prevent Iran from developing nuclear weapons.”²⁹ The poll also found that “Americans are the most supportive of a military option to deal with Iran; 66% of those who oppose a nuclear-armed Iran would consider the use of force,” followed by 59% in France, 51% in Germany, 50% in Spain, 48% in Britain, 55% in Egypt, and 53% in Jordan.³⁰(Figure 5)

The exception is Israel. The Israeli public is the least enthusiastic about a war with Iran. In a poll conducted Feb. 22-26, 2012, by Shibley Telhami, Brookings nonresident senior fellow and the Anwar Sadat Professor for Peace and Development at the University of Maryland, only 19% of Israelis supported an attack against Iran without the backing of the United States. According to Telhami, “the Israeli public is neither enthusiastic about the prospect of war with Iran nor swayed by the seeming embrace of Israel by our presidential candidates.”³¹

Israeli fears of an Iran war notwithstanding, when it comes to evaluating the plausibility of strikes against Iran, there is the lure of the Osirak precedent.³² As early as 2005, Joseph Cirincione and others were writing eloquently about why “bombs won’t solve Iran,” but without convincing Iran hawks. As recently as September 2010, Jeffrey Goldberg argued that military strikes against nuclear facilities have worked against Iraq and Syria. So what would be different in the case of Iran? As he put it:

“Israel has twice before successfully attacked and destroyed an

24 Ibid.

25 “Obama Presses Netanyahu to Resist Strikes on Iran,” Mark Landler, *New York Times*, 6 March 2012.

26 Ibid.

27 Elaine Sanchez, “Panetta Cites ‘Red Lines’ Iran Should Avoid,” *American Forces Press Service*, 16 February 2012, <<http://www.defense.gov/News/NewsArticle.aspx?ID=67230>>.

28 Yochi Dreazen, “Panetta: U.S. Has Potential Military Plans for Iran,” *National Journal*, 8 March 2012.

29 “Obama More Popular at Home than Abroad,” *Pew Research Center Global Attitudes Survey Report*, 17 June 2010, <<http://pewglobal.org/Files/pdf/Pew-Global-Attitudes-Spring-2010-Report.pdf>>.

30 Ibid.

31 “19% of Israelis Support Non-US-Backed Iran Strike,” *Jerusalem Post*, 29 February 2012.

32 Joseph Cirincione, “Bombs Won’t Solve Iran,” *The Washington Post*, 11 May 2005.

enemy's nuclear program. In 1981, Israeli warplanes bombed the Iraqi reactor at Osirak, halting—forever, as it turned out—Saddam Hussein's nuclear ambitions; and in 2007, Israeli planes destroyed a North Korean-built reactor in Syria. An attack on Iran, then, would be unprecedented only in scope and complexity.³³

Concerns about Iran's nuclear program and faith in the efficacy of military strikes are not limited to the United States and Israel. Although they have not been as vocal in their support for strikes, America's Arab allies were instrumental in financing Saddam Hussein's war against Iran. The fall of Saddam, the fear of American withdrawal and the prospects of a nuclear Iran acting as regional hegemon have created considerable unease in Saudi Arabia and the Gulf states. According to Wikileaks, in an April 2008 cable, Adel A. al-Jubeir, Saudi Arabia's ambassador to the United States, talked about the Saudi King Abdullah's frequent exhortations for the United States to "cut off the head of the snake" while there was time.³⁴ The Saudis have also threatened to develop their own nuclear weapons to counter an Iranian bomb. As late as June 29, 2011, Prince Turki al-Faisal, the former Saudi intelligence chief and ambassador to Washington, was warning that "if Iran develops nuclear weapons, that will be unacceptable to us, and we will have to follow suit."³⁵

Comparisons of Iran to Nazi Germany have not been restricted to American and Israeli politicians. In a July 2009 memo, Prince Mohammed bin Ziyad, the Defense minister of the United Arab Emirates, warned that "Ahmadinejad is Hitler" and called on the United States not to "appease Iran."³⁶ In a November 2009 cable, King Hamad of Bahrain stated that Iran's nuclear program must be stopped and "the dangers of letting it go are greater than the dangers of stopping it." According to *The New York Times*, Iran "has unified Israel and many longtime Arab adversaries—notably the Saudis—in a common cause. Publicly, these Arab states held their tongues, for fear of a domestic uproar and the retributions of a powerful neighbor. Privately, they clamored for strong action—by someone else."³⁷ With Saddam Hussein and the Iraqi army unable to do their bidding, it appears that the rich Arab states wish to wage a proxy war against the Islamic Republic by having the United States and Israel step into the vacuum created by the fall of Saddam Hussein.

Threatening Iran with use of military force has not been confined to the realm of political rhetoric. As Dan Shapiro, the U.S. ambassador to Israel put it, the military option was not only available, it was ready. The Iran plan exists as a concrete military plan. There exist a number of detailed studies on the military requirements to destroy Iran's nuclear facilities, most notably "A Study on a Possible Israeli

Strike on Iran's Nuclear Development Facilities."³⁸ There have also been a number of war games and simulated military strikes by the Brookings Institution and others.³⁹ In 2007, the Swedish Defense Agency concluded an extensive strategic review titled "Consequences of Military Action," which also examined the environmental and legal dimensions of attacks. Yet, by their very nature, the primary focus of these studies is on the military challenges of destroying Iran's nuclear program and the strategic and political ramifications.⁴⁰ With the exception of one study by Physicians for Social Responsibility, there are virtually no comprehensive or detailed studies on the impact of military strikes against Iran's nuclear sites on the Iranian people.⁴¹

Ironically, despite the very public nature of the rhetoric and posturing over Iran's nuclear program, politicians on both sides of the nuclear divide have failed to consider the costs of nuclear brinkmanship. There is no political incentive for disclosing the full risks and costs of military attacks on nuclear sites.

The starting point of this study is the end point of most other studies, namely to fill in the gaps about the military option. The risks and costs to the Iranian people must be factored into strategic and military equations focused on the destruction of Iran's nuclear facilities. Doing so not only clarifies the diplomatic stakes by providing parameters for understanding the risks and costs of such strikes, but also provides a constructive basis for involving the public and the media—civil society inside Iran, the United States and beyond—as active participants in finding an amicable and practical solution to the dispute over Iran's nuclear program.



Figure 6: Iran-Iraq War: Victim of Chemical Warfare (Photo: www.iranvision.com)

Our goal is neither to confirm nor to contradict perceptions and prejudices about the nature of Iran's nuclear policies, program or

33 Jeffrey Goldberg, "Point of No Return," *Atlantic Monthly*, September 2010.

34 Muhammad Sahimi, "Using Wikileaks to Advance the Narrative of War on Iran," *Tehran Bureau*, 5 December 2010.

35 Jason Burke, "Riyadh will build nuclear weapons if Iran gets them, Saudi prince warns," *The Guardian*, 29 June 2011, <<http://www.guardian.co.uk/world/2011/jun/29/saudi-build-nuclear-weapons-iran>>.

36 Muhammad Sahimi, "Using Wikileaks to Advance the Narrative of War on Iran," *Tehran Bureau*, 5 December 2010.

37 Jo Becker, James Glanz and David E. Sanger, "Around the World, Distress over Iran," *The New York Times*, 28 November 2010.

38 Anthony Cordesman and Abdullah Toukan, "Study on a Possible Israeli Strike on Iran's Nuclear Development Facilities," *Center for Strategic and International Studies Report*, 14 March 2009, <<http://csis.org/publication/study-possible-israeli-strike-irans-nuclear-development-facilities>>.

39 James Fallows, "Will Iran be Next?" *The Atlantic Magazine*, December 2004, <<http://www.theatlantic.com/magazine/archive/2004/12/will-iran-be-next/3599/>>.

40 Bengt Bergstrand et al., "Consequences of Military Action Against Iran," *Swedish Defense Research Agency (FOI) Report*, March 2008, <http://www.humansecuritygateway.com/documents/FOI_Iran_ConsequencesMilitaryActionAgainst.pdf>.

41 Martin Butcher, "War Is Not the Answer: The Medical and Public Health Consequences of Attacking Iran," *Physicians for Social Responsibility*, March 2007, <<http://action.psr.org/site/DocServer/WarIsNotTheAnswer.pdf?docID=2181>>.

POTENTIAL WEAPONIZATION

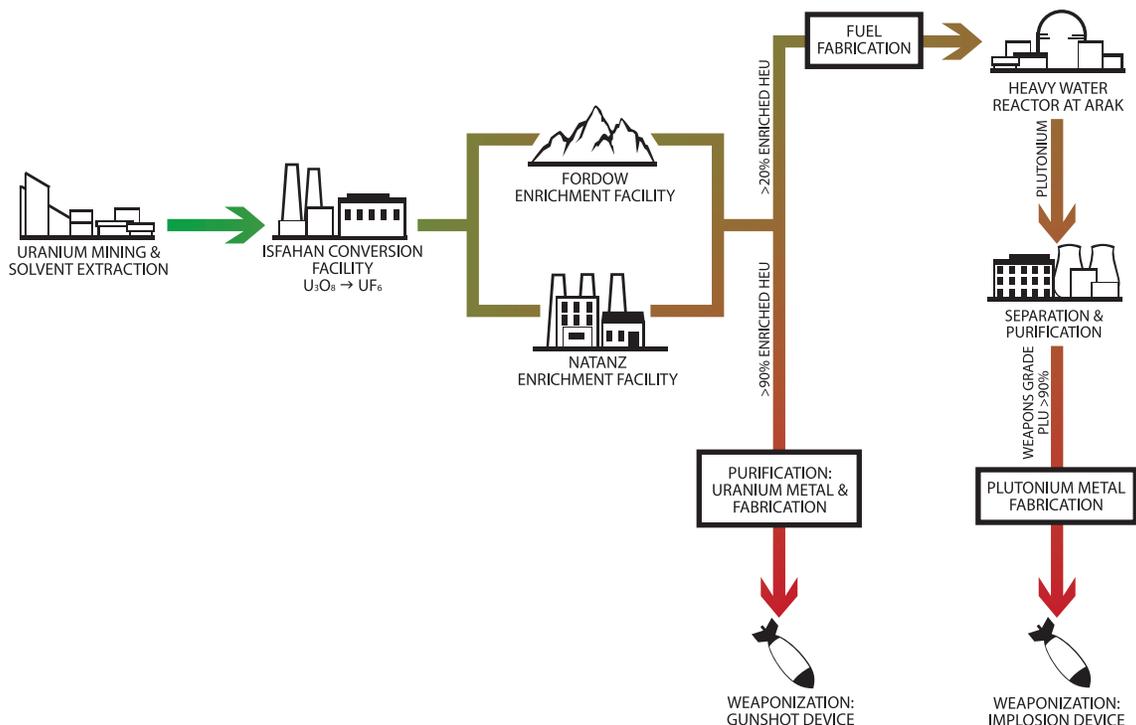


Figure 7: Weaponization Chart

rights, nor to debate the morality, legality, or practicality of the strikes. It is to provide the policymakers, the media, and others, including American, Israeli, and Iranian people, with an objective estimate of the risks and costs of military strikes against Iran’s nuclear sites: the risks and costs to the Iranian people, particularly innocent scientists, civilians and soldiers working at or living in the vicinity of targeted nuclear facilities. The questions that need to be asked to quantify the damage from such strikes are simple, even if the Ayatollah’s gamble with Iranian life promises to play itself out on a scale that exceeds the limits of the imagination.

THE TARGET OF STRIKES: KEY FACILITIES

In “A Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities,” Abdullah Toukan and Anthony H. Cordesman defined Iran’s Nuclear Target Set as the main facilities that are critical nodes in Iran’s nuclear infrastructure—those that can stop or at least delay the program.⁴² For the purpose of this study, we have limited our analysis to the facilities at Isfahan, Natanz, Arak and Bushehr.

The uranium conversion facility (UCF) at Isfahan and the enrichment facility near Natanz are likely the top two targets. The Arak heavy water reactor, though not yet operational, is the next likely target. Among the four potential targets studied, the Bushehr nuclear

power plant is the least likely to be attacked. The Fordow enrichment facility near Qom is a research and development facility as well as an enrichment operation for producing 20 % enriched U-235. This underground facility is protected by more than 80 meters of earth and rocks. It would be an important military target but one which is difficult to destroy. We have not included it in our study.

Beyond the four primary targets, there are dozens of other probable targets, which include:

Very probable targets: Air defense systems, centrifuge workshops, secret nuclear sites known only to Western intelligence, missile facilities.

Probable targets: Parchin military base (where some suspect weaponization testing has taken place).

Possible Targets: Uranium mines and mills, leadership targets.

It is important to note that strikes against some of these facilities, such as centrifuge workshops, which are reportedly located in downtown Tehran, would result in significant casualties.

Finally, we have paid special attention to the consequences of military strikes on the city of Isfahan. Isfahan, the capital of Iran’s Safavid Dynasty, is the crown jewel of Iranian cities. Its architecture alone makes it one of the world’s most beautiful cities, comparable to Kyoto or Florence. The center of the city, designated as a UNESCO world heritage site, is only 15 km (9.3 miles) from the Isfahan Uranium Conversion Facility.

42 Anthony Cordesman and Abdullah Toukan, “Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities,” Center for Strategic and International Studies Report, 14 March 2009, <<http://csis.org/publication/study-possible-israeli-strike-irans-nuclear-development-facilities>>.

THE NATURE OF THE STRIKES: THE CONVENTIONAL OPTION

Any military strike against Iran would have as its objective the total destruction of Iran's hardened nuclear sites. Retired Air Force Col. Sam Gardiner, an expert on targeting, outlined a five-day operation that would require 400 "aim points" at nuclear facilities, at least 75 of which would require "penetrating weapons" as well as "two chemical production plants."⁴³ Gardiner also states that an attack would resemble the 1967 war against Egypt. Besides air strikes from the Hammers in the Israeli Air Force's 69 squadron, the plan would include "Shaldag commando teams, possibly some version of sea-launched missiles and even explosive-carrying dogs that would penetrate the underground facilities."⁴⁴

The Swedish Defense Agency considered two options, a "Go Big" plan engaging both the uranium and plutonium paths that would require strikes against up to 20 nuclear site targets with 600 air sorties and 200 cruise missiles over 48 to 60 hours, and a "Go Fast" plan that would entail fewer and more focused strikes, but which would take out critical nodes such as Natanz over 6 to 12 hours.⁴⁵ Another leading expert, Joseph Cirincione, at the time the director for non-proliferation at the Carnegie Endowment for International Peace, has said that "a more likely target would be Isfahan."⁴⁶

Although some have argued for the use of tactical nuclear weapons, opponents have pointed out that the Pentagon has a number of conventional weapons that can destroy hardened targets, including the GBU-28 that was developed and deployed in the Gulf War. It destroyed one of Saddam's most heavily protected bunkers north of Baghdad, a site fortified by "more than 30 feet of earth, concrete and hardened steel."⁴⁷ Although Israel's request for bunker-busters was denied by the Bush administration in 2005, according to *Newsweek*, the Obama administration sold Israel 55 GBU-28 Hard Target Penetrators—potentially to be used against Iran—in early 2009, shortly after taking office.⁴⁸

As Michael Levi pointed out following speculation about the use of tactical nuclear weapons, Natanz could be destroyed with conventional weapons through repeated bombing over a longer period of time:

"The United States could repeatedly bomb the plant if it wished, drilling down until it reaches the underground chambers. Even if that took days it would set back the Iranian program just as decisively as a nuclear attack."⁴⁹

43 Col. Sam Gardiner, "The End of the Summer of Diplomacy: Assessing U.S. Military Options on Iran," The Century Foundation, 2006, <<http://tcf.org/publications/2006/9/pb578>>.

44 Ibid.

45 Bengt Bergstrand, et al., "Consequences of Military Action Against Iran," Swedish Defense Research Agency (FOI) Report, March 2008, <http://www.humansecuritygateway.com/documents/FOI_Iran_ConsequencesMilitaryActionAgainst.pdf>.

46 Peter Baker, Dafna Linzer and Thomas E. Ricks, "US Is Studying Military Strike Options on Iran," *The Washington Post*, 9 April 2006.

47 Ibid.

48 Eli Lake, "Obama Sold Israel Bunker-Buster Bombs," *Newsweek*, 23 September 2011.

49 Michael A. Levi, "Iran's Sitting Duck: A Nuclear Attack on Natanz Would Make No Sense," *The New York Times*, 18 April 2006.

The Toukan and Cordesman study echoed Levi. They made the case that a military strike with powerful conventional bunker-busters could ensure the destruction of Iran's nuclear facilities and proposed a sequenced strike against the hardened facility at Natanz. More recently, in March 2012, Air Force deputy chief of staff for operations, Lieutenant General Herbert Carlisle, said that the U.S. had developed a massive 30,000-pound (13,600 kg) bunker buster bomb that could smash through some 200 feet (65) of concrete before exploding. He described the massive ordnance penetrator as a "great weapon" that could be used against Iran.⁵⁰

Isfahan: 5 GBU-27

To destroy the conversion facility at Isfahan, Toukan and Cordesman assumed a conventional attack with five F-16s each carrying one GBU-27 PG bomb capable of generating a 5-psi blast.⁵¹ The GBU-27 is a BLU-I09 2000-pound class penetrating warhead. It can pierce 1.8 to 2.4 meters (7.68 ft) of concrete/hard targets, depending on the angle of attack. It carries 550 pounds of high explosives and can blast through more than 6 feet of reinforced concrete.⁵²

Natanz: 47-50 GBU-28

To destroy the facility at Natanz, Toukan and Cordesman calculated that the more powerful GBU-28 Blu-224 5,000-pound class penetrating warhead would be more appropriate, since it could penetrate at least 6 meters (20 feet) of reinforced concrete and 30 meters (100 feet) of earth. They estimated that two properly sequenced GBUs would certainly pierce the 20 meters (64 feet) of earth and 6 meters (20 feet) of concrete. They found that 22 GBU-28 would cover the underground facilities of 585,000 square feet (assuming 90% coverage) and assuming a 50% penetration for each GBU-28 pair, they concluded that 44 GBU-28 would be required to cover the underground facilities and another three GBU-28 to cover the Uranium Separation Building.⁵³

Arak: 4 GBU-10

For the heavy water nuclear reactor at Arak, a production plant of some 55,000 square feet, they estimated the use of four GBU-10s would be required.⁵⁴

Bushehr: GBU-10/GBU-28

The nuclear reactor at Bushehr was not identified as a target in the Cordesman study, although Cordesman did point out that the environmental consequences of an attack on the Bushehr reactor, once

50 David Alexander, "Clash with Iran could see use of huge, new U.S. bomb," *Thompson Reuters*, 9 March 2012.

51 Anthony Cordesman and Abdullah Toukan, "Study on a Possible Israeli Strike on Iran's Nuclear Development Facilities," Center for Strategic and International Studies Report, 14 March 2009, <<http://csis.org/publication/study-possible-israeli-strike-irans-nuclear-development-facilities>>.

52 Ibid.

53 Ibid.

54 Ibid.

IRAN'S FOUR NUCLEAR SITES: MILITARY CONSIDERATIONS				
Plant Location	Isfahan	Natanz	Arak	Bushehr
Site Description	Uranium Conversion Facility & Fuel Manufacturing Facility	Enrichment Plant	Heavy Water Production Plant (D ₂ O) & Heavy Water Reactor	Nuclear Power Plant
Construction	Active	Active	D ₂ O Production: Active Heavy Water Reactor due: 3-Qtr 2013	Reactor operating at 75% capacity
Surface Area	100,000 sq.ft.	646,000 sq. ft.	55,000 sq.ft.	187,000 sq. ft
Strike Force ⁵⁵	5 F-16 Aircraft 5 GBU-27 (240 kg warhead)	25-15 F-15 E 50 GBU-28 (306 kg warhead)	4-8 F-16 4-8GBU 10 (428 kg warhead)	Not specified
Physical Blast	5-10 PSI	5-10 PSI	5-10 PSI	Not specified
Main Toxins & Fission Products Released	Fluorine Compounds including (HF, UF ₆ , UO ₂ F ₂)	Fluorine Compounds including (HF, UF ₆ , UO ₂ F ₂)	Fission Products Including Iodine-131 Strontium-90 Caesium-137 (Once Reactor becomes operational)	Fission Products including Iodine-131 Strontium-90 Caesium-137

Table 1: Projected chemical and radiological releases at Iran's four major nuclear facilities

operational, could lead to hundreds of thousands of deaths. Bushehr would presumably be targeted by the more powerful GBU-10 or GBU-28 due to the heavily fortified reactor dome.

TIMING OF THE STRIKES: 2011-2015

Timelines for a unilateral strike against Iran are not set in stone. Perceptions of the Iranian threat shift, not only as a function of intelligence assessments about when Iran will cross the nuclear threshold, but also as a function of the domestic and international context in which policy is being formulated. Iran's 2009 presidential election protests, the Arab Spring of 2011, the war in Libya, protests in Syria, the United States' decision to pull troops out of Iraq and Afghanistan, and growing rifts within Iran's revolutionary establishment all

impact the timelines for military strikes. Yet, in the aftermath of the failure of the latest round of diplomatic talks in Istanbul, Baghdad and Moscow, the threat of a military strike in 2012-2013 is no longer a matter of speculation. It is real.

As with the Iraq war, perceptions about Iranian nuclear intentions—rather than actual capabilities—can trump reality, legality and facts. The timelines assume the legality of strikes, a rather dubious proposition premised on the notion that once intelligence agencies estimate that Iran has crossed the nuclear threshold, the United States and Israel can assert the doctrine of self-defense to engage in pre-emptive unilateral or coordinated military strikes to eliminate the Iranian threat by attacking Iran's nuclear sites. From a strictly legal perspective, the targeting of nuclear power plants such as Bushehr—and the potential death of countless civilians—raises serious concerns in terms of international law, both in terms of humanitarian law and in terms of the doctrine of proportionality. Even in war, such strikes are expressly forbidden under Additional Protocol to the Geneva Conventions of 1977 which states that: "nuclear electrical generating

55 Anthony Cordesman and Abdullah Toukan, "Study on a Possible Israeli Strike on Iran's Nuclear Development Facilities," Center for Strategic and International Studies, 14 March 2009.

stations shall not be made the object of attack, even where these objects are military objectives, if such attack may cause the release of dangerous forces and consequent severe losses among the civilian population” (Protocol I, Article 56, and Protocol II, Article 15).⁵⁶

Since the timelines assume both the existence of an imminent threat from Iran’s nuclear program and the legality of strikes as acts of self-defense, the time horizons they provide serve as a reliable guide for gauging the pressure for strikes.

Although there is some difference of opinion between policymakers and intelligence agencies about how long it would take Iran to produce enough fissile material to make a nuclear weapon, based on the 2007 National Intelligence Estimate, the timeline in which Iran is likely to produce enough HEU for a weapon has ranged from 2010 to 2015. The estimates for producing enough plutonium for a weapon are 2015 and beyond.⁵⁷

AMOUNT OF FISSILE MATERIAL NEEDED TO BUILD A NUCLEAR BOMB

HEU Enriched to 90% U-235	Simple gun-type nuclear weapons	90 to 100 lbs (40 to 50 kg)
	Simple implosion weapons	33 lbs (15kg)
	Sophisticated implosion weapons	20 to 26 lbs (9 to 12 kg)
Plutonium	Simple implosion weapons	14 lbs (6 kg)
	Sophisticated implosion weapons	4.5 to 9 lbs (2 to 4 kg)

Table 2: Source: Fact sheet, Union of Concerned Scientists, April 2004.

Discussing Israel’s timetable for strikes in the September 2010 issue of *The Atlantic*, Jeffrey Goldberg wrote that, based on his conversation with Israeli decision makers, “this period of forbearance in which Netanyahu waits to see if the West’s nonmilitary methods can stop Iran will come to an end this December.”⁵⁸

The *New York Times* reported on August 19, 2010, that the Obama administration had convinced Israel that it would take Iran at least a year, not months as Israelis had claimed, to convert its stock of low enriched uranium into weapons-grade material.⁵⁹

Nevertheless, the tighter Israeli timeline had considerable support in Congress. In an interview with *The Financial Times*, Howard

Berman, then Democratic chairman of the House of Representatives Foreign Affairs Committee, said that the administration had “months, not years” to make sanctions work and that “military action was preferable to accepting an Iran with nuclear weapons capability.”⁶⁰ In a speech on November 8, 2010, following the Republican sweep of Congress, Israeli Prime Minister Benjamin Netanyahu ratcheted up the pressure on the United States and the international community. He said that the United States faced a simple paradox: “If the international community, led by the U.S., wants to stop Iran without resorting to military action, it will have to convince Iran that it is prepared to take such action.” Then U.S. Defense Secretary Robert Gates countered that sanctions against the Islamic Republic were “biting more deeply than they anticipated.” Speaking to a convention of Jewish groups, Vice President Joseph Biden told the Israeli leader that “we are absolutely committed to preventing Iran from acquiring nuclear weapons.”⁶¹

In a June 6, 2011, *New Yorker* article titled “Iran and the Bomb: How Real Is the Nuclear Threat,” Seymour Hersh reported that the U.S. National Intelligence Estimate of 2011 reaffirmed its 2007 NIE report that “with high confidence” there is “no conclusive evidence that Iran has made any efforts to build the bomb since 2003.”⁶² Yet Hersh warned that “there is a large body of evidence, however, including some of America’s most highly classified intelligence assessments, suggesting that the United States could be in danger of repeating a mistake similar to the one made with Saddam Hussein’s Iraq nine years ago—allowing anxieties about the policies of a tyrannical regime to distort our estimations of the state’s military capacities and intentions.”⁶³

Picking up on Hersh’s report, Roger Cohen points to the shifting estimates about Iran as “the Godot of nuclear threats, the country always on the verge of producing a nuclear weapon or acquiring ‘breakout capacity’ to make one, but never, despite the dire warning of Israeli leaders dating back to 1990, doing either.”⁶⁴ Recalling forecasts of a bomb dating back to 1999 (Shimon Peres), 2004 (Ehud Barak) or July 2011 (Jeffrey Goldberg), Cohen notes that Meir Dagan, former head of Israel’s Mossad spy agency, had dismissed an Israeli attack on Iran as a “stupid idea” and that Dagan was less worried about Iran than “Netanyahu’s susceptibility to ‘dangerous adventure.’”⁶⁵ Sabotage has also muddied timetables and shifted U.S. and Israeli estimates. In January 2011, after attacks using the Stuxnet computer worm and the destruction of up to one-fifth of Iran’s centrifuges, U.S. Secretary of State Hillary Clinton and Meir Dagan, the retiring head of Mossad, separately announced that they believed Iran’s efforts had

56 Note: For a discussion of international law and military strikes against Iran’s nuclear facilities, consult chapter 10 of: Bengt Bergstrand, et al., “Consequences of Military Action Against Iran,” Swedish Defense Research Agency (FOI) Report, March 2008, <http://www.humansecuritygateway.com/documents/FOI_Iran_ConsequencesMilitaryActionAgainst.pdf>.

57 “Iran: Nuclear Intentions and Capabilities,” a study from the Office of The Directors of National Intelligence, <www.dni.gov/press_releases/20071203_release.pdf>.

58 Jeffrey Goldberg, “The Point of No Return,” *The Atlantic*, September 2010.

59 Mark Mazzetti and David Sanger, “US Persuades Israel that Iran Threat Is Not Imminent,” *The New York Times*, 19 August 2010.

60 Daniel Dombey, “Obama Faces Pressure Over Iran Policy,” *Financial Times*, 29 September 2010.

61 Gwyn Ackerman and Johnathan Ferziger, “Netanyahu Says U.S. Must Show a Military Strike Against Iran is Possible,” *Bloomberg News Online*, 8 November 2010, <<http://www.bloomberg.com/news/2010-11-08/netanyahu-says-u-s-must-show-a-military-strike-against-iran-is-possible.html>>.

62 Seymour M. Hersh, “Iran and the Bomb: How Real Is the Nuclear Threat?” *The New Yorker*, 6 June 2011.

63 Ibid.

64 Roger Cohen, “Iran Without Nukes,” *The New York Times*, 13 June 2011.

65 Ibid.

been “set back by several years.”⁶⁶ *The New York Times* reported that in “a sharp reversal from Israel’s long-held argument that Iran was on the cusp of success,” Dagan had told the Israeli Knesset that Iran had run into “technical difficulties” that could delay a bomb until 2015.⁶⁷ Prior to Stuxnet, statements by Netanyahu and Obama had led some analysts to predict an Israeli strike after December 2010, with the timeline for an American military strike in 2011. If the Obama administration’s diplomacy and sanctions fail to provide a solution to the nuclear issue, which is likely, especially after Moscow, one can assume that the gap between the Israeli and American timelines will only narrow with the passage of time. Assuming that the United States and Israel would bargain over establishing a date for targeting Iran, it is almost certain that the timelines for a possible coordinated strike against Iran will overlap if not by the end of 2012, then certainly sometime between 2013-2015 (Figure 8). However, it is also possible that the timelines do not converge, in which case Israel may opt for a unilateral strike without U.S. support.

IRAN NUCLEAR WEAPON TIMELINE



Figure 8: U.S. estimates based on 2007 National Intelligence Estimates (NIEs) produced for the director of National Intelligence)

As Senator Lieberman has indicated, Israel may prefer to wait for a later strike based on an American timeline, if one assumes that Israel would not risk antagonizing the United States to attack Iran. Despite the Israeli attacks on Iraqi and Syrian nuclear facilities, a potentially dangerous and ineffective unilateral strike against multiple targets in Iran without an American security blanket would expose Israel to grave regional and international repercussion. An American strike would have a higher chance of military success and lower political risks for Israel. As Lieberman put it:

“It would be a failure of U.S. leadership if this situation reaches a point where the Israeli government decides to attempt a unilateral strike on Iran. If military action is absolutely necessary to stop Iran from gaining nuclear weapons capacity, then the United States is clearly in the strongest position to confront Iran and manage the regional consequences. This is not a responsibility we should outsource.”⁶⁸

66 William J. Broad, John Markoff and David E. Sanger, “Israeli Test on Worm Called Crucial in Iran Nuclear Delay,” *The New York Times*, 15 January 2011.

67 Ibid.

68 “Lieberman Delivers Address on the Future of American Power in the Middle East,” 29 September 2010, <<http://lieberman.senate.gov/index.cfm/news-events/speeches-op-eds/2010/9/lieberman-delivers-address-on-the-future-of-american-power-in-the-middle-east>>.

IV. THE IMPACT OF STRIKES:

THEORETICAL, HISTORICAL, AND ECONOMIC MODELS AND STUDIES

“A military attack against nuclear facilities of any state necessarily poses grave radiological risks to tens of thousands of innocent civilians and soldiers, especially citizens who lack the necessary preparation or information to protect themselves.”

A number of credible sources and methods help define the outer parameters for measuring the extent of the human, economic, and environmental damage from military strikes against Iran’s nuclear sites. Since prompt government intervention using effective recovery and response plans, evacuations, and medical treatment can shift casualty rates by a factor of ten, if not a thousand, we have also considered the Islamic Republic’s historical experience with natural disasters and radiological accidents.

1. The Theoretical Model: Hazard Prediction and Assessment Capability Software

In March 2007, following publication of Seymour Hersh’s Iran Plans, Physicians for Social Responsibility (PSR) published a fact sheet called the “Medical Consequences of a Nuclear Attack on Iran.”⁶⁹ Using the Department of Defense’s Hazard Prediction and Assessment Capability Software, PSR used meteorological models to map the thermal and radiation effects from strikes by tactical nuclear weapons against the nuclear facilities in Isfahan and Natanz (Figure 9).

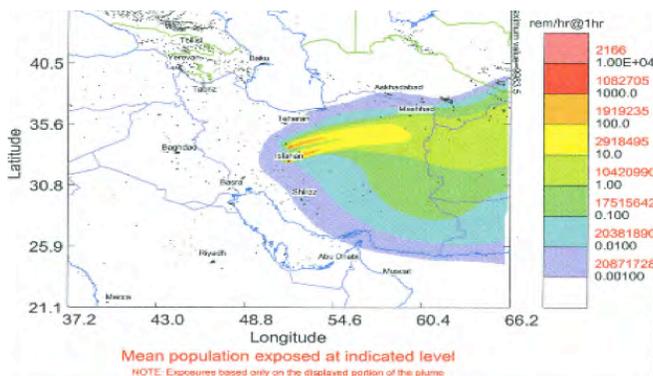


Figure 9: Fallout from nuclear attack on Natanz and Isfahan.⁷⁰

69 “Global Research Fact Sheet,” Physicians for Social Responsibility, 21 June 2008, <<http://www.globalresearch.ca/index.php?context=va&aid=9409>>.

70 Ibid.

Assuming a tactical nuclear attack with three B61-11 earth-penetrating nuclear weapons for each target, PSR estimated that within 48 hours of an attack on the nuclear facilities in Isfahan and Natanz, 2.6 million people would die from radiation-related causes. More than 1 million people would suffer immediate injuries. And another 10.5 million people would be exposed to significant radiation from fallout. The medical consequences would range from radiation sickness, cancer, stillbirths, malignancies, and hypothyroidism to genetic abnormalities such as those witnessed in the aftermath of Chernobyl.⁷¹

Some experts argue that PSR’s assumptions about the use of tactical nuclear weapons were not realistic and are problematic, so consequently, the casualty estimates were too high. Still, as an alternative, the Department of Defense’s Hazard Prediction and Assessment Capability Software can and should be used to estimate casualties based on more conservative conventional strike scenarios.

2. The Historic Model: The Chernobyl Nuclear Accident

Although there are considerable differences between a military attack on Iran’s nuclear facilities and an industrial accident such as the Chernobyl accident (Figure 10), we are the beneficiaries of a number of studies that have tried to quantify the damage from nuclear disasters. One of the most comprehensive of these studies is the “Chernobyl Forum’s 2006 Report on the Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience.”⁷² That report examined radionuclide release and deposition in the urban, agricultural, forest and aquatic environments in Belarus, Ukraine, and the Russian Federation following the Chernobyl disaster in April 1986.⁷³

71 Ibid.

72 “Environmental Consequences of the Chernobyl Accident and Their Remediation: Twenty Years of Experience,” International Atomic Energy Agency and the Chernobyl Forum Report, 2006, <http://www-pub.iaea.org/mtcd/publications/pdf/pub1239_web.pdf>.

73 “Chernobyl’s Legacy: Health, Environmental and Socioeconomic Impacts and Recommendations to the Governments of Belarus, the Russian Federation, and Ukraine,” International Atomic Energy Agency and the Chernobyl Forum, 2005, <<http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf>>.



Figure 10: Chernobyl Disaster (Photo: www.cofcsd.org)

Some of the consequences of Chernobyl are worth considering:

- The immediate deaths of plant workers and emergency responders
- Severe radiation exposure to responders and clean-up personnel
- Unprecedented release of radioactive material to the environment
- Evacuation of more than 100,000 people from the region
- Later relocation of about 200,000 people after 1986
- 5 million people live in areas contaminated by radioactivity
- Destruction of contaminated livestock and food crops
- Loss of 10,000 square kilometers (3,861 square miles) of agricultural land
- Contamination of fresh water supplies and tables in Iran and the Persian Gulf region

Any attack on Iran’s nuclear installation would have as its objective the total destruction of the facilities—reactors, centrifuges, buildings, equipment, warehouses, supplies, and, almost certainly, employees. Strikes on the nuclear plant at Bushehr and Arak (once the reactor is operational) would result in the death of plant workers and emergency first responders, including members of the Revolutionary Guard and soldiers not equipped to handle radiation; severe radiation exposure for clean-up personnel; unprecedented release of radioactive material; the evacuation and relocation of thousands of local residents; the exposure of millions to contamination; the destruction of livestock and food crops; and the loss of agricultural land and water resources.

Particularly telling is the fate of populations in cities near the nuclear sites. The residents of Pripyat, a city housing the workers at the Chernobyl plant, were evacuated shortly after the accident. More than 20 years later, Pripyat remains a ghost town. Iranian cities could suffer a similar fate (Figure 11).



Figure 11: Pripjat (Photo: Tricon Films & Television Inc.)

Many argue that in the end it was incompetence, corruption, and mismanagement—the Communist Party’s failure to inform, prevent, and protect the people of Russia, Belarus, and Ukraine against exposure to their own nuclear program — that sealed the Soviet Union’s fate. Yet, ironically, the Islamic Republic appears not only to depend on Russian reactors and engineers to salvage the Shah’s nuclear program, but also to discount and neglect safety issues. Despite some design differences, including a containment dome, Iran’s Bushehr nuclear plant with its VVER-1000 Russian reactor is comparable in size and power production to the Chernobyl RBMK-1000 reactor. Worse, the same negligent culture regarding safety that led to Chernobyl exists in Bushehr, as repeated delays and testing due to old and incompatible parts, including the cooling system, demonstrate. Even without strikes, just as with the Soviet Union, a political approach to management that promotes ideologues over professionals can only ensure that the Iranian people will face political, economic, and ecological catastrophe.



Figure 12: Isfahan in 2006 (Photo: Younes Kolahdouz)

Whether Isfahan, Bushehr and other cities become casualties of the nuclear gamble is a question that the Iranian people and parliament should address before, not after, an attack.

3. The Macro-Economic Model: Belarus, Ukraine, and Japan

According to the IAEA’s Chernobyl Forum, the government of Belarus has estimated that the direct and indirect cost of Chernobyl over three decades amounted to \$235 billion dollars.⁷⁴ This figure includes:

- Direct damage caused by the accident
- Expenditures related to:

⁷⁴ Ibid.

- Actions to seal off the reactor and mitigate consequences of exclusion zone
- Resettlement and reconstruction of housing and infrastructure
- Social protection and welfare to the affected population
- Radio-ecological improvement of settlements and disposal of radioactive waste
- Indirect losses relating to the opportunity cost of removing agricultural land and forests from use and closure of agricultural and industrial facilities
- Other opportunity costs such as the additional costs of energy resulting from the loss of power from the Chernobyl nuclear plant and the cancellation of the Belarus nuclear power program
- Total spending by Belarus on Chernobyl between 1991 and 2003 is estimated at U.S. \$13 billion; this amounted to 22.3% of the national budget in 1991, declining gradually to 6.1% in 2002
- In Ukraine, 5 to 7% of government spending each year is devoted to Chernobyl-related expenditures

Thus, Iran's leaders risk a military confrontation that not only promises the destruction of Iran's nuclear facilities, but also shackles generations to illness, misery, poverty, and dependence. The estimates of Iran's national budget vary. If one assumes that the 5% ratios for Belarus and Ukraine would also apply to Iran, at the CIA World Fact Book estimate of \$105.7 billion⁷⁵ national budget in 2010, military strikes against Bushehr would cost Iran more than \$5 billion a year. And the CIA estimates are at the low end of some estimates of Iran's budget. A *Reuters* story quoted *The Islamic Republic News Agency* in April as saying the Iranian parliament passed a budget of \$500 billion⁷⁶ for 2011-12—nearly five times the CIA estimate.

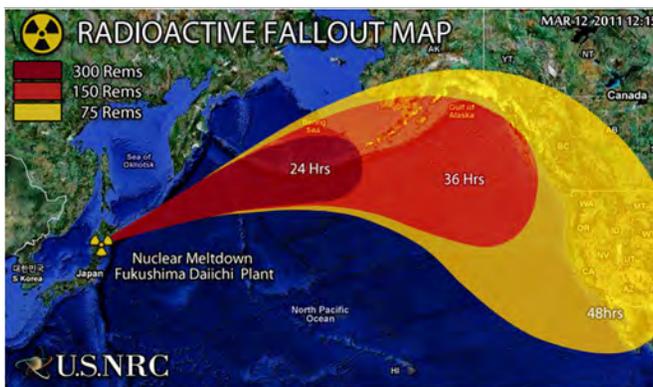


Figure 13: Source: *The United States Nuclear Regulatory Commission*

Japan's experience with Fukushima is also instructive (Figure 13). Although it is still too early to put a final cost on the Fukushima nuclear tragedy, the evacuation of tens of thousands of Japanese citizens, the contamination of agricultural and industrial supply chains, the disruption of the marine ecology and the banning of fishing along the northeastern coast of Japan have led economists to estimate the

cleanup and compensation costs at over \$200 billion.⁷⁷ Although Iran's economy does not compare with Japan's, considering the fact that military strikes against Iran would not be limited to Bushehr, it is reasonable to estimate that the human, economic, and environmental cost of military strikes against Iran would be more severe than Fukushima. In case of military strikes leading to a prolonged war, those costs would climb. The Iran-Iraq war claimed more than 1 million casualties (262,000 Iranian war dead, 105,000 Iraqi war dead, and more than 700,000 injured), with direct monetary costs for each country estimated as high as \$100 billion, and indirect costs in terms of lost income at more than \$1 trillion dollars (\$561 billion and \$627 billion for Iraq and Iran respectively).⁷⁸

4. The Micro-Economic Model: September 11th Victim Compensation Fund

To gain an understanding of the scale of disasters of such magnitude, the costs of the September 11th terrorist attacks on New York City serve as a powerful reference. A 2004 study by the Rand Institute for Civil Justice titled "Compensation for Losses from the 9/11 Attacks" put the benefits provided to those killed in the attacks on the World Trade Center (WTC), Pentagon, and the Pennsylvania crash site, and to businesses and individuals in New York City affected by the attack on WTC at \$38.1 billion.⁷⁹ \$10.6 billion went to the families of those who were killed or to those who were seriously injured. Emergency responders received \$1.9 billion. And \$23.3 billion of the benefits went to businesses for property damage and business interruption. The benefits' sources included insurance (51%), government (42%), and charity (7%).⁸⁰

According to Rand, private insurance payments were expected to be the "largest for any single-event loss in U.S. history and far in excess of losses for any terrorist-related event."⁸¹ Estimates of insured losses were as high as \$32.5 billion, or over 50% more than Hurricane Andrew, the second-largest single event loss in U.S. history. Insured losses were 30 times larger than the next-largest insured loss for a terrorist attack.

Congress also set up a \$7 billion September 11th Victim Compensation Fund to provide compensation to families and dependents of those killed and injured after the September 11, 2001, attacks. According to Rand, quantifiable benefits for the 2,551 killed and 215 seriously injured totaled \$8.7 billion, or \$3.1 million per recipient.

77 Note: According to Kazumasa Iwata, president of the Japan Center for Economic Research, the Fukushima nuclear accident could cost Japan between 5.7 and 20 trillion yen, and would require a 12 trillion "nuclear power burial fund" to cover cleanup and compensation costs. The JCER also predicted that a 10% electric power shortage in the Kanto region in the summer could lead to a 2% decline in economic activity over the year. "Impact to Last Decade or More if Existing Nuclear Plants Shut Down," Japan Center for Economic Research, 25 April 2011, <[http://www.jcer.or.jp/eng/research/pdf/pe\(iwata20110425\)e.pdf](http://www.jcer.or.jp/eng/research/pdf/pe(iwata20110425)e.pdf)>.

78 Maj. Dexter Teo Kian Hwee, "The Iran-Iraq War: An Examination of War Termination Theories," *Journal of the Singapore Armed Forces*, Vol. 29 (January-March 2003), <www.mindef.gov.sg/safti/pointer/back/journals/2003/Vol29_1/2.htm>.

79 Lloyd Dixon and Rachel Stern, "Compensation for Losses from the 9/11 Terrorist Attacks," RAND Institute for Civil Justice, 2004 (pg. 20), <http://www.rand.org/pubs/monographs/MG264.html>.

80 Ibid.

81 Ibid.

75 CIA World Factbook, last updated 11 January 2011, <<https://www.cia.gov/library/publications/the-world-factbook/geos/ir.html>>.

76 "Iran parliament passes 2011-12 budget," *Reuters*, 26 April 2011, <<http://www.reuters.com/article/2011/04/26/iran-budget-approved-idUSPOM65348720110426>>.

The Department of Justice's September 11th Victim Compensation Fund payment statistics put the median deceased victim award after offsets at \$1,677,633.⁸² Awards have ranged from \$250,000 to \$7.1 million depending on age and income levels. In all, 7,408 claims were processed.⁸³

It is highly unlikely that the Iranian government, insurance industry, and philanthropic organizations would be able to compensate the families of the scientists, emergency workers, and soldiers killed as a result of the bombing of Iran's nuclear facilities in a way that would match the U.S. response to the September 11th terrorist attacks. Although the number of civilians likely to be killed or injured as a result of the bombing of nuclear facilities near Isfahan, Natanz, Arak, and Bushehr can exceed the number of victims of the September 11th attacks several-fold, and the radius of economic damage to property and business is likely to be extensive, it is highly unlikely that the Iranian government, industry, and philanthropies could provide adequate and timely support to ensure the recovery of families and local businesses from massive and sudden loss.

If the Iranian government had the budget and plans to compensate victims of attacks on Iran's nuclear facilities, the costs would be significant. With U.S. gross domestic product (GDP) per capita of \$45,934 compared to Iranian GDP per capita of \$10,939 (the U.S. GDP is 4.2 times greater), adjusting the U.S. \$3.1 million quantifiable benefits per recipient would translate to about \$749,000 per recipient. Adjusting for the median deceased victim award of \$1,677,633, the Iranian government's compensation fund would have to pay a medium deceased victim award of \$419,500. Awards would range from about \$60,000 to \$1,700,000. Assuming deaths and injuries at the same level as 9/11, the Iranian government would have to allocate approximately \$1.7 billion to a nuclear strike victim compensation fund.⁸⁴

If we assume deaths and serious injuries among scientists and workers at four nuclear plants at approximately 5,000 people, the benefits would be approximately \$2.1 billion. If one factors in the tens of thousands of soldiers, rescue and recovery workers, local residents, and clean-up crews who would suffer serious injuries from exposure to fissile material and toxins released from the bombing, the costs of compensating the victims for economic loss could be in the range of \$5-50 billion. Assuming provisions are not made to cover the costs and protect the victims, the political, economic, and social consequences of having a large population in key provinces absorb such a high level of damage with no hope of recovery and no support from government, industry and charities would be enormous.

Just as the U.S. government and insurance industry facilitated the recovery of lower Manhattan with more than \$23.3 billion in insurance awards, low-interest loans, government grants and tax breaks, the Iranian government would need an urban recovery plan for Isfahan, Natanz, Arak, and Bushehr. Such a plan would have to enable local residents to reclaim or replace the land, property, housing, and businesses that would be exposed to contamination as well as

other forms of loss of income caused by the bombing. Such costs could certainly match the recovery costs of lower Manhattan as they would require cleaning up much more pernicious chemical and radioactive agents. The alternative to such intervention—negligence—would create sharp economic decline and urban blight marked by a spike in insecurity, unemployment, depression, homelessness, and unrest.⁸⁵ That is clearly not the utopia Iran's nuclear program was intended to deliver; yet as long as these costs remain hidden from the Iranian people, nothing stops the Ayatollah from gambling at their expense.

5. Casualty and Morbidity Rates: From Traffic to Natural Disasters

One can get some indication of the impact poor governance would have on casualty and morbidity rates in the event of nuclear strikes by examining the government's responses to natural disasters such as earthquakes and forest fires, as well as airline and traffic accidents. The Iranian government's approach to crisis management is one that shifts liability for massive failures of governance and management onto the Iranian people. Every year, thousands of Iranians are killed or injured as a result of wounds or burns from accidents and disasters that could have been prevented if government made the protection of Iranian life a priority. In fact, one study of the annual mortality rate of Iranians from road accidents concluded that Iran's rate of 44/100,000 is the worst of any country studied. It stated that with more than 30,000 people dying from road traffic crashes, the annual mortality rate is "substantially higher than the Bam earthquake, one of the worst natural disasters of recent decades."⁸⁶



Figure 14: Blankets cover quake victims in Bam (Photo: Reuters)

82 "September 11th Victim Compensation Fund, Award Payment Statistics," Department of Justice, <http://www.justice.gov/archive/victimcompensation/payments_deceased.html>.

83 Ibid.

84 "World Economic Outlook Database," International Monetary Fund, October 2010, <<http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx>>.

85 Michael Cooper, "Spill Fund May Prove as Challenging as 9/11 Payments," The New York Times, 21 August 2010.

86 "Iran's death rate from traffic accidents highest in the world," Institute for Health Metrics and Evaluation, 19 May 2009, <<http://www.healthmetricsandevaluation.org/research/publication-summary/adverse-health-outcomes-road-traffic-injuries-iran-after-rapid-motoriza>>.

As for Bam and similar earthquakes, such natural disasters have struck Iran on a regular basis—and with devastating force. Despite this experience, almost 30,000 Iranians lost their lives in the Bam earthquake.⁸⁷ A prominent Iranian seismologist at the scene of the Bam earthquake bemoaned the ignorance and neglect that had multiplied the casualties and trauma (Figure 14). Turkey, Iran's neighbor, lost fewer people following the 7.6-magnitude Izmit earthquake of 1999—an earthquake 10 times the magnitude of the Bam earthquake and unleashed in a much more densely populated region.⁸⁸ The Turkish example suggests that better planning, prevention, and response could have reduced the death toll in Iran by at least a factor of 10. Compared to the United States, an earthquake of similar magnitude to Bam struck Los Angeles at roughly the same time of night. It reportedly only claimed 20–60 lives.⁸⁹ If one were to simply compare the difference in the casualty figures after the Bam and Los Angeles earthquakes, it becomes evident that in the event of a disaster, whether natural or manmade, planning, preparation, and prevention can reduce the death toll by a factor of 100, if not 1,000. Conversely, a poor emergency response—lack of planning, preparation, prevention, and intervention due to significant underfunding—can mean that the death toll from a strike against an Iranian nuclear site might be 100 to 1,000 times greater than necessary. It is a gamble where the initial loss from strikes gets compounded by subsequent losses from a woefully underfunded response.

Yet, sadly, a Supreme Leader, Council of Guardians and Parliament that claim power as deputies of God and representatives of an absent Messiah hold themselves to slippery standards. They excuse the government's failures of funding, planning, and preparation as acts of God and the Prophets, rather than reflections of man. The death, misery, and poverty afflicting thousands of Iranians—whether from car accidents, plane accidents, or nuclear accidents—get concealed under the shroud of an ideology that glorifies martyrdom and gets priced into an economy that rewards victimhood rather than initiative, accountability, and responsibility for the life of the Iranian people and others. In this regard, the Ayatollah's failure to demand and fund the development of a serious nuclear emergency and recovery plan is every bit as damaging as the fraud and corruption leading to the collapse of faith in Iran's government.

6. Recovery and Response: Radiological Accidents

Despite the obvious threats of accidents, earthquakes, terrorism, sabotage, and strikes to Iran's nuclear program, the Iranian government has not publicly demonstrated that it has a manual for organizing a coordinated national response to a nuclear catastrophe. Yet, after a radioactive accident involving a nuclear plant, site remediation activities require a highly complex response plan, beginning with a unified command structure at the national and local level that can provide security, communications, logistics, medical, and public

affairs support by deploying, coordinating, and managing specialized assets. The "National Response Plan" developed by the U.S. Department of Defense for its nuclear, chemical, and biological defense programs, provides an overall framework that makes the complexity of these operations abundantly clear.⁹⁰ Without a framework for organizing a response, defining the role of government agencies, developing a plan for each nuclear installation, securing the assets and equipment for each phase of a response, training the teams at the sites as well as nationally, and developing a site remediation plan that takes into account the specific characteristics of each plant and area, accidents and strikes would lead to chaos and paralysis rather than an immediate and effective response. Basic questions such as who is in charge, where to set up an operational command center, how to secure and intervene at the sites, where to evacuate and how to treat the casualties, how to detect and dispose of contaminated materials, how to deliver food, water and other uncontaminated materials, how to inform the public, and who to contact to secure international assistance would remain open. Crucial time would be lost and the Iranian people would be left to fend off threats they would not be able to see, identify or avoid. When it comes to responding to nuclear disasters, the Iranian government is woefully ill-prepared. It has not had experience with nuclear accidents, radiation or contamination on a large industrial scale, let alone simultaneous military strikes on four nuclear facilities.

The high casualty ratios following the Bam earthquake provide a glimpse into what would follow in the event of a nuclear catastrophe. Problems of inadequate funding, poor planning, communications, and logistics would be compounded by corruption, looting, and insecurity. The local population has not been notified or trained to react to an early warning system and would not know how to follow evacuation plans. Additionally, there would be minimal civil defense, minimal capacity to detect, minimal equipment to monitor, and few medicines to mitigate the consequences of exposure to physical blasts, toxic dust, chemical plumes, and radiation. As in Bam, thousands of lives that could be saved would be lost.

As in Chernobyl, there is no reason to believe that the scale of such an accident would be properly assessed and reported and no evidence to suggest that the movement of toxic plumes and radiation would be detected and monitored, or that local residents would be rapidly warned and evacuated. And like the Soviet soldiers and firefighters sent into the accident site armed with nothing but shovels or the rescue workers exposed to toxic dust after 9/11, there is no reason to believe that Iranian soldiers and firemen would be better prepared or equipped. While Iran's leaders would be making fiery speeches against foreign aggressors, Iran's rescue teams would be dispatched into highly contaminated sites to provide the public with a false sense of security. They would not have the training, equipment, or planning to handle hazardous toxins and radioactive materials released as a result of policies beyond their control.

87 "Iran Lowers Bam Earthquake Toll," BBC News, 29 March 2004, <http://news.bbc.co.uk/2/hi/middle_east/3579173.stm>.

88 "Preliminary Earthquake Report," US Geological Survey, 17 August 1999, <http://neic.usgs.gov/neis/eq_depot/1999/eq_990817/>.

89 "Massive Earthquake Hits LA," BBC News, 17 January 1994, <http://news.bbc.co.uk/onthisday/hi/dates/stories/january/17/newsid_4079000/4079741.stm>.

90 "Nuclear Weapon Accident Response Procedures (NARP)," Department of Defense (DoD 3150.8-M), 22 February 2005, <<http://www.dtic.mil/whs/directives/corres/pdf/315008m.pdf>>.

7. Medical Infrastructure: The Radiological Accident in Gilan

There are no clear models for assessing the medical infrastructure and resources required to treat the casualties from military strikes on Iran’s nuclear plants, particularly in the case of Bushehr. What is certain is that the victims would number in the thousands, and the cause and range of injuries—physical, chemical, thermal, radiological, and psychological—would stretch even the most advanced medical system to its limits. But unlike traditional accidents, radiological accidents require highly specialized medical training and equipment. Despite a remarkably accomplished medical profession, Iran lacks the resources and expertise to treat radiation injuries.

Strikes on Iran’s nuclear facilities would expose everyone in their vicinity to two types of radiation, each with different consequences. At Bushehr and Arak, victims would be exposed to both short-term acute and long-term chronic radiation. Attacks on Natanz and Isfahan would result in exposure to long-term radiation from depleted uranium.



Figure 15: Slight retraction of the body to the right side due to the fibrotic chest graft in November 1997 (Photo: IAEA)

According to the International Atomic Energy Agency “Study on the Radiological Accident in Gilan,” July 24, 1996, Iran experienced one of its first serious radiological accidents at the combined fossil fuel power plant there when a lock on a radiography container failed and an Iridium source fell in a trench without being detected by the radiography team. A worker later picked up the Iridium source (IR 192) and placed it in his right breast pocket for 90 minutes (Figure 15). He started to experience nausea, lethargy, dizziness, and a burning sensation in his chest. As a result, an inspection team from the Atomic Energy Organization of Iran recommended blood checks for all 600 personnel. All of the samples, which were processed in Tehran, were reported normal except that of the worker, who was transported to Tehran two days later for blood tests and tests to determine cell damage. His chest lesion got worse over the next 16 days, leading to red and moist, peeling skin, typical of radiation exposure.

Almost a month after the accident, following treatments in Iran, the patient was sent to the Radiopathology unit at the Institut Curie of Paris, where he was treated in an isolation room using reverse barrier nursing techniques for two months for a blood condition and skin lesions induced by radiation (Figures 16 and 17).⁹¹



Figure 16: Necrosis of the epidermis on Day 15 (Photo: IAEA)



Figure 17: Moist desquamation on the left palm on Day 35 (Photo: IAEA)

The Gilan radiological accident makes it pretty clear that the AEOI’s Medical Service had to turn to the Institut Curie in Paris to treat a single worker exposed to a radiation source for 90 minutes. In the event of large-scale exposure involving hundreds of workers at a site, let alone an explosion that would spread radioactive debris, toxins and clouds across entire cities and provinces, it is almost certain that Iran would not be able to provide instant bone marrow stimulating cytokine treatment, thermography, grafting and a variety of other treatments necessary for restoring platelet counts, burned skin, and the like.⁹² While Iranian doctors have the training and equipment necessary for responding to earthquakes, strikes on nuclear facilities require a highly complex medical infrastructure able to treat thousands of people exposed to wounds, burns, toxins, and radiation. The number of hospital beds in Isfahan, Arak, Natanz, and Bushehr is not enough to cover a fraction of the casualties resulting from military strikes,

91 “The Radiological Accident in Gilan,” International Atomic Energy Agency, 2002, <<http://www-pub.iaea.org/books/IAEABooks/6284/The-Radiological-Accident-in-Gilan>>.

92 Ibid.

let alone begin to treat them.⁹³ If the Gilan case proves anything, it is that the Islamic Republic's ability to cope with radiation-related sickness is so limited that scientists and workers who are exposed to radiation at the sites must be sent abroad for medical treatment. Since the Gilan accident, there is no evidence to suggest that Iran has developed the necessary medical programs to handle large-scale radiological accidents.

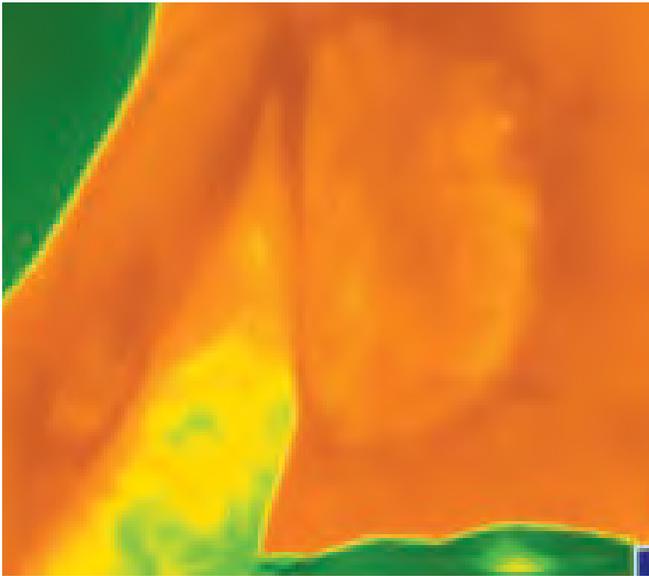


Figure 18: Thermography of the chest and right elbow on Day 28 (Photo: IAEA)

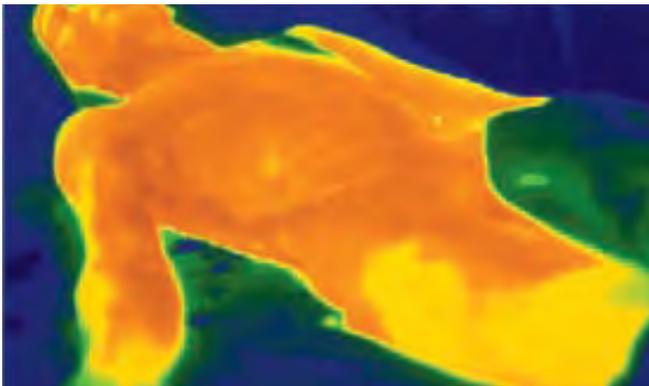


Figure 19: Thermography of the chest and right elbow on Day 28 (Photo: IAEA)

93 Note: It is important to remember that Iran is already dealing with a large number of people who were victims of chemical attacks in the war against Iraq. According to the Christian Science Monitor, Iranian officials “estimate that in the eight-year war with Iraq, 100,000 were exposed to nerve agents like sarin and soman and blistering agents like mustard gas.” Scott Peterson, “Lessons from Iran on facing chemical war,” Christian Science Monitor, 19 November 2002. Another source said Iran spends about \$67 million a year treating its chemical victims and notes indirect costs including psychosocial damage to victims and their offspring who, though born since the war, may suffer from severe deformities and disabilities. No studies have confirmed that mustard gas can alter DNA as some believe. It has not been quantified, but is widely believed as well that people living in the affected areas have a higher incidence of diseases such as cancer. “Iranian Chemical Attacks Victims,” Speech by Kamin Mohammadi (Payvand News), <<http://www.payvand.com/news/06/dec/1239.html>>.

8. Limits of Models

Critics may argue that these models exaggerate the costs of the bombing of Iran's nuclear sites. While none of these models can predict precisely what would unfold in Iran, they provide a realistic framework for understanding a catastrophe on the scale being contemplated. The models offer a point of reference and methodology that accounts for the potential scale of the human, economic, and environmental damage that might result. And while there would be substantial variation between models, the historic, scientific, medical, and economic experience of Russia, Belarus, Ukraine, Japan, the United States, and Iran with catastrophes and disasters allows us to put brackets around scenarios likely to take place in Iran. In the case of Bushehr, the similarities with Chernobyl are such that the risks of a nuclear catastrophe caused by technical malfunction and human error are every bit as grave as the risks from military strikes (Figure 20).



Figure 20: Aerial view of a neighborhood in the city Bushehr

Finally, there is common sense. A massive military assault designed to guarantee the destruction of four major nuclear facilities in any country is an event of enormous magnitude. A military strike with powerful conventional weapons is intended to destroy Iran's nuclear program by destroying its hardware: the buildings, equipment, and testing material. It will only delay and degrade Iran's nuclear capability. Still, no one disputes that fact that one unintended consequence would be the release of tons of radioactive materials and toxic gases. As Ehud Barak has pointed out, after a certain point in time, “any military solution would result in unacceptable collateral damage.”⁹⁴ The parameters for measuring the actual impact of such a release can only be determined in real time after the fact.

We contend that a military attack against nuclear facilities of any state poses grave risks to tens of thousands of innocent civilians and soldiers, most of whom have the least degree of preparation or information about radiological risks. An attack against nuclear facilities guarantees the release of vast amounts of toxic materials. Pre-emptive military strikes against nuclear power production facilities — whether they are located in Iran, Israel, the United States, or any other nuclear state — amount to the premeditated murder of thousands of civilians, constitute a grave breach of the Geneva Conventions, and can be prosecuted as war crimes.

The level of harm caused by military strikes makes it imperative to devise a long-term strategy that makes it harder for the

94 Jo Becker, James Glanz and David E. Sanger, “Around the World, Distress over Iran,” *The New York Times*, 28 November 2010.

IV. THE IMPACT OF STRIKES:

Ayatollah and others to gamble with the Iranian peoples' lives. It is nearly impossible to verify and inspect Iran's nuclear program, let alone change Iran's nuclear policies, as long as the Iranian state remains cloaked and the Iranian people confined under his rule. Given Iran's claims about the peaceful nature of its nuclear programs, the belligerent rhetoric and secretive policies only make it more difficult to verify if Iran has allocated the necessary funding, training, and transparency to ensure that safety standards at existing facilities meet international standards.

V. CASE STUDIES

“To develop a complete understanding of the costs of a military attack against Iran, it is imperative to understand the topography, history, infrastructure, and population density of the areas surrounding the potential targets. With this local picture in mind, we have developed case studies for the cities of Isfahan, Natanz, Arak, and Bushehr.”

To develop a complete understanding of the costs of a military attack against Iran, it is imperative to understand the history, background, infrastructure, and makeup of the areas surrounding the potential targets. With this local picture in mind, we have developed case studies for the cities of Isfahan, Natanz, Arak, and Bushehr. These cities and their surrounding area would be those most likely to suffer from a military strike and its aftermath. We have not included a case study on the impact of an attack on Qom’s Fordow enrichment facility, which deserves its own study after an escalation in activity in late 2011 and early 2012.

CASE 1: ISFAHAN

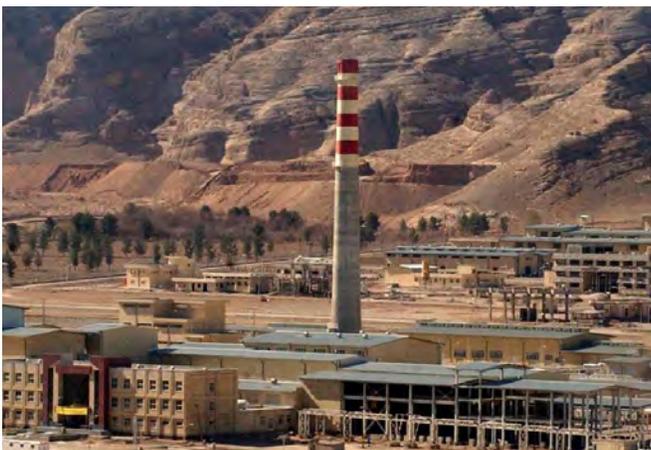


Figure 21: Isfahan Nuclear Facility (Photo: Associated Press)

Few cities would pay as high a price for the Islamic Republic’s nuclear gamble as Isfahan. There is nothing abstract about targeting the Uranium Conversion Facility at Isfahan (Figure 21). As the main site for the production of uranium hexafluoride (UF₆), as well as fuel manufacturing and fuel plate fabrication, the facility at Isfahan contains UF₆ as well as other corrosive, toxic fluorine compounds.

According to the IAEA, from 2004 to 2010, the Isfahan Uranium Conversion Facility (UCF) has produced in excess of 371 metric tons (409 US):

“The total amount of uranium produced at UCF since March 2004 remains 371 tonnes in the form of UF₆”⁹⁵

These compounds are classed as acidic poisons that form hydrofluoric acid when they come in contact with bodily fluids. In lethal concentrations, they attack the lungs, eyes, skin, and tissue. Thus, should a substantial stock of this material still be stored at Isfahan, a successful attack on such facilities, as with attacks on any industrial chemical plant where vast amounts of toxic chemical are stored, can be viewed as a lethal chemical attack—a form of chemical warfare that would lead to the release of highly toxic plumes close to a major population center. With the city center of Isfahan less than 10 miles from the Uranium Conversion Facility, and prevailing wind directions blowing in a westerly direction at average speeds of 9-13 miles per hour, a toxic plume would reach the suburbs of Isfahan in less than an hour (Figure 23).

Given the population densities of the districts along the path of the toxic plume, tens and quite possibly hundreds of thousands of people could be exposed to dangerous concentrations of highly reactive fluorine compounds. Even the most developed of countries with advanced early warning and civil defense capabilities, let alone the Islamic Republic of Iran, would be overwhelmed by military strikes on a nuclear plant this close to a major population center.

A military strike on the Isfahan facility could be compared to the 1984 Bhopal industrial accident at the Union Carbide plant in India (Figure 22). In that accident, the release of 42 metric tons (47 U.S. tons) of methyl isocyanate turned the city of Bhopal into a gas chamber. Estimates of deaths have ranged from 3,800 to 15,000. The casualties went well beyond the fatalities: More than 500,000 victims received compensation for exposure to fumes.

⁹⁵ “Implementation of NPT Safeguards Agreement and relevant provisions of Security Council resolutions,” IAEA Report to the Board of Governors, 18 February 2010: 6.



Figure 22: Victims of the Bhopal disaster (Photo: www.wsws.org)

Human Casualty Estimates at Site

According to Dr. Ghannadi-Maragheh, 800 to 1,000 experts are employed at Iran’s Uranium Conversion Facility.⁹⁶ If we assume an expert-to-worker ratio of 1 to 1, then we can assume that in addition to the scientists and engineers at the site, a large percentage of the 2,000 workers, soldiers, and support staff would be killed immediately as a result of a military attack on the site. They would be exposed to overpressure of 5 PSI at the blast point which would almost certainly destroy all the buildings and kill virtually all the people at the site. The number of the dead could vary depending on the timing of the attack, but if the goal of an attack on the site is to damage and delay Iran’s nuclear program, then it is likely that it would be timed to inflict the highest possible damage, not only to the site, but to the skilled scientists, technicians, and workers needed to operate the site. We have assumed that a strike on the plant would kill the entire shift working at the plant at the time of the strikes, approximately 800 to 1,000 people.



Figure 23: City limits of Isfahan—Distance to City: 9.3 miles (15 km) (Source: Google)

Additional Casualties: The Isfahan Toxic Plume

Estimating the additional casualties from military strikes against Isfahan is more complex. While there is no question about the fact

that thousands of people living in close proximity to the strikes would be at risk, casualty figures will depend on the length of exposure to lethal concentrations of chemicals released from the plant.

We have discussed our key assumptions about the properties, inventory, storage, location, release, vaporization, reactivity, lethality, and dispersal of the highly toxic chemicals stored and processed at the Isfahan facility (please see section on Methodology and Assumptions). These assumptions are critical to any calculation about the nature of the chemical and radiological threat facing the people of Isfahan and, one might add, Natanz.

To arrive at specific estimates of casualties at Isfahan, we have factored in variables related to climate, geography and demography such as topography, wind direction and speeds, and population densities.

A third component for quantifying the impact of military strikes on Isfahan is assessing the Islamic Republic’s civil defense capabilities, such as early warning systems, evacuation and crisis management plans, medical infrastructure and public education.

Isfahan Toxic Plume Profile

To understand the transport profile of the gases, one must recognize that the force of the blast would disperse these agents, along with other debris and dust into the atmosphere, allowing it to be carried by the prevailing winds. The Isfahan Meteorological Bureau reports prevailing winds from the UFC in a westerly direction, toward Isfahan city eight months out of the year (Table 3). With average winds ranging from 9.4 to 13 mph, these gases could easily reach the residential suburbs of Isfahan in less than a half-hour, and the densely populated city center and beyond within an hour.

Month	Prevailing Wind Direction	Average Prevailing Wind Speed	Average Prevailing Wind Speed
		(meters/second)	(miles/hour)
January	West	4.5	10.07
February	West	5.2	11.63
March	West	5.7	12.75
April	West	5.8	12.97
May	West	5.6	12.52
June	West	4.9	10.96
July	East	5.3	11.85
August	East	5.1	11.41
September	East	4.3	9.62
October	West	4.6	10.29
November	South-West	4.7	10.51
December	West	4.2	9.4

Table 3: Isfahan’s Prevailing Winds (Source: Isfahan Meteorological Office)

⁹⁶ M. Ghannadi-Maragheh, “Iranian Nuclear Fuel Cycle Experience,” presented at the World Nuclear Association Annual Symposium, 3-5 September 2003.

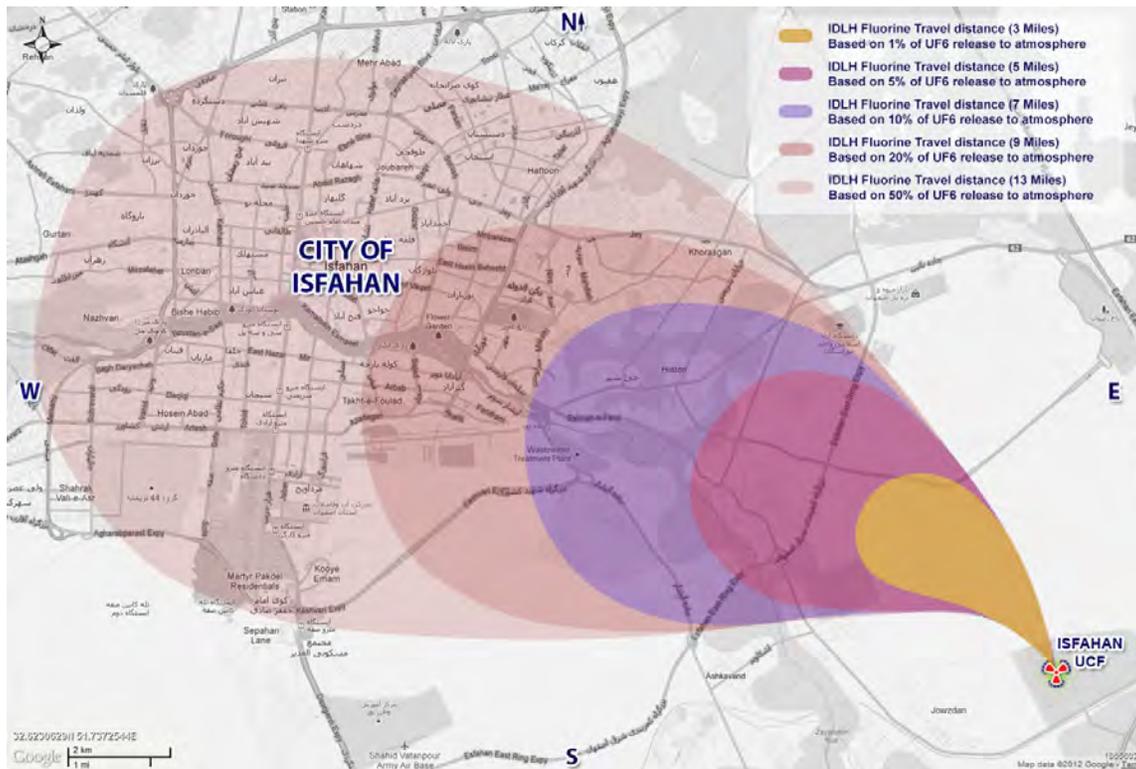


Figure 24: Possible Plume Travel Scenarios Towards Isfahan

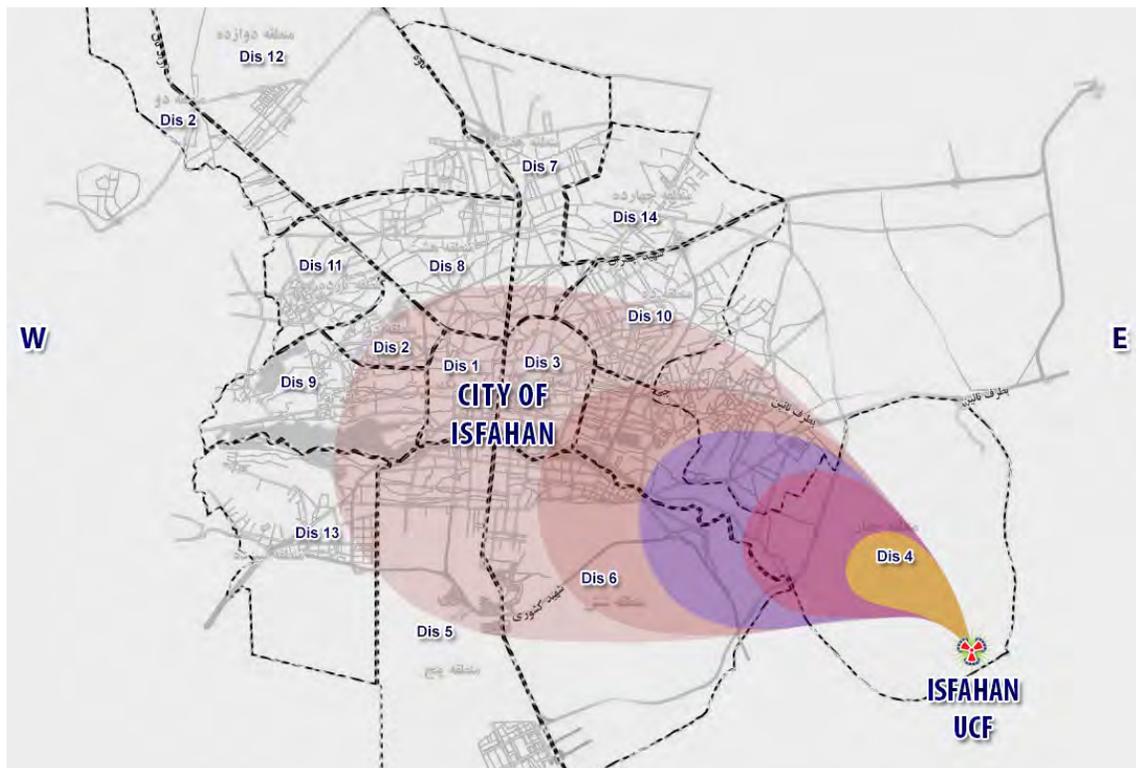


Figure 25: Isfahan Municipality's Districts

The Isfahan plume map (Figures 24 & 25) demonstrates the travel pattern of the IDLH (Immediately Dangerous to Life or Health) plume at 1%, 5%, 10%, 20% and 50% of UF6 releases. Based on our calculations, if there is only a 1% release of UF6 to the atmosphere, this plume will travel approximately 3 miles, covering a surface area of 5 square miles. The resulting poisonous gases may expose some, if not a majority of the 132,000 residents in district 4 to deadly or harmful levels of an IDLH of 25 parts per million (Table 4). If only 5% of the uranium hexafluoride stockpile at the Isfahan facility becomes airborne, the toxic plumes could travel 5 miles with the IDLH level of 25 ppm covering a surface area of 13 square miles. With prevailing wind moving in a westerly direction towards the city for most of the year, this plume could expose some of the 239,000 residents of the Isfahan municipality’s eastern districts, particularly districts 4 and 6. At a 20% release, the IDLH plume will travel 9 miles covering 41 square miles and could expose some of the 352,000 residents in districts 3, 4 and 6, including residents in the region north of district 4, where population figures are unavailable (Table 4). If we assume a 5-20% casualty rate among these populations at a 1%-20% release, we can expect casualties in the range of 5,000-70,000.

District	2006 Population	2011 Estimated Population
1	73,926	74,153
2	56,028	59,834
3	111,816	111,950
4	119,455	132,725
5	144,963	165,272
6	107,871	107,956
7	135,854	166,568
8	205,437	248,782
9	69,321	71,943
10	189,976	215,836
11	56,246	65,230
12	105,312	148,786
13	109,101	125,705
14	139,532	166,670
TOTAL	1,624,838	1,861,410

Table 4: Isfahan District Population (Source: Statistical Center of Iran, Population and Housing Census of 2006)

Radiological

Another consequence of the release of uranium compounds to the environment would be the radiological contamination of soil and water followed by radiation exposures to people. Radiation from these uranium compounds would produce external exposure from alpha rays and internal exposure from inhaled

and ingested materials. A RESRAD⁹⁷ analysis shows that 8.4 grams of uranium deposited per square meter of land surface area poses a radiation exposure of about 1 milliSievert/year (or 100 millirem/year) from all pathways for human radiation exposure. This level is generally considered the maximum allowable increase in dose to the public from surface-deposited uranium materials. The land area that could be contaminated at this level from the release to the environment of 371 tons of UF6 is approximately 11.6 square miles (30 square km) around the facility. This area would be permanently contaminated by uranium and uranium compounds deposited in the soil because of the very long radioactive lifetime for decay of uranium. Furthermore, soluble uranium compounds could permeate into surface and ground water and be dispersed into plants and drinking water. Human exposure to radiation from these uranium compounds will result in increased cancer and birth defects over time. Estimate of total human casualties for such long-term chronic risks is not possible because of the uncertainty in location of surface contamination and future land use.

Military Defense Capabilities

The city of Isfahan lacks the appropriate air defense systems to protect the inhabitants against a sophisticated U.S. or Israeli air assault. Russia’s decision to cancel its deal to supply S-300 ground-to-air missiles to Iran leaves Isfahan largely exposed to U.S. or Israeli military strikes. According to Cordesman, Iran’s Air Defense System “has become largely obsolescent” and Iran “lacks the modern weapons systems, integration and C41 Battle Management”⁹⁸ to reduce the potential destructive effectiveness of any offensive interdiction missions.⁹⁹

Isfahan’s air defense system consists of no more than five F-E and SU-24.¹⁰⁰ There are two HAWK sites and one HQ-2 site in the vicinity of Isfahan. One of the HAWK sites and the S-200 site are located on the grounds of the Isfahan AB, with the HAWK site likely situated to provide point defense of the airbase. The HQ-2 site and the remaining HAWK site are located south of Isfahan proper.¹⁰¹

What this means in practice is that the Islamic Republic has very limited air defense capabilities to shield Isfahan’s nuclear facility.

97 RESRAD is a computer code developed by the U.S. Department of Energy to evaluate human health and ecological risks resulting from residual radioactive and chemical contamination. The RESRAD code has been widely used in the United States and abroad for assessing environmental radiation risks.

98 Note: C41 command, control, computing, communications and intelligence systems are crucial to protection of Iran’s nuclear facilities: Anthony Cordesman and Abdullah Toukan, “Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities,” Center for Strategic and International Studies Report, 14 March 2009, <<http://csis.org/publication/study-possible-israeli-strike-irans-nuclear-development-facilities>>.

99 Arleigh A. Burke and Anthony Cordesman, “Israeli and US Strikes on Iran: A Speculative Analysis,” a Center for Strategic and International Studies study working draft as of 5 March 2007, <http://csis.org/files/media/isis/pubs/070305_iran_Israelius.pdf>.

100 Cordesman and Abdullah Toukan, “Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities,” Center for Strategic and International Studies, 14 March 2009: 77.

101 Sean O’Connor, “Strategic Sam Deployment in Iran,” 2009, <http://www.airsairpower.net/APA-Iran-SAMDeployment.html>; AND “Iran Military Guide,” <<http://www.globalsecurity.org/military/world/iran/index.html>>.

The Iranian air force cannot defend or repel an air strike. The U.S. and Israeli air force can elude Iran's limited early warning systems and, thus, there will not be sufficient time to evacuate the workers, scientists, and engineers at the sites.

Civil Defense and Emergency Response Capabilities

Civil defense and emergency response capabilities are crucial to mitigating casualties in the immediate prelude and aftermath of military attacks. Preparedness, whether in the form of early warning systems, rapid evacuation, timely medical intervention, and basic protective measures can reduce the risks of exposure to toxic plumes and radiation.

Isfahan's civil defense capabilities are among the best in Iran. Isfahan province has been designated as the province that would handle the city of Tehran in the aftermath of a major earthquake. Isfahan Province Crisis Management Council (IPCNC) has the provincial and military logistics, infrastructure, funding and human resources, and thus a higher capacity than most other provinces to respond to emergencies.

Nevertheless, Isfahan lacks the specialized capability needed to cope with the consequences of a military attack on nuclear sites. The total crisis management budget of Isfahan province is around \$20 million.¹⁰² The city of Isfahan's budget for emergency response is \$6 million.¹⁰³ Neither the city nor the province has the experience, resources, logistics, infrastructure, budget, or even emergency response plans, procedures and equipment necessary for detecting or responding to nuclear accidents, let alone to military strikes against nuclear facilities.

Responding to attacks on nuclear facilities requires a high level of planning, coordination, and communication. Securing the sites requires an established command and control structure capable of coordinating military, medical, logistics, and communications aspects of operations. Without that training and preparation, it is highly likely that the first response teams themselves would be exposed to concentrated and dangerous levels of poisonous gases that would be fatal. Yet, there is no evidence that the Iranian government has provided the military, Revolutionary Guards, and local officials with adequate information, funding, equipment, training, and medical resources necessary for detection, evacuation, and treatment of exposed populations and areas surrounding Iran's nuclear facilities.

Medical Capabilities

Strikes would also trigger an immediate and massive medical emergency with casualties in the tens of thousands. Based on the best available information, there are 26 hospitals in Isfahan with about 5,200 hospital beds,¹⁰⁴ many of which are already occupied. These hospitals would in all likelihood be overwhelmed with tens of thousands of casualties in the immediate aftermath of an attack. They would also be

flooded with non-injured people worried about being contaminated by radiation, as was the case after the Goiânia Incident in Brazil when a medical radioactive source containing Cs-137 was opened.¹⁰⁵ There is no evidence that the government at the national or local level has taken the necessary precautions to train, treat, and supply these medical hubs for the specific medical problems of mass exposure to toxic clouds.

Public Awareness

Educating the public about the dangers of radiation and contamination can reduce the risks of exposure in the event of strikes against Iran's nuclear facilities. Although in certain instances, such as Bushehr, the government has sought to relocate local inhabitants or limit development around sites, much more needs to be done to educate the public, particularly those living by the nuclear sites, about defensive measures they can take to protect themselves and their families. These steps include establishing active programs for communicating and protecting civilians: preventing people from swarming around the sites after the strikes, and providing people with timely information about contamination zones, evacuation plans, and safe food and water and building trust in the instructions issued by the government in an emergency.

Remediation Capabilities

Iran's nuclear program is young, and, consequently, there is limited experience with remediation. No technical data is currently available to assess such capability, especially in the case of Isfahan.

Environmental Consequences

Beyond human casualties, the Ayatollah's gamble would degrade the environment and severely damage Isfahan's economy, agriculture, industry and culture. With the high likelihood of soluble uranium compounds permeating into the groundwater, strikes would wreak havoc on Isfahan's environmental resources and agriculture. The Markazi water basin, one of six main catchment areas, which covers half the country (52%), provides slightly less than one-third of Iran's total renewable water (29%) (Figure 26). According to the Food and Agriculture Organization (FAO), the groundwater discharge in the basin from approximately 155,000 wells, 22,000 channels and 13,500 springs is the primary water source for agricultural and residential uses.¹⁰⁶ It is almost certain that the contamination of groundwater as a result of strikes would damage this important fresh-water source.

102 Isfahan budgetary and fiscal information available at <<http://www.hoshdaresf.ir/?id=8445>>(Persian).

103 Ibid.

104 <<http://mihanfa.com/culture-art/introduction-of-hospital/>>, <<http://www.tebyan.net/newindex.aspx?pid=21821>>.

105 Lisa W. Foderaro, "Columbia Scientists Prepare for a Threat: A Dirty Bomb," *New York Times*, 8 July 2010.

106 "Iran water report," Food and Agriculture Organization of the United Nations (report 34), 2009, <<http://www.fao.org/nr/water/aquastat/countries/iran/tables.pdf#tab2>>.



Figure 26: Major basins in Iran (Source: United Nations Food and Agriculture Organization)

Given that Isfahan's nuclear facilities are only 5 km (3.1 miles) away from many existing water wells along the Zayandeh Rud river basin, this uranium could spread quite extensively across miles of urban and industrial hubs as well as arable land along Zayandeh Rud and Isfahan's eastern districts. The introduction of contaminants would have profound ramifications not only for the security and safety of Isfahan's water supply but also for the water and food supply of the entire region, including the rural and agricultural backbone of the province.

Isfahan, like much of the Iranian plateau, is arid and semi-arid, with low precipitation ranging from 0 to 19.6 millimeters per month. Management of its water resources is vital to its economy, agriculture, and urban geography. According to Dr. Habib Borjian, of the 10.7 million hectares of surface area of the province, only 600,000 hectares are arable. In 2002, 535,000 hectares were under cultivation, of which 263,000 hectares were under cultivation for irrigated annual crops, with orchards accounting for 56,000 hectares.¹⁰⁷

Should agricultural products be contaminated, or even be perceived as contaminated though they are safe, as was the case with produce from Fukushima, Japan and Goiânia, Brazil, the region's fruit and vegetable markets would be devastated for years to come.¹⁰⁸ In addition to the major loss from the contamination of agricultural crops, there would also be an impact on orchards and farms, and thus the apples, pears, apricots, and peaches, as well as the quinces and melons that give Isfahan its flavor. Should the river remain dry, as it has been in recent years, then the contamination of the river bed is highly likely, with problems exacerbated once the water flow resumes.

To gain some sense of the scale of the economic damage, it is important to recognize the district of Isfahan proper ranks as the second most important industrialized region in Iran, after Tehran.¹⁰⁹

The distribution of economic and industrial activity in the

107 Habib Borjian, "Isfahan, Modern Economy and Industries," *Encyclopedia Iranica*, Vol. 14, 2007, <<http://www.iranicaonline.org/articles/isfahan-xiv-modern-economy-and-industries>>.

108 L. David Roper & Marco Antônio Sperb Leite, "The Goiânia Radiation Incident: A Failure of Science and Society," *Veneer Magazine*, No. 01/18. See also: John S. Petterson, Ph.D., "From Perception to Reality: The Goiânia Socio-economic Impact Model," *Waste Management Symposia Papers*, 1988: 3

109 Ibid.

province of Isfahan is focused around an 80-km (49.7 miles) radius of the city of Isfahan, where the bulk of the province's industrial agglomerations are located. Tourism would also suffer immensely. In 2010, the total number of domestic tourists to Isfahan was more than 300,000 with more than 50,000 foreign tourists from European, Scandinavian, and Asian countries.¹¹⁰

Once Isfahan is perceived as a contaminated city, and a potential health hazard to visitors, the city would cease attracting tourists. Hundreds of millions of dollars of revenue from tourism would be lost in the wake of strikes.

Cultural and Historic Consequences



Figure 27: Isfahan: Masjed-i Shah (Photo: esential-architecture.com)

Isfahan is one of Iran's cultural and historic jewels. Indeed, the center of the city, built by the Safavid King Shah Abbas, has been designated as a world heritage site by UNESCO.¹¹¹ Justifying the decision to protect Isfahan as a World Heritage site (Figure 27), UNESCO cited the site's authenticity and integrity:

"Monuments, buildings and spaces that constitute this complex might individually be losers in a competition with unique world heritage properties, but are unrivaled in the world as an ensemble! Thus it requires to be included as a World Heritage site in order to make rehabilitation policies and programs realized."¹¹²

In addition to the architectural splendor of its city center, there are more than 20,000 historical and cultural sites in Isfahan. An attack on Iran's nuclear facilities would destroy a city and a tradition that have been integral to Iran's history and heritage for centuries. The city would be covered under a toxic and radioactive shroud that would render it unlivable. The price of such a loss amounts to the stripping away of the Iranian people's historic, religious, and cultural identity.

Instead of opening up Iran to the world so that millions could benefit from the cultural and artistic flowering of Iranian civilization, the Ayatollah's nuclear gamble threatens to transform Isfahan, one of the marvels of human civilization, into a nuclear and chemical wasteland.

110 "Isfahan, tourist figures" available at <<http://www.isfahancht.ir/Fa.aspx?p=5&ai-uid=95091157-5479-4geO-bd51-e7b6d57eOOed>>(Persian).

111 "Historic-Natural Axis of Isfahan City," UNESCO, 2007, <http://whc.unesco.org/en/tentativelists/5176/>.

112 Ibid.

CASE 2: NATANZ



Figure 28: Aerial View of the Natanz Facility (Source: AP/GeoEye Satellite Image)

As the site of Iran’s underground Uranium Enrichment Facility, the Natanz facility (Figure 28) sits at the heart of Iran’s nuclear program. With a capacity eventually to house more than 50,000 centrifuges, it is feared that the Natanz facilities will soon produce enough highly enriched uranium (HEU) for Iran to make dozens of nuclear weapons. Natanz houses a Fuel Enrichment Plant (FEP) for the production of low enriched uranium (LEU) up to 5%, as well as a Pilot Fuel Enrichment Plant (PFEP), which has produced 110 kg of 20% enriched U-235 since February 2010.¹¹³ The Iranian government claims it intends to use the 20% U-235 UF6 to manufacture fuel for the Tehran research reactor; however, others believe that some of this material could be used to produce fuel for reactors that may be further processed for the production of weapons grade plutonium. Thus, much of the fear about Iran’s nuclear program is focused on the operation and efficiency of the centrifuges buried in this plant. The concern is that the material is a strategic stockpile for weapons.

The Natanz facility is located nearly 200 miles south of Tehran (Figure 29). It is one of the most sensitive and most hardened of Iran’s nuclear facilities. The 670,000 square-foot facility is built 8 meters (25.6 feet) deep into the ground, and is encased by a concrete wall that is 2.5 meters (8 feet) thick. That is, in turn, protected by another concrete wall. In 2004, a roof made of several meters of reinforced concrete was added.

Destroying Natanz is not easy. The destruction of this underground facility requires the use of a powerful strike force consisting of GBU-28 bunker busting bombs.¹¹⁴ The on-site casualties will be significant, effectively turning the buried nuclear site into a mass grave for all

113 “Implementation of NPT Safeguards agreement and relevant provisions of the Security Council resolutions in the Islamic Republic of Iran,” IEAE Board of Governors report, 25 May 2012.

114 Anthony Cordesman and Abdullah Toukan, “Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities,” Center for Strategic and International Studies Report, 14 March 2009, <<http://csis.org/publication/study-possible-israeli-strike-irans-nuclear-development-facilities>>.

the people working there. Although the toxic plumes will be as large and lethal as those released in Isfahan, if not more so, the threat from toxic plumes will not be as severe. The facility is not in close proximity to a major urban center, the surrounding area is sparsely populated and the prevailing winds blow away from the cities of Natanz and Kashan (Table 5). However, several small towns such as Baad Rud (14 miles from site with a population 26,000), Abuzeidabad (11 miles with a population about 10,000), Shoja Abad (3 miles with a population of 500) and Komjan (10 miles with a population of 200) could be impacted.

Month	Prevailing Wind Direction	Wind Speed (mi/h)
January	North-East	10.7
February	North-East	13
March	North-East	13
April	North	15.4
May	North	13.9
June	North-East	14.3
July	North-East	14.5
August	North-East	14.8
September	North-East	13.6
October	North-East	12.5
November	South-West	11.4
December	North-East	10.5

Table 5: Prevailing Wind in Natanz (Source: Fourth National Iranian Forum of Energy, 2002)



Figure 29: Natanz, Iran (Map Source: Parsi Times)



Figure 30: Distance: Natanz 28 km, (17.4 miles) Kashan 35 km (21.7 miles)

Human Casualties

An attack on the Natanz nuclear facility, whether it is with the GBU-28 earth-penetrating bunker buster, or repetitive strikes using less powerful weapons, would destroy the facility. Assuming the site employs 2,000 total workers, engineers, scientists, and soldiers working in two shifts, few, if any, of the personnel onsite during an attack would survive. We have estimated approximately 1,000 casualties at the site. Most would be killed as a result of the physical shock from the blast, toxic clouds releases in and around the site, and asphyxiation in a deep underground chamber whose roof, and the earth piled upon it, would collapse on them.

Natanz Toxic Plume Profile

The presence of unknown quantities of uranium hexafluoride at Natanz, up to the total 371 metric tons produced for enrichment at Natanz by the Isfahan Conversion Facility, raises the level of threat to civilians around the facility. As with Isfahan, the force of the blast would disperse these toxic agents into the atmosphere, and the plumes would be carried by prevailing winds. Fortunately, the prevailing wind direction at the Natanz facility are to the Northeast, North and Southwest (Table 5).¹¹⁵ They do not blow in the direction of the city of Natanz and Kashan. Still, about 35,000 people live within a 14-mile radius of the site. The lethal toxic plumes would endanger virtually everyone in their path, and while we do not expect casualties in the tens of thousands, it is reasonable to assume that hundreds of people in the smaller towns and villages would face serious health risks. It is highly likely that the rural inhabitants of this region would not be prepared to respond to the grave medical emergencies they would face.

115 Behyarm Mohammadbagher and Victoria Ezzatian, "Researching wind energy in different geographical locations of Iran for clean power," <http://www.civilica.com/Paper-NEC04-NEC04_027.html>.

While the UF₆ inventory at Natanz is not clear, the Natanz plume map demonstrates the travel pattern of the IDLH plume at a 1%, 5%, 10%, 20% and 50% of UF₆ release scenarios (Figure 31). Based on our calculations, if there is only a 1% release of UF₆ to the atmosphere, this plume will travel approximately 5 miles, covering a surface area 13 square miles. If only 5% of the uranium hexafluoride stockpile at Natanz becomes airborne, the toxic plumes could travel 6 miles with the Immediately Dangerous to Life or Health (IDLH) level of 25 ppm covering a surface area of 18 square miles. If we assume that this toxic plume would reach half the 35,000 people living in Abuzeidabad, Shoja Abad, and Komjan and assume the casualty rate of 5-20%, then we can expect additional civilian casualties in the range of 1,700-7,000 people.

As with Isfahan, the land area that could be contaminated at RESRAD levels from uranium compounds resulting from 10% release of 371 tons of UF₆ is around 3 square kilometers around the facility. This area would be permanently contaminated by uranium and uranium compounds, with attendant health risks. Furthermore, large quantities of the soluble uranium compounds released after the strikes will also permeate into the water table. We have not estimated casualties for such long-term chronic risks.

Military Capabilities

The Natanz facility is as vulnerable to a U.S. or Israeli strategic air campaign as Isfahan. Iran currently has seven active S-200 sites, with one of these firing batteries situated to defend the facilities in and around Isfahan, including the Natanz nuclear facility. The Natanz facility is protected by recently deployed tactical and strategic SAM systems. Natanz is defended by one HQ-2 site, three HAWK sites, one 2K12 battery, and four Tor-ME Telars. These systems were deployed between September 2006 and September 2009. The problem with Iran's strategic SAM deployment is the evident over-reliance on the S-200 system to provide air defense over most of the nation. Yet, according to military experts, Libyan S-200 systems proved completely ineffective against U.S. Navy and the U.S. Air Force strike aircraft in 1986, and the Iranian S-200 would fare no better in a much more challenging contemporary air combat environment.¹¹⁶

The Iranian air force would not be able to mount an adequate defense of the site. Thus, for all practical purposes, Natanz and its surrounding areas are defenseless. They would face one of the most severe bombings in modern history.

Civil Defense Capabilities

In Natanz, local officials and residents have either been kept in the dark, or encouraged to dismiss and discount the price of the Ayatollah's nuclear gamble — severe and sustained bombing with some of the most powerful bunker busters in the US and Israeli military arsenal. Citing the Iran-Iraq war in the 1980s, the mayor, Javad Ali Jamali, told foreign reporters that the municipality did not see the need for setting up a warning system or organizing evacuation drills: "We

116 Sean O'Connor, "Strategic Sam Deployment in Iran," 2009, <http://www.ausairpower.net/APA-Iran-SAMDeployment.html>.

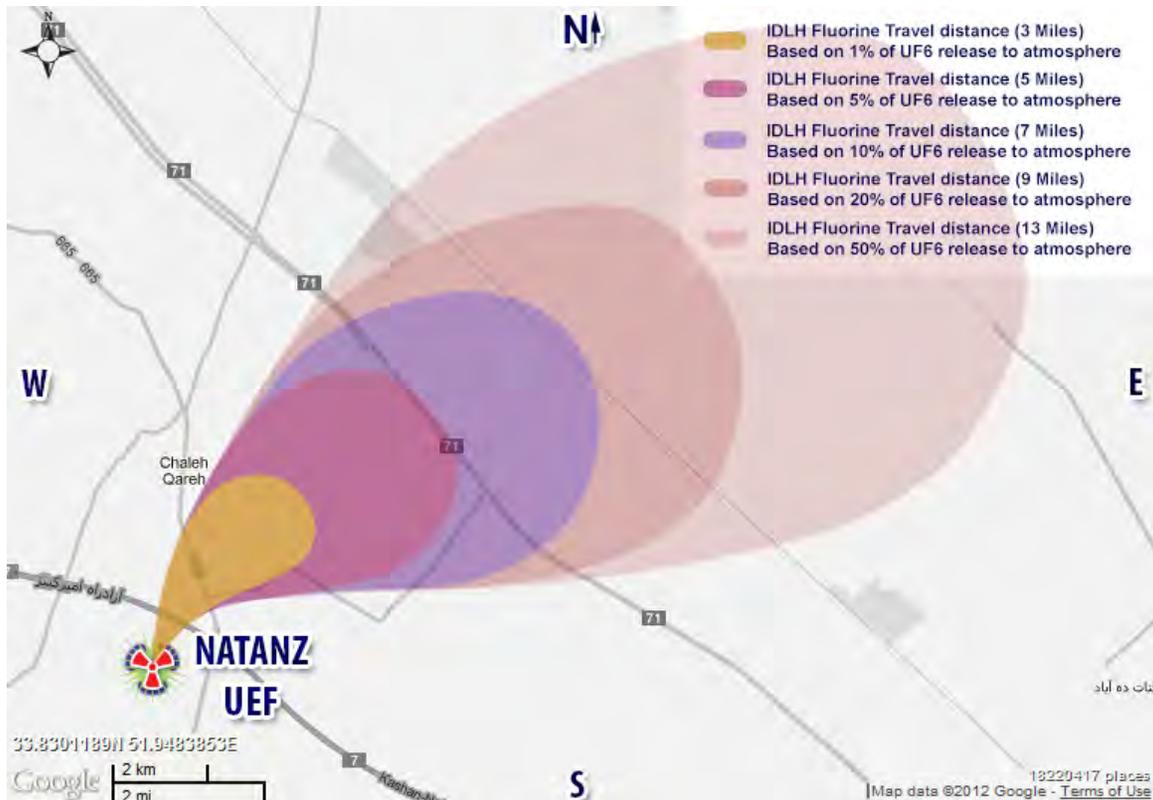


Figure 31: Possible Plume Travel Scenario (Source: Google)

don't need this, we've gone through worse."¹¹⁷ He had not heard of Chernobyl. The local Friday prayer leader, Mohammad Mortazavi, spoke of the economic benefits of the site to the inhabitants. As for a repeat of Chernobyl, he declared, "We're not afraid. Maybe something will happen. We trust in God."¹¹⁸ According to an interview a local shopkeeper gave to *Bloomberg*, until 2002 the residents were told that Natanz was a grain silo, and later that it was an air force base.¹¹⁹ To date, we have not been able to identify information regarding a substantial civil defense capability for the protection of the Natanz facility. Typically, it relies on Isfahan and possibly Kashan. However, since the facilities in Natanz and Isfahan may be attacked simultaneously, responsibility for Natanz might be shifted to Tehran or Qom. Tehran is expected to be more capable in the event of an attack and to have a more comprehensive civil defense capability, but it is more than 100 miles away.

The governor of Natanz is the head of the city's Crisis Management Council and would work closely with Isfahan Province Crisis Management Council (IPCNC). IPCNC is responsible for all emergency responses at provincial level. The Isfahan province governor heads IPCNC and there is a director general of Crisis Management in Isfahan Province. Total crisis management budget of Isfahan Province was more than \$20 million in 2010,¹²⁰ but such levels of funding will be

inadequate for any response or recovery operation involving mass exposure to radiation. Because a nuclear accident in Natanz would expose thousands of people to highly toxic chemicals as well as low-level but long-term radiation, such provincial emergency budgets grossly underestimate the nature of these nuclear emergencies, as well as the associated medical and clean-up costs. Military strikes on the Natanz facility will result in hundreds if not thousands of injuries at and around the site. It would require significant emergency response actions which local authorities are not equipped to handle.

The emergency response, radiation detection, and remediation capabilities in the Natanz area are minimal. As for subsequent clean-up costs related to damaged nuclear sites and the remediation of nuclear waste, a \$20 million budget reveals profound ignorance about the nature and scale of radioactive contamination. Cleaning up the Three Mile Island accident took 12 years and cost \$973 million.¹²¹ Although the cleanup of radioactive materials would primarily be limited to Uranium, the scale and distribution pattern of such an environmental contamination cannot be immediately assessed but would certainly exceed tens of millions of dollars—well above and beyond the existing emergency response budget.

Medical Capabilities

According to our sources, there are two hospitals in Natanz. Managed by Isfahan Medical University, Khatam ol Anbiyah was established in

117 Marc Wolfensberger, "Iranian Nuclear Site Makes Nearby City Boom While Tourists Flee," *Bloomberg*, 16 August 2006.

118 Ibid.

119 Ibid.

120 Islamic Republic News Agency Report news report, available at <www.irna.ir/View/FullStory/?NewsId=721626> (Persian).

121 "Three Mile Island Accident," World Nuclear Association, March 2001, <<http://www.world-nuclear.org/info/inf36.html>>.

1986 and has 50 general beds.¹²² The second, smaller facility, Badrood Hospital, has 21 beds. As with most rural regions, Natanz lacks the emergency medical facilities to treat the scientists and workers suffering from severe blast, thermal and chemical injuries.

Environmental and Economic Consequences

The destruction of the Natanz facility would result in the loss of a multibillion-dollar facility and expensive cleanup and reclamation of radioactive-contaminated soils and water. The contamination of water, land, and air, and thus vegetation and livestock by uranium compounds would pose an adverse health risk, particularly to pregnant women and children in the Natanz rural region. The impact on the gene pool of humans, as well as other animals and species could be of major concern.

In Natanz, three seasonal rivers start from Karkas Mountain. Hanjan River is the closest river to Natanz enrichment facility, about 3 km (1.8 miles) to the south. It moves east toward Badrood and is 20 km (12.4 miles) long. Other rivers which originate from the Karkas Mountain are Avareh and Tamehe. Both are about 4 km (2.5 miles) to the south of Hanjan River and about 7-8 km (4.3-4.9 miles) from Natanz Nuclear Facility. They extend about 50 km (31.05 miles) to the east and end at Dagh Shorkh, a lake in the desert near the town of Ardestan. If any of these rivers gets contaminated with radioactive materials—which is highly likely—contamination can spread downstream, affecting drinking water as well as irrigation networks.

Natanz and its surrounding areas are not major urban or industrial hubs. They are well-known for gardening, agriculture, carpet making, pottery, tourism, metal factories, mining, and some industrial units. Sixty-five industrial units are located in Natanz.¹²³ Kashan and surrounding small towns and villages are well-known for carpet making and weaving, agriculture, mining, pottery, tourism, metal production, ornamental stones, and chinaware factories.¹²⁴ The potential impact on the economy of Natanz and Kashan, neither of which are in the path of the immediate toxic plumes, comes from the potential environmental contamination of the region. The demographic impact can also be significant as it may result in the possible displacement of thousands from the villages and rural towns near the site.

122 <<http://mihanfa.com/culture-art/introduction-of-hospital/>>, <<http://www.tebyan.net/newindex.aspx?pid=21821>>.

123 "Active Industrial Units of the city of Natanz," <<http://www.natanz.gov.ir/Default.aspx?tabid=1149>> (Persian).

124 "Kashan," <<http://persia.org/imagemap/kashan.html>>.

CASE 3: ARAK



Figure 32: Arak Nuclear Facility (Source: Reuters)

The nuclear facilities at Arak house two nuclear programs: an operational heavy water production plant and a 40 MW heavy water nuclear reactor facility, which is still in development and is not expected to come online until the third quarter of 2013, according to the IAEA.¹²⁵ The 40 MW Heavy Water Reactor at Arak has been compared to Israel’s Dimona Nuclear Plant, and, according to the Institute for Science and International Security, will be capable of producing 9 kilograms of plutonium annually, or enough for two nuclear weapons each year when operational.¹²⁶ The United States and Israel allege that contrary to Iran’s claim that the Heavy Water Research Reactor is operated for peaceful purposes, Iran really intends to develop an alternate methodology for the manufacturing of nuclear weapons using Plutonium-239 instead of an enriched Uranium-235 based device.

In many ways, production of PU-239 is much less complex than highly-enriched U-235. Naturally produced U-238 is radiated with neutrons and PU-239 can be obtained through the following steps:

- A. U-238 + Neutron → U-239
- B. U-239 decay to Ne-239
- C. Ne-239 after alpha emission decay → PU-239

Although production of PU-239 is simpler than highly-enriched PU-235, the more sophisticated implosion detonation devices needed for a Plutonium-239-based weapon will be significantly more challenging than simpler gunshot assembly used for a highly-enriched U-235-based weapon.

Unlike Isfahan and Natanz, with Arak, the primary threat is from the release of fission products and other radioactive products. If strikes take place after the reactor is operational, the destruction

of the reactor pressure vessel or spent fuel could lead to the release of dangerous quantities of Iodine-131, Strontium-90, Cesium-137, and Plutonium-239.

Human Casualties

An attack before the reactor becomes operational would kill most of the 500 employees at the site but it would not pose significant risks to the population centers around the site. However, once the reactor becomes operational, an attack would expose Khondab, a town of 72,000 residents less than 3.5 km (2 miles) from the facility, to large quantities of radioactive material (Figure 34). In such a scenario, potential casualties at Khondab could be in the thousands. In addition to Khondab, there are approximately 27 villages with more than 60,000 inhabitants living in a 10 km (6.2 miles) radius of the plant. These villages would almost certainly be within the range of the radioactive fallout. Therefore, the number of human casualties may vary between 500 to 3,600, assuming additional exposure and a casualty rate of 5% of the population of neighboring villages close to the facility. The city of Arak, with a population of 600,000 inhabitants, is about 50 km (31 miles) southeast of the facility (Figure 34). Prevailing winds in the area trend in a westerly direction away from Arak (Table 6).¹²⁷

Season	Prevailing Wind Direction
Spring	South-West, West
Summer	South-West, West
Fall	West, South-West
Winter	West, South-West

Table 6: Prevailing Winds of Arak (Source: Arak Government.)

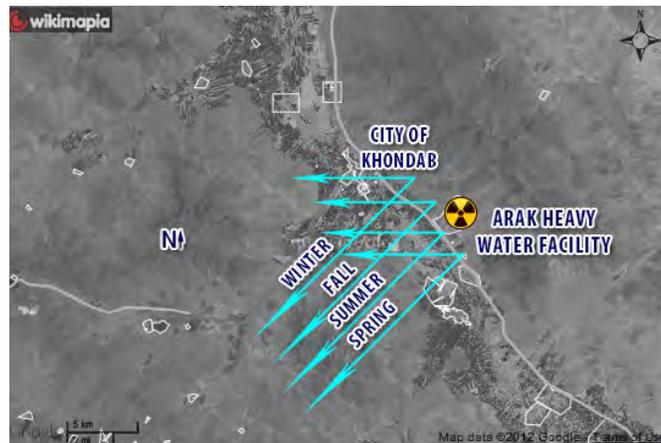


Figure 33: Possible Toxic Release Scenario (Map source: Wikimapia, TerraMetrics)

Civil Defense Capabilities

Arak’s civil defense capabilities are poor. The Markazi Province Crisis Management Council (MPCNC) is responsible for all emergency

125 “Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran,” IAEA Board of Governors report, 11 November 2011.

126 “Nuclear Iran,” Institute for Science and International Security, <<http://www.isisnucleariran.org/sites/facilities/arak-ir-40/>>.

127 “Information Technology Center Post Company of Iran,” <<http://www.arak.post.ir/HomePage.aspx?TabID=10150&Site=arak.post&Lang=fa-IR>>.

responses at the provincial level. In 2011, the budget of emergency response and disaster mitigation was set about \$6 million, a nominal sum for a disaster-prone province.¹²⁸

According to reliable sources, there is a heightened awareness of defense and security concerns arising from a potential strike against the Arak facility. The town of Khandab was approved for coordinating civil defense by the Political and Defense Commission of Government in 2009.¹²⁹ At the town level, the mayor of Khondab is the head of the Crisis Management Task Force. Security issues are addressed by the Security Committee, which consists of members from the intelligence agencies, police, the Revolutionary Guard and the heads of some civil organizations. The town suffers from a lack of funds and has a limited capacity in terms of responding to emergencies. Despite frequent Sky Guard drills, the facility cannot be shielded against a U.S. or Israeli military strike.¹³⁰ The total number of hospital beds in Arak is reported to be 1,033.¹³¹



Figure 34: Arak Heavy Water Plant Distance to City of Arak : 50 km (31 miles) (Map source: Wikimapia, TerraMetrics)

Environmental Consequences

If the Arak facility is bombed before it becomes operational, the environmental effects would be limited. However, once operational, the environmental threat becomes severe. Radioactive contamination resulting from the spread of fissile products (iodine-131, strontium-90, cesium-137, cesium-134, and, in certain cases, plutonium-239) will pose a threat to the soil and water surrounding the plant. Arak nuclear facility is very close to one of the main sources of Ghareh Chaye River, one of the major rivers in central Iran. After crossing the industrialized city of Saveh, the river flows into the Salt Lake of Qom, 100 km (62 miles) south of Tehran. It is important to note that the Arak facility is located on the northern edge of the Markazi

aquifer, which supplies drinking water as well as underground water for agricultural production throughout the region. Some 90.75% of the underground water of Markazi province is used for agricultural production, while 4.75% is used for drinking and the remaining 4.5% is used for industrial production.

Economic Consequences

Arak is a well-known industrial hub in Iran with 25 factories in the field of machinery, metals, food, tires, and others, employing a considerable number of workers. It is part of the Markazi Province, comprised of 2,650 industrial units and 320 mining units.¹³²

At present, exports include a range of products such as machines, metal, electronics, food and health products, cements, and glass. In 2010, this province managed to export \$562 million USD to foreign markets. The short-term consequences of military strikes include closed factories, impaired local businesses, unemployment, and experts who abandon the facilities. In the long term, military strikes would damage the export of industrial products from the region.

128 MPCNC information available at <http://www.ostan-mr.ir/index.php?option=com_content&task=view&id=473&Itemid=510> (Persian).

129 Khandab information available at <http://fa.wikipedia.org/wiki/%D8%A8%D8%AE%D8%B4_%D8%AE%D9%86%D8%AF%D8%A7%D8%A8>(Persian).

130 "Heavy Water Plant of KHANDAB is awaiting investment," <<http://www.ravy.ir/content4638033.html>> (Persian).

131 <<http://www.tebyan.net/newindex.aspx?pid=38129>>.

132 "Industries and Mines Organization of the Central Province," <<http://markazi.mim.gov.ir/index.php?name=news&file=article&sid=40925&archive=1>>.

CASE 4: BUSHEHR



Figure 35: Bushehr power plant (Source: AP)

Although the chances of a military strike against Bushehr are low, the potential human, environmental and economic tragedy unleashed by such an assault make Bushehr the most dangerous of Iran's nuclear facilities. While in the case of Isfahan, the primary risk comes from the exposure of hundreds of thousands of civilians to toxic chemical plumes, in the case of Bushehr, the nuclear gamble threatens to expose millions to radioactive fallout. Strikes against Bushehr would have profound international ramifications, as, in addition to Iranian casualties at and around the site, virtually all the countries in the Persian Gulf region, particularly the smaller Persian Gulf states, would face a major threat to their national security, economic viability and longevity as states. Given the presence of Russian personnel at the site, an attack on the plant would also mean risking a confrontation with Russia.

The reason most experts consider a strike on Bushehr as highly unlikely is that the plant's primary function is to generate electricity. Iran claims it has an agreement with Russia to collect and reprocess spent fuel from the facility, which some experts have said makes Bushehr less of a proliferation threat.¹³³

What makes it a potential target is the possibility that Iran would renege and fuel from the plant could be diverted for the separation of plutonium from irradiated fuel. This process is slow and requires several years or much more frequent refueling cycles which can be easily detected by the Russians and the IAEA. The timeline for Iran producing a plutonium weapon has been placed at no earlier than 2015 and perhaps beyond. This May, the plant was reported to be operating at 75% capacity and was expected to reach full capacity soon thereafter.¹³⁴

133 Ariel Zurulnick, "Iran nuclear program: 5 key sites," *Christian Science Monitor*, <<http://www.csmonitor.com/World/Middle-East/2011/1117/Iran-nuclear-program-5-key-sites/Bushehr-nuclear-power-plant>>.

134 "Iran's Bushehr nuke power plant nears full capacity," *Xinhua*, 4 May 2012, <<http://english.peopledaily.com.cn/90777/7807636.html>>.



Figure 36: Bushehr Nuclear Power Plant (Map source: Iranmap.com)

History of the Site

Bushehr is not an ordinary nuclear power plant. It is a nuclear experiment. Originally, Iran and Germany planned a joint venture to build two pressurized water reactors subcontracted to ThyssenKruppAG based on the design of the German Biblis Nuclear Power Plant. The construction of the first reactor at Bushehr that began in 1971 was scheduled for completion in 1980 and the second, in 1981. It was abandoned after the revolution of 1979 and damaged during the Iran-Iraq war in the 1980s. For much of those years, the plant was frozen in time, subjected to an embargo that left Iran with no access to German expertise and documentation concerning over 80,000 random pieces of equipment and spare parts, many of which were exposed to a hot and humid climate.

The challenge of salvaging Iran's white elephant on the Persian Gulf fell upon the Russians, at a cost to the Iranian citizens of 10 billion dollars. In 1995, Iran signed a contract with Russia's Ministry for Atomic Energy to revive the plant by installing the V-320 915 MW(e) VVER 1000 pressurized water reactor. The project was scheduled for completion in 2001, and then in September 2007. Finally, on August 21, 2010, at a ceremony with his Iranian counterparts, the chief of Russia's Rosatom state agency, former Soviet Prime Minister Sergei Kirienko, marked the official opening of the Bushehr nuclear plant with the transfer of enriched uranium from a fuel rod to the plant.

In February 2011, Russia was forced to shut down the plant to "thoroughly clean the reactor core and the primary cooling system to remove metal shards left by the cooling pump failure." The failure was blamed on German cooling pumps dating back to the 1970s. Russia's Ambassador to Iran stated that the delay was necessary since it is better "to prevent unwanted consequences rather than to regret it later," which Iranian state radio confirmed.

In a joint press conference held on February 26, 2009, Reza Aghazadeh, then head of the Atomic Energy Organization of Iran, blamed

the delays on the design anomalies at Bushehr: “24% of the parts and equipment used at the Bushehr power plant are German, 36% Iranian, and 40% Russian.”¹³⁵ Kirienko agreed. As he put it, “Until now, no one has succeeded in operationalizing such a plant, and, actually completing the Bushehr nuclear plant is not the same as constructing a new plant but rather it is completing a plant that has been constructed by a company from another company and consequently, we have had to make extremely important technical decisions about it.”¹³⁶ When pressed to explain a decade of delays, Kirienko could not resist a dig at his Iranian counterparts: “Of course, it is 35 years past the deadline.”

In a report released by the IAEA in November 2011, the agency reported that the reactor at Bushehr is operational; however, information regarding its electrical production was unavailable. Finally, in May 2012, Rosatom announced that it had conducted a test on May 1, and that the power plant had successfully generated electricity at 90% of its capacity.¹³⁷ The head of the Atomic Energy Organization of Iran (AEOI) Fereidoun Abbasi, announced that the plant had produced 730 MW of electricity since February and the Mohammad Hossein Jahanbakhsh, Governor-General of the province declared that “the Russian contractor will definitely deliver the power plant to the Iranian side by the end of autumn [2012].”¹³⁸

Human Casualty Estimates

Most immediate casualties would occur among the Bushehr plant workers and people close by. We estimate the total number of workers at the site at between 2,000-3,000 people, plus their families. The number of Russian advisors at the site was estimated at 1,500¹³⁹ with another 500 Iranian personnel.¹⁴⁰ Additional casualties will occur in the two villages of Bandargah and Helileh, which are next to the site and have a combined population of 4,500 inhabitants in 1,100 households.¹⁴¹ In recent years, the government has tried to relocate the people of Bandargah and Helileh, but faced considerable resistance.¹⁴²

135 “ASR-Iran News Analysis,” <<http://www.asriran.com/fa/pages/?cid=66101>> (Persian).

136 Ibid.

137 “Russian Contractor: Bushehr N. Power Plant to Reach Full Capacity in May,” Fars News Agency, 4 May 2012, <<http://english.farsnews.com/newstext.php?nn=9102110533>>.

138 Ibid.

139 “Moscow: The number of workers at Bushehr facilities will double,” Islamic Republic News Agency, <<http://www2.irna.com/ar/news/view/line-8/8611269045074856.htm>> (Persian).

140 John C.K. Daly, “Iranian Bushehr Nuclear Plant Comes Online,” Stock Market Review, <http://www.stockmarketreview.com/extras/iranian_bushehr_nuclear_plant_comes_online_world_survives_20110916_162652/>.

141 Bushehr geographical and census information available at <<http://www.nasir-bushehr.com/Journal-01-issue140-3964.html>>(Persian). This newspaper and its website were created by the Iranian government in late 2011.

142 Note: Ahmadinejad announced in his last visit to Bushehr Province that the people of these two places should be relocated as part of the Bushehr Nuclear Power Plant development plan. Subsequently, the Bushehr governor banned the movement of certain construction material to Bandargah and Helileh. This subject was approved in a visit of the Iran government headed by Ahmadinejad to Bushehr province in 2006 and mentioned on president.ir website (<<http://www.president.ir/fa/?ArtID=8151>>). The head of Iran Atomic Energy Organization announced in an interview that this is part of Bushehr power plant development plan and was also approved in National Security Council.

To complicate matters, the location of the plant next to the sea limits site access to one road.

Beyond the immediate casualties, several factors make Bushehr particularly dangerous. The site is 10 km (6.2 miles) south-east of Bushehr, a city with a population of more than 240,000 people (Figure 37). The prevailing winds in the area blow predominantly to the North-West in the direction of the city of Bushehr (Table 7). An attack on the facility would result in the release of large quantities of fission products including iodine-131, strontium-90, and cesium-137 which, due to their heavy concentration, could easily engulf the city. Recognizing that radioactive material outside the plant operating area is less likely to have acute health consequences, even if only 1-5% of the population is exposed to significant radiation levels, 2,400 to 12,000 people could suffer from chronic effects such as those witnessed in the aftermath of Chernobyl. Given the proximity of Bandargah and Helileh, the casualty rates from the effect of bombing and exposure to radiation can exceed 50%. Further, as with Pripjat, the Russian city evacuated after Chernobyl, Bushehr would become uninhabitable for many decades into the future.

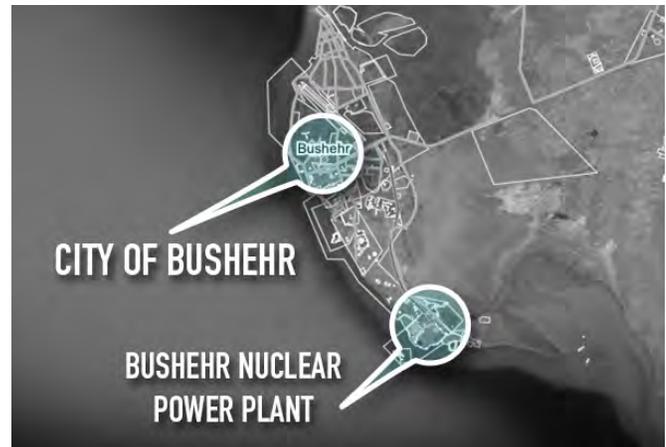


Figure 37: Bushehr Nuclear Power Plant distant. Distance to Bushehr City 10 miles (Map source: Wikimapia, TerraMetrics)

Station Name	Yearly Average Wind Direction	Max. Wind Speed (mi/h)
Bushehr Synoptic Station	N	34
Jam Synoptic Station	SW	31
Borazjan Synoptic Station	W	29
Khark Island Synoptic Station	N	38
Chahkootah Synoptic Station	NW	27
Asalooyeh Synoptic Station	NW-SW	34

Table 7: Wind speed and direction in the vicinity of the Bushehr Nuclear Power Plant (Source: I.R. of Iran Meteorological Organization)

Although they did not focus on Bushehr as a likely target, in “A Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities” published by the Center for Strategic and International Studies (CSIS) in March 2009, Anthony H. Cordesman and Abdullah Toukan predicted the highest level of environmental damage would come from an attack on the Bushehr Nuclear Plant.¹⁴³ They estimate the damage from an attack on an operational nuclear facility can cause casualties in the hundreds of thousands. Drawing on Bennett Ramberg’s “Destruction of Nuclear Facilities in War,” they point out that the release of highly radioactive actinide and uranium fuel fission products resulting from the fission process would lead to the release of iodine-131, strontium-90, cesium-137, and activation production material, plutonium-239, all of which are “most damaging to human health” since they attack critical organs such as the lungs, thyroid, bones, tissues, organs, and cells.¹⁴⁴ In fact, according to this study, more than 300 radioisotopes can be released into the environment, over 40 of which are produced in abundance and have a significant half-life. These radioactive particles can contaminate the body through clothing and skin, or through wounds. They can be inhaled as dust, or ingested through food and water. Once released, it is very hard to contain their damage as they can have a “physical half-life ranging from eight days to 24,400 years, and a biological half-life ranging from 138 to 500 days.”¹⁴⁵

As the CSIS study warns, “Any strike on the Bushehr Nuclear Reactor will cause the immediate death of thousands of people living in or adjacent to the site, and thousands of subsequent cancer deaths or even up to hundreds of thousands depending on the population density along the contamination plume.”¹⁴⁶

The major Iranian city closest to the site after Bushehr is Shiraz (pop. 1,500,000) to the northeast of the power plant. However, the prevailing winds could carry this radioactive material in the opposite direction across the Persian Gulf to contaminate Iraq, Kuwait, Bahrain and other countries along the southern coast (Figure 36). Virtually all population centers in the Persian Gulf, including Kuwait, Bahrain, Qatar, and the United Arab Emirates would be at risk. As noted earlier, a 2007 study published by the U.S. Army War College warned that attacks on Bushehr would likely result in catastrophic regional environmental consequences, including the contamination of the majority of the water desalination plants in Saudi Arabia, Kuwait and the United Arab Emirates, which account for more than half of the world’s water desalination capacity.¹⁴⁷

143 Anthony Cordesman and Abdullah Toukan, “Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities,” Center for Strategic and International Studies Report, 14 March 2009, <<http://csis.org/publication/study-possible-israeli-strike-irans-nuclear-development-facilities>>.

144 Bennett Ramberg, “Destruction of Nuclear Facilities in War,” Lexington Books: 3, as quoted in Toukan, et al., “Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities,” Center for Strategic and International Studies, 14 March 2009.

145 Ibid.

146 Anthony Cordesman and Abdullah Toukan, “Study on a Possible Israeli Strike on Iran’s Nuclear Development Facilities,” Center for Strategic and International Studies Report, 14 March 2009, <<http://csis.org/publication/study-possible-israeli-strike-irans-nuclear-development-facilities>>.

147 Col. Salem Al Jaber, “Implications on the Gulf States of Any American Military Operation Against Iran,” U.S. Army War College: 30 March 2007.

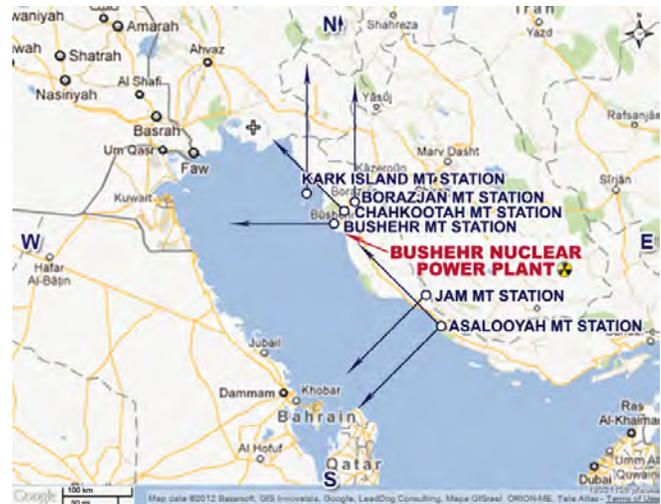


Figure 38: Direction of prevailing wind in the vicinity of the Bushehr Nuclear Power Plant (Map source: Wikimapia, TerraMetrics)

Civil Defense Capabilities

A military strike on the Bushehr nuclear facility would trigger a catastrophe on a scale that would overwhelm the civil defense capabilities of the most advanced industrial countries, let alone the Islamic Republic of Iran. Iran simply lacks the civil defense capabilities and emergency response plans to respond to a tragedy similar to Chernobyl or Fukushima. The Bushehr Province Crisis Management Council (BPCNC) is responsible for all emergency responses at the provincial level. In the event of major disasters, Fars Province would be called on for support.¹⁴⁸ Still, the total emergency response budget of Bushehr province is less than \$10 million, excluding the drought response budget.¹⁴⁹ As for medical facilities, there are four hospitals in Bushehr with 520 total beds:¹⁵⁰ Fatemeh Zahra, Amir al Momenin Hospital, Hospital of Air Force, and Salman e Farsi, the general hospital of the Welfare Organization. None can cope with radiation-related injuries.

Environmental and Economic Consequences

The destruction of the nuclear facility can lead to the contamination of the Persian Gulf and the Gulf of Oman water basin, which covers one-fourth of the country but accounts for nearly half of its renewable water resources. Approximately 97,000 wells, 4,000 channels, and 13,500 springs discharge 26.39 km³ (16.38 miles) per year of groundwater in this major sub-basin.¹⁵¹ Though not a major industrial hub, this

148 Note: Mohammad Hussein Jahanbakhsh, Bushehr province governor is head of BPCNC. He is an experienced manager, but never had experience before his appointment last January with Bushehr Province. He was governor of North Khorasan Province in the past. The same problem exists in other main administrative and response organizations. High turnover of managers, poor performance and lack of budget and resources have made its response system inefficient and incapable.

149 Planning Deputy of Bushehr County, <<http://ostb.ir/?part=news&inc=news&id=2120>>.

150 <<http://www.tebyan.net/mobile.aspx/index.aspx?pid=21824>>.

151 “Iran water report” Food and Agriculture Organization of the United Nations (report 34), 2009.

province is one of the main producers of dates and oranges in Iran, as well as limited beef and lamb production.¹⁵² Fisheries also have an important role in the economy, with production of 50,000 tons (56,000 U.S. tons) of fish and shrimp in Bushehr province annually.¹⁵³ Given the province's heavy reliance on agriculture, husbandry, and fisheries, the contamination of water and soil can have a profound impact on the food supply, local economy, and health of the local population.

Bushehr is also one of Iran's main ports, its capacity about 5 million tons (5.6 million U.S. tons) with offloading/loading non-oil products of 200,000 tons (224,000 U.S. tons) per month and offloading/loading oil products about 130,000 tons (145,600 US tons) each month.¹⁵⁴ Ship, vessel, and marine industrial factories, weaving, pottery, gas, petrochemical, and oil are also other main industrial activities of the province. The destruction of the Bushehr facility and contamination of the port facility would be a serious setback to domestic industries and foreign exports.

The Bushehr facility also strengthens local markets. Destroying the plant would result in the loss of a multibillion-dollar facility and expensive cleanup and reclamation of radioactive-contaminated soils and water.

152 Agriculture Organization of Bushehr, <http://www.sjkob.ir/index.php?option=com_content&view=article&id=70:22000-&catid=42:1389-02-04-04-20-52&Itemid=110>(Persian).

153 Agriculture Organization of Bushehr, <<http://khzshilat.ir/page.php?49>>.

154 "Bushehr Port Special Economic Zone," <<http://bushehrport.pmo.ir/introduction-portataglace-facilities-fa.html>>(Persian).

VI. HUMAN CASUALTIES

“One can categorize the casualties from military strikes against Iran’s nuclear facilities into three groups of victims. The first group would be those exposed to the physical and thermal impact of the blasts. The second group would be those exposed to the chemical consequences of the military strikes, primarily due to release of lethal chemical compounds, toxic plumes and dusts. A third group would be those exposed to the radiological consequences of military strikes, more specifically, should operational nuclear reactors be targeted.”

CIVILIAN CASUALTIES



Figure 39: Chernobyl Victims after thyroid cancer surgery (Photo: Gerd Ludwig, National Geographic)

Isfahan:

The probability of an attack on the Isfahan Uranium Conversion Facility is high. Among the 2,000 workers we estimate 1,000 casualties resulting from a military strike. In addition, the casualties resulting from exposure to toxic plumes could range between 5,000-70,000.

Natanz:

The probability of an attack on a Natanz is high. With 2,000 total workers onsite, we estimate 1,000 casualties resulting from a strike. In addition, the casualties from toxic plumes in the Natanz rural region could range between 1,700-7,000 people.

Arak:

The likelihood of an attack against this facility is high. We estimate 500 onsite casualties. Additional casualties would be of serious concern

should and if the Heavy Water Reactor becomes operational for an extended length of time prior to strikes. Such events would result in the release of fissile and transuranic materials with both short-term and chronic radiation complications effecting Khondab, the small town with 72,000 residents within 3.4 km of the site. We estimate casualties from exposure to radiation at between 500 and 3,600 people.

Bushehr:

We predict 3,000 casualties at the site in the event of an attack. With prevailing winds in the area blowing Northwest toward Bushehr, a city with a population of 240,000 just 10 km away, an attack against the Bushehr nuclear power plant could potentially expose this population to dangerous radiation pollution. If only 1-5% of the population of Bushehr get exposed to radiation, the casualties can range between 2,400 to 12,000 people.

Beyond Iran, strikes against Bushehr could potentially wreak havoc on the Arabian side of the Persian Gulf coast, where countries like Kuwait, Saudi Arabia and the United Arab Emirates rely heavily on sea water desalination, a process extremely susceptible to and unprotected against radiation pollution.

Totals: Physical, Chemical and Radiological Exposures

5,500 people would be killed or injured from the direct impact of the bombing of the four sites.

5,000 to 70,000 people in Natanz and Isfahan could be killed or injured as a result of exposure to toxic plumes.

3,000 to 15,000 people in Bushehr and Arak, after the heavy water reactor is operational, could be killed or injured as a result of exposure to radiation.

Total Casualties:

Total casualties at all four sites could range from 5,500 to 85,000.

Other Casualties: Beyond casualty rates among those close to specific nuclear sites, there are professions and populations that would be particularly vulnerable in the event of military strikes. Although we have not included them in our estimates, these groups deserve as much consideration as the inhabitants of Isfahan, Natanz, Arak, and Bushehr, since they will assume a disproportionate share of the risks associated with the destruction of Iran's nuclear program.

MILITARY PERSONNEL

As with the Iran-Iraq war, it is almost certain that a high percentage of soldiers near these highly contaminated combat zones will develop symptoms from exposure to the cocktail of complex toxins and radioactive agents released from the smoldering sites. Although the Iranian government has not published any estimates on the impact of nuclear attacks on Iran's nuclear sites on the military or developed the medical infrastructure to treat soldiers in the aftermath of exposure to what amounts to nuclear folly, it is certain that casualty rates among Iran's armed forces and Revolutionary Guards will be exceptionally high. As with the veterans of the Iran-Iraq war, the Arab-Israeli wars, and the Gulf wars, it is soldiers who will absorb the brunt of any attack on Iran's nuclear sites as well as the burden of civil defense, while policymakers gamble with their lives from safe bunkers.



Figure 40: Iran-Iraq War: Victim of Chemical Warfare (Photo: www.iranvision.com)

Even in situations where there is a great level of protection, casualty rates among soldiers and first responders can be exceptionally high. For example, according to the U.S. Department of Veterans Affairs, at least one-fourth of the 697,000 veterans who served in the Gulf War suffer from a complex of concurrent symptoms. These range from persistent memory and concentration problems to chronic headaches, widespread pain, gastrointestinal problems, and other abnormalities that have persisted for 17 years.¹⁵⁵ This should come as no surprise to Iranians, as many veterans and their families continue to suffer from the health effects and social and financial costs of the Iran-Iraq war more than 20 years later. One can assume an equally high percentage of Iranian soldiers near these highly contaminated combat zones will develop symptoms from chemical exposures. For

155 "Gulf War Illness and the Health of Gulf War Veterans: Scientific Findings and Recommendations," Research Advisory Committee on Gulf War Veterans' Illnesses, November 2008.

the purposes of this study we have restricted our focus on damage to civilians, and have not attempted any estimates of the damage to Iranian, American, or Israeli armed forces.

RESCUE AND RECOVERY WORKERS

One can expect a disproportionately high level of exposure to radiation and other chemical toxins among soldiers sent into the nuclear sites to rescue, contain, seal, and recover the sacrificial zone. It is highly unlikely that the soldiers dispatched to secure the sites would have the specialized training, equipment, leadership, and coordination for nuclear disaster management. Rescue and recovery workers are the first to arrive at the scene of an attack and the last to leave it. Even absent a radiological threat, exposure to dust from a conventional attack can put their health in jeopardy. One does not need to look far to understand the threat. The 2010 annual report on 9/11-related health by the World Trade Center Medical Working Group of New York City documents the health impact the 2001 terrorist attack on the Twin Towers had on rescue and recovery workers. The group's review of nearly 250 studies published from 2001-2010 found that "thousands of individuals—including rescue, recovery, and clean-up workers and people who lived, worked or went to school in Lower Manhattan on 9/11—have developed chronic, and often co-occurring mental and physical health conditions."¹⁵⁶ A study of 12,781 New York fire department employees present at the World Trade Center from September 11-24, 2001, found that 18% of firefighters had lung problems in the first year after the 2001 attacks and 13% continued to have lung problems seven years after the attacks.¹⁵⁷ According to Philip Landrigan, dean of Global Health at Mount Sinai Medical School, their lungs aged 12 years from one week of exposure to the dust cloud.¹⁵⁸

The Zadroga 9/11 Health and Compensation Act covering health care costs for 9/11 rescue workers called for the provision of \$3.2 billion dollars over eight years to monitor and treat injuries stemming from exposure to toxic dust and debris at ground zero.¹⁵⁹ A major study conducted by the Mount Sinai Hospital World Trade Center and Screening Program, the largest of its kind, found that the 40,000 Ground Zero workers exposed to toxic dust following the al-Qaeda strikes on the Twin Towers were exposed to health problems that were "more widespread and persistent than previously thought" and "likely to linger into the future."¹⁶⁰ The study found that roughly 70% of the nearly 10,000 workers tested from 2002 to 2004 reported new or

156 "2010 Annual Report on 9/11 Health," World Trade Center Medical Working Group of New York City: 3, September 2010.

157 T.K. Aldrich, et al., "Lung Function in Rescue Workers at the World Trade Center," *New England Journal of Medicine* 362 (14):1263-1272.

158 "Nine Years Later: Health Effects in World Trade Center Responders, with Philip Landrigan, dean of Global Health at Mt. Sinai Medical School," *Environmental Health Perspectives*, 1 September 2010, <<http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.trp090110>>.

159 Raymond Hernandez, "House Passes 9/11 Health Care Bill," *New York Times*, 29 September 2010. Note: The bill also set up \$4.2 billion dollars to reopen the Sept. 11 Victim Compensation Fund to provide compensation for any job and economic losses.

160 Anthony De Palma, "Illness Persisting in 9/11 Workers, Big Study Finds," *The New York Times*, 6 September 2006.

substantially worsened respiratory problems while or after working at ground zero.¹⁶¹ Dr. Phillip J. Landrigan, an author of the Mount Sinai study, said that “the toxic nature of the World Trade Center dust had led doctors to conclude that there would be serious health issues for years to come, especially for workers who were exposed to the heaviest concentration in the early days of the terrorist attacks.”¹⁶² According to Landrigan, “this was extremely toxic dust” and “samples had shown it to be as caustic as drain cleaner, with innumerable shards of glass, which could get lodged in the lungs, and a stew of toxic and carcinogenic substances, like asbestos and dioxin, that could cause cancer years from now.”¹⁶³

Earth-penetrating bunker-buster bombs designed to pierce through layers of concrete and travel deep into the earth before they explode release massive amounts of toxic dust. It is estimated that more than 44 GBU-28 bunker buster bombs would be needed to ensure the destruction of Iran’s underground nuclear facility at Natanz. With Natanz’s surface area at approximately 646,000 square feet, the military strikes would cover a much larger surface area than that occupied by the Twin Towers with an explosive force much greater than the civilian aircraft used in 9/11. The amount of toxic dust released from an attack on the Natanz nuclear facility alone could exceed the dust released on 9/11 by a factor of 10, if not greater.

While the chemical composition of the toxic dust is much more dangerous than 9/11, the thermal impact of the bombs combined with the pulverized concrete and chemicals in the plants would guarantee the creation and release of highly toxic dust. It would be fair to assume that at least 70% of rescue and recovery workers dispatched to save the people trapped in the smoldering remains of Iran’s nuclear plants would inhale dusts as caustic as drain cleaner, as well as a slew of carcinogenic substances. Like the 40,000 or so ground zero workers in New York City, they would suffer from serious respiratory, gastrointestinal, and mental health problems over the course of their lives. The difference would be that Isfahan, Natanz, Arak, and Bushehr lack the medical resources of New York City. While we are confident that tens of thousands of Iranian recovery and rescue workers — firemen, policemen, medics, and volunteers—would be exposed to toxic dust, we do not have access to reliable sources to make estimates about the number of casualties among rescue and recovery teams.



Figure 41: 9/11 rescue and recovery workers suffering from respiratory ailments (Photo: Time Magazine)

161 Ibid.

162 Ibid.

163 Ibid.

LIQUIDATORS AND CLEAN-UP CREWS

It is not clear whether Iran’s Atomic Energy Organization has a properly trained and equipped crew to cleanup the contamination at the plants and surrounding areas in the aftermath of military strikes. Yet, as with rescue and recovery workers, in the event of an attack on Bushehr, a sizeable percentage of clean-up crews sent to Iran’s nuclear sites can suffer from exposure to fallout. According to the International Atomic Energy Agency’s staff report, many of the 700,000 liquidators involved in the Chernobyl clean-up, among them firefighters, soldiers, and miners, suffer from social and psychological consequences of their work. While the Chernobyl Forum—a group of specialists including representatives of the IAEA and the World Health Organization—presented a report on the health effects of the Chernobyl accident which estimated that 4,000-9,000 people died or will die from radiogenic cancer, that figure was contested by Greenpeace and others as too low.¹⁶⁴ The Chernobyl Union, as association of liquidators, put the death toll at 60,000 dead and 165,000 disabled liquidators. Radiobiologist Edmund Lengfelder of the University of Munich estimated the number of dead liquidators at between 50,000 to 100,000.¹⁶⁵ Even if one assumes that 10% of the liquidators involved in Iran’s nuclear sites would die and 50% would be exposed to dangerous levels of radiation, the number of casualties among liquidators, especially at Bushehr, could be on a similar order of magnitude.

Whether it is the Iran-Iraq war, Chernobyl or Hurricane Katrina, the weaker and more marginal elements of society are those least able to escape manmade and natural disasters. Segments of the Iranian population—pregnant women, children, the elderly, the poor, as well as rural and traditional populations living close to Iran’s nuclear sites—will be at greater risk than those capable of moving to safer locations. Children and the elderly have weaker and more susceptible immune systems; rural populations have inadequate access to specialized and extensive medical care, and are also more susceptible due to their greater dependence on land, agriculture, and local economies. Finally, the poorer and more traditional sectors of society have a much tougher time relocating due to constraining social, economic and cultural factors. We have not addressed the long-term costs and consequences of strikes.

PSYCHOLOGICAL CONSEQUENCES

Finally, a significant percentage of populations exposed to military strikes will suffer from psychological illnesses such as post-traumatic stress disorder (PTSD), depression, anxiety and panic attacks. Studies of 9/11 victims have found that 11% of ground zero workers had PTSD and 62% had substantial mental stress.¹⁶⁶ As many as 4%

164 “Chernobyl Catastrophe—Consequences on Human Health,” Green Peace (study), <<http://www.greenpeace.org/international/en/publications/reports/chernobylhealthreport/>>.

165 Ibid.

166 Jeanne Mager Stellman, et al., “Enduring Mental Health Morbidity and Social Function Impairment in World Trade Center Rescue, Recovery and Cleanup Workers: The Psychological Dimension of an Environmental Health Disaster,” *Environmental Health Perspectives*, Vol. 116, No. 9: 1248-1253, 2 October, 2008, <<http://www.medscape.com/viewarticle/580678>>.

CIVIL DEFENSE TABLE*				
Location	Isfahan	Natanz	Arak	Bushehr
Air Defense	Iran Army Air Forces, Isfahan Base. Revolutionary Guard Air Defense, 10 Sky Guards Ineffective against strikes	Iran Army Air Forces, Isfahan Base. Revolutionary Guard Air Defense, 10 Sky Guards Ineffective against strikes	Iran Army Air Forces, Isfahan Base. Revolutionary Guard Air Defense, 10 Sky Guards Ineffective against strikes	Iran Army Air Forces, First base. Planned purchase of S-300 Missiles from Russia Ineffective against strikes
Civil Defense	Capable in general, but not capable of nuclear response	Capable in general, but not capable of nuclear response	Not capable, have some logistic capacity	Near full activation
Civil Defense Budget	\$20 million USD (Shared with Natanz)	\$20 million USD (Shared with Isfahan)	\$6 million USD	\$10 million USD
Hospital Beds	5,200 ¹⁷¹	71 ¹⁷²	1,033 ¹⁷³	590 ¹⁷⁴
Hazard Management	Poor	Poor	Poor	Moderate
Public Awareness	Poor	Poor	Poor	Poor

Table 8: *Note: Based on best available estimates and data

of Americans were suffering from 9/11-related post-traumatic stress disorders, including 11.2% of New Yorkers.¹⁶⁷ Almost half of the Latvian liquidators—the nuclear janitors and cleaners—involved in the Chernobyl clean-up had psychosomatic disorders. And a large number of people exposed to fallout developed symptoms related to the fear of contamination.¹⁶⁸ While we expect strikes to cause tremendous mental stress, we have not made any estimates about the psychological, emotional, or social impact of military strikes on the Iranian people. It is fair to assume that strikes would impact similar percentages, and traumatize a substantial percentage of the population.

The extent of civilian casualties from exposure to lethal chemical fumes, toxic dusts leads, depleted uranium and other radioactive material leads us to conclude that military strikes against nuclear and chemical plants can be construed as an illegal form of chemical

warfare that is banned under the Geneva Conventions. The protection of civilians in war remains one of the bedrock principles of the United Nations Charter. Eroding this norm to justify pre-emptive attacks on nuclear facilities of any state establishes a dangerous precedent that puts civilians everywhere, especially in urban areas close to nuclear facilities, at grave risk. As Mohamed El-Baradei and others have pointed out, “The need to prohibit armed attacks on all nuclear facilities and the urgency of concluding an international agreement relating thereto seems to be generally recognized.”

167 Jeffrey Klurjer, “Charting the Emotions of 9/11 — Minute by Minute,” Time, 3 September 2010.

168 “Treatment of Nuclear and Radiological Casualties,” Military Manual distributed to the departments of the Army, the Navy, the Air Force, and Commandant, Marine Corps: 95, 20 December 2001.

169 Mohamed El-Baradei, Edwin Nwogugu and John Rames, “International Law and Nuclear Energy: Overview of the Legal Framework,” IAEA Bulletin, March 1995.

170 Ibid.

171 <<http://mihanfa.com/culture-art/introduction-of-hospital/>>< <http://www.tebyan.net/newindex.aspx?pid=21821>>

172 Ibid.

173 <<http://www.tebyan.net/newindex.aspx?pid=38129>>

174 <<http://www.tebyan.net/mobile.aspx/index.aspx?pid=21824>>

VII. UNINTENDED CONSEQUENCES OF THE MILITARY OPTION

“The failure of diplomacy and engagement does not make a military option a more credible and attractive default option. An examination of the unintended human and sociopolitical consequences of a military strike, leads us to conclude that proponents of a military solution to Iran’s nuclear program rest their argument on a fallacy. Such utopian fantasies about the efficacy of military solutions are simply catastrophic.”

As far as strategic intent is concerned, far from being a tactical solution to the nuclear impasse, military strikes can fall short of their declared objective. Instead of eliminating or delaying Iran’s nuclear program, the United States and Israel can find themselves drawn into yet another strategic quagmire. Strikes can make the restoration of Iran’s nuclear program a symbol of Iranian nationalism and Islamic fundamentalism. Far from encouraging Iran to become more pacific, they can make Iran more insecure and belligerent—intent on developing a strategic deterrent. And the regime can become more, not less, popular.

The failure of diplomacy and engagement does not make the military option a more credible, attractive, or effective option. The military option has to be evaluated on its own merits. An examination of the unintended human, economic, and environmental consequences of military strikes leads us to conclude that proponents of a military solution to Iran’s nuclear program rest their argument on a fallacy. Such utopian fantasies can become dangerous. The ugly reality they seek to change through force is premised on ignoring the even uglier reality strikes can create. As U.S. Admiral Mike Mullen and other seasoned military men who have considered such Iran strikes have stated, “the consequences, known and unknown, are very serious.”¹⁷⁵

Mohamed El-Baradei, the former head of the International Atomic Energy Agency, and other diplomats have argued that the military option is not an alternative to diplomacy. In an interview with the *Washington Post* in December 2009, El-Baradei said that strikes would be “absolutely the worst thing that could happen. There is no military solution.... If a country is bombed you give them every reason—with the support of everybody inside the country and outside the country—to go for nuclear weapons.”¹⁷⁶ The former director of the Shin Bet, Yuval Diskin, went further. He warned that strikes

could even speed up Iran’s nuclear program: “What the Iranians prefer to do today slowly and quietly, they will do... quickly and in much less time.”¹⁷⁷

OSIRAK: THE FALSE ANALOGY

Applying the Osirak “precedent” to Iran’s nuclear facilities can lead to gross underestimation of the scale and scope of damages to the Iranian people and the region. As with the Iraq war or the Arab-Israeli wars, it also underestimates the gravity and duration of the conflicts that would be unleashed.¹⁷⁸

Without a realistic perspective and debate about “collateral damage,” the price of the Ayatollah’s gamble or US/Israeli miscalculation—namely, the costs and consequences of a conflict with Iran—will not become apparent until after the dice have been rolled. As with Iraq, a military option can exacerbate the intractable problem its advocates seek to solve.¹⁷⁹

Proponents of the military option point to the Israeli bombing of Iraq’s Osirak reactor in 1981 (Figure 42), before it became operational, and the bombing of the incomplete Syrian reactor in 2007, as proof that destroying Iran’s nuclear reactor can be simple, quick, and easy. The

175 “Adm. Mike Mullen: I Support Diplomacy in Iran; Iraq Needs to Stand up a Government,” *Christian Science Monitor*, 8 October, 2010.

176 Joby Warrick, “A Nuclear Watchdog’s Parting Shots,” *The Washington Post*, 6 December 2009.

177 Yaakov Lappin, “Former Shin Bet Chief Slams ‘Messianic’ PM, Barak,” *The Jerusalem Post*, 29 April 2012

178 Note: As Cirincione and others have pointed out, the Osirak strikes did not arrest the development of Iraq’s nuclear program. They accelerated it.

179 Note: A great deal hinges on the definition and conception of a solution to Iran’s nuclear program. Proponents of the military option argue that it may be the only efficient and certain way of eliminating the existential threat an Iranian bomb would pose Israel. To them, the only difference between the Iraqi and Syrian case and the Iranian case is one of scale. There is a military solution. The problem is that Israel, alone, may lack the military capability to launch a successful pre-emptive strike that would guarantee the destruction of Iran’s nuclear capability. And so, as the guarantor of Israel’s security, the United States can eliminate the perceived threat from Iran’s weapons of mass destruction to defend Israel against imminent threat of annihilation by President Ahmadinejad.

Osirak option is seen as a possible solution.¹⁸⁰ The only difference, in this view, is the scale and complexity of such an operation. As Joseph Cirincione and others have pointed out, such an analogy is false.¹⁸¹



Figure 42: Osirak (Photo: Agence France-Presse)

The Osirak analogy is the fantasy that there will be no blowback from strikes against Iran's nuclear facilities. It discounts the complexity, severity, scale, consequences, and casualties such an operation would entail. Iran's nuclear program is not an empty shell, nor is it a single remote target. The facilities in Iran are fully operational, they contain thousands of personnel, they are located near major population centers, they are heavily constructed and fortified, and thus difficult to destroy. They contain tons of highly toxic chemical and radioactive material. To grasp the political and psychological impact of the strikes, what our estimates suggest is that the potential civilian casualties Iran would suffer as a result of a strike — in the first day — could exceed the 6,731 Palestinians and 1,083 Israeli's reported killed in the Israeli-Palestinian conflict over the past decade.¹⁸² The total number of fatalities in the 1981 Osirak raid was 10 Iraqis and one French civilian, Damien Chaussepied. As Bob Woodward wrote in his book, *State of Denial*, far from ending Iraq's nuclear program, the Israeli raid acted as a spur. It led Saddam Hussein to initiate a covert program to develop a nuclear bomb.¹⁸³

MILITARY CONSEQUENCES

It is almost certain that the casualties from a conventional war would extend well beyond the death toll from strikes against Iran's nuclear sites. The Iranian military would have to be targeted to minimize Iran's capacity to launch a counterattack — and that would mean

pre-emptive strikes against hundreds of military targets scattered around Iran. As U.S. Senator Lindsey Graham of South Carolina, a senior member of the Committee on Armed Services, argued at the Halifax International Security Forum, strikes against Iran would have to entail the total destruction of the Iranian military:

“So my view of military force would be not to just neutralize their nuclear program, which are probably dispersed and hardened, but to sink their navy, destroy their air force, and deliver a decisive blow to the Revolutionary Guard. In other words, neuter that regime. Destroy their ability to fight back and hope that people.... inside Iran would have a chance to take back their government and be good neighbors to the world in the future.”¹⁸⁴

In March 2012, *The New York Times* reported that a simulation of an Israeli military strike against Iran's nuclear infrastructure had predicted that an attack would lead to a wider regional war that could draw the United States in and leave hundreds of American soldiers dead.¹⁸⁵ Earlier that same month, Meier Dagan, former head of the Mossad, warned that an Israel attack on Iran would “ignite a regional war,” which he predicted would end in the death of Israeli citizens.¹⁸⁶ Dagan called the idea of attacking Iran the “stupidest thing ever.” Similar predictions have come from the Persian Gulf states. In his 2007 study “The Implications on Gulf States of Any American Military Operation against Iran,” Colonel Salem al Jaber warned that Iran would respond to military strikes attacking “all U.S. allies in the region, especially the Gulf states.”¹⁸⁷ Jaber also cautioned that Iran would also likely launch missile strikes on American bases in the Gulf, which include locations in Bahrain, Saudi Arabia, Kuwait and The United Arab Emirates.

Should military strikes trigger a short or prolonged regional war, we can expect the damages to go well beyond the nuclear sites. Iraqi civilian casualties from the violence unleashed by the Iraq war, according to the Iraq body count, are more than 100,000.¹⁸⁸ A heavily criticized Lancet survey estimated in excess of 600,000 violent deaths.¹⁸⁹ UNHCR estimates put the total number of Iraqi refugees outside Iraq at 1,683,570, with another 1,343,568 internally displaced persons inside Iraq.¹⁹⁰ In terms of economic damage, the costs of the Iraq war to the United States alone was placed in \$3 trillion range.¹⁹¹ Should strikes result in a war, the Iran body count can certainly

184 Tod Lindberg, “Speaking Truth to Mullah Power,” *The Weekly Standard*, 22 November 2010, <http://www.weeklystandard.com/print/articles/speaking-truth-mullah-power_516688.html?page=2>, accessed 23 November 2010.

185 Marl Mazzette, “U.S. War Games Sees Perils of Israeli Strike,” *New York Times*, 19 March 2012.

186 Lesley Stahl, “The Spymaster: Meir Dagan on Iran's Threat,” *60 Minutes*, 11 March 2012, <http://www.cbsnews.com/8301-18560_162-57394904/the-spymaster-meir-dagan-on-irans-threat/>.

187 Col. Salem Al Jaber, “The Implications on the Gulf States of any American Military Operation against Iran,” *U.S. War College*, 30 March 2007.

188 “Iraq body count” accessed 8 July 2011, <www.iraqbodycount.org>.

189 Gilbert Burnham, et al., “Mortality after the 2003 invasion of Iraq: a cross-sectional cluster sample survey,” *Johns Hopkins Bloomberg School of Public Health*, 11 October, 2006, <<http://www.brussellstribunal.org/pdf/lancet111006.pdf>>.

190 “2011 UNHCR country operations profile—Iraq: Statistical Snapshot,” accessed on 8 July 2011, <<http://www.unhcr.org/cgi-bin/texis/vtx/page?page=49e486426>>.

191 Linda J. Birmes and Joseph E. Stiglitz, “The Iraq war will cost us \$3 trillion, and much more,” *Washington Post*, 9 March 2008.

180 Jeffrey Goldberg, “Point of No Return,” *Atlantic Monthly*, September 2010.

181 Joseph Cirincione, “Bombs Won't Solve Iran,” *The Washington Post*, 11 May 2005. Note: As Cirincione and others have pointed out, Osirak did not put an end to Iraq's nuclear program. It encouraged Saddam to revive his nuclear program and set the stage for the Iraq war.

182 “B'Tselem: Since 2000, 7,454 Israelis, Palestinians killed,” *Jerusalem Post*, 27 September 2010. See also: “27 September '10: 10 years to the second Intifada — summary of data,” *The Israeli Information Center for Human Rights in the Occupied Territories (B'Tselem)*, <http://www.btselem.org/english/press_releases/20100927.asp>.

183 Bob Woodward, *State of Denial* (New York: Simon and Schuster, 2006): 215.

reach the levels in Iraq, with more than 100,000 dead and millions displaced. The economic costs could also exceed a trillion dollars, many times more than the cost of Iran's nuclear program. Given that the number of American soldiers killed or injured in the Iraq and Afghan wars exceeds 50,000, one can expect the toll from an Iran war to be much higher—a price advocates of military strikes and solutions fail to recognize.

REGIONAL AND STRATEGIC CONSEQUENCES

Although we have restricted the scope of this study to examining the consequences of conventional strikes against four nuclear sites, our estimates of the costs and consequences of military strikes provide only a snapshot into what can become a larger, longer, and deadlier regional war with dangerous religious and apocalyptic overtones. The casualties and costs of such a clash of civilizations would have to be measured in terms of millions of people across entire provinces, regions, and continents. As with the shadow cast by the Iran-Iraq war, the Arab-Israeli wars, as well as the Iraq and Afghan conflicts, such a blood feud would feed what one prominent Middle East analyst has called a cycle of "crisis and carnage."¹⁹² Strikes would act as a curse that would stain the memory, scar the face, and blacken the future of generations of civilians and soldiers throughout the Middle East and beyond.

¹⁹² Karim Sadjadpour, "Wikileaks Should Prompt a Rethink on Iran," *The Financial Times*, 30 November 2010.

VIII. CONCLUSION AND RECOMMENDATIONS

The assumption that the military option would force the Ayatollah to consider diplomacy rests on the false projection that Ayatollah's government is motivated by the protection of the Iranian people's life, property and sovereignty. Iran's presidential elections should have put such an assumption to rest. Iran's nuclear program allows the Ayatollah to keep Iran in a state of permanent political and economic crisis. He gets to blame the West for conspiring to deprive the Iranian people of the right to enrich uranium while stripping the Iranian people of fundamental rights. It is only natural that keeping the nuclear dispute alive, even if it is at the price of sanctions and war, serves his interests. A theocracy whose ideology is premised on sacrifice and martyrdom can only survive as long as its leaders can capitalize on the death of the Iranian people.

The number of casualties behind the Ayatollah's nuclear gamble cannot be ignored. Between 3,500 and 5,500 people at Iran's four nuclear sites would be killed or injured as a result of the physical and thermal impact of the blasts. If one were to include casualties at other targets, one could extrapolate to other facilities, the total number of people killed and injured could easily exceed 10,000. At Isfahan alone, anywhere between 240,000 to 352,000 people could be exposed to toxic plumes. Similarly, a strike on Bushehr would not only expose the 240,000 residents of Bushehr to fallout, it would essentially contaminate much of the Persian Gulf. Major cities, business centers, and trading routes throughout the region would be at risk. The environmental and economic costs of strikes on the facilities would be in the tens of billions of dollars, and that is assuming that there will be no war.

While such attacks would almost certainly destroy many of Iran's nuclear facilities, as El-Baradei and others have pointed out, military attack can only temporarily slow down Iran's nuclear program.¹⁹³ But while strikes may have tactical allure and domestic appeal as a quick fix to the nuclear dispute, the death of thousands of Iranians cannot be dismissed as collateral damage. It would draw the United States, Israel and Iran into a strategic quagmire — a cycle of war and hostility every bit as destructive and pernicious as the decade long Arab-Israeli conflict.

The human casualties alone should make it clear that it is a mistake to assume that the failure of diplomacy makes the military option the only real, effective or reliable default option. The military option, should be judged on its own merits, and virtually no one has explained how the humanitarian fiasco—the death of thousands of Iranian civilians from military strikes—will do anything other than unleash a war that will strengthen the Ayatollah and his allies at the expense of the United States, Israel and the Iranian people.

For Israel or the United States to target the Iranian people as the only way to destroy Iran's nuclear capacity is to allow Khamenei and Ahmadinejad to drive a permanent wedge between the United States, Israel and the Iranian people. As with the Iran-Iraq war, strikes would turn thousands of Iranians into the martyrs of a bankrupt ideology premised on hatred and enmity. Khamenei would convert the wreckage of Iran's nuclear program into a stage and the remains of the Iranian people into a prop for salvaging a broken and bankrupt theocracy held together by fraud, fear, and force. As former U.S. Secretary of Defense Robert Gates and others have cautioned, while Israel could strike Iran without American support, "any strike would only delay Iranian plans by one to three years, while unifying the Iranian people to be forever embittered against the attacker."¹⁹⁴ The Iranian people, the Islamic world, the United States, Israel, and the Arab world would get drawn into a catastrophic war in which Khamenei, Ahmadinejad, and other extremists would emerge as the only victors.

The costs of the Islamic Republic's policies have become increasingly apparent to the Iranian people, both inside and outside Iran. This study attempts to make the risks and costs of the Ayatollah's gamble and Ahmadinejad's rhetoric apparent. By classifying the nature and quantifying the extent of this threat, we have tried to define parameters for understanding the scale of the damage facing the Iranian people, especially the people of Isfahan, Natanz, Arak, and Bushehr. This does not mean that the people of Tehran, Qom, and other cities would be immune. A disastrous, obscurantist foreign policy that has converted Iran's nuclear program into a strategic liability rather than an economic or industrial asset puts all Iranians at risk.

Although, for the most part, we have sought to inform and address decision-makers about the dangers of attacking the Iranian people and falling into the Ayatollah's trap, the Iranian people—both inside and outside Iran—cannot remain silent before a calamity on this scale. We believe that virtually all sectors of Iranian society have a responsibility to protect one another from the Ayatollah's gamble. With the fate of Isfahan and the future of Iran at stake, virtually all sectors of Iranian society—scientists, engineers, doctors, and soldiers as well as merchants and farmers—have a stake in finding an alternative solution that leads to the peaceful—and permanent—resolution of the nuclear dispute. Far from being a sign of humiliation, demonstrating Iran's commitment to its international obligations is a badge of honor.

While Ayatollah Khamenei may have every reason to play a game of nuclear poker with the Iranian people and nuclear program as his chips, once the price of his gamble becomes apparent to the Iranian people, his willingness to risk the destruction of Isfahan alone would turn millions of Iranians against his belligerent policies. The Iranian

193 <<http://www.pbs.org/wgbh/pages/frontline/tehranbureau/2012/03/news-former-un-atom-agency-chief-attack-cant-stop-iran-nuclear-program.html>>.

194 Jo Becker, James Glanz and David E. Sanger, "Around the World, Distress over Iran," *The New York Times*, 28 November 2010.

people put a much higher price on their cultural heritage than do their current leaders.

Rather than planning a military attack that can have more than 400 aim points, and result in the devastation of Isfahan, it is time to recognize that the Iranian people pose a far greater threat to the Islamic Republic than the U.S. or Israeli military power. While President Obama and Prime Minister Netanyahu have repeatedly stated that they do not view the Iranian people as the enemies of the United States and Israel, the scale of the casualties resulting from military strikes will allow the Ayatollah, and other extremists, to portray them as aggressors: enemies of Iran, the Islamic world and humanity. It is time to adopt a strategy that recognizes that the Iranian people are the primary victims—not the defenders—of the Ayatollah's policies. It is they, and not the United States and Israel, who are the hostages of the Islamic Republic's tyranny and terrorism. Discounting the impact of massive military strikes on their lives and their future is a moral and strategic failure of the highest order.

The Iranian people and their political and religious leaders — the parliament, clergy, military, and others—have an interest and an obligation to bring about an end to reckless policies purchased at the price of gambling with the security and prosperity of the Iranian people. Whatever the differences between the Iranian people, there is a clear, urgent, and immediate need for them to unite against the Ayatollah's nuclear gamble before they are drawn into yet another

disastrous war—a calamity for Iran, the United States, Israel and the rest of the region. At stake is not only the future of generations of Iranians, but the peace, security, and prosperity of their friends and neighbors in the Middle East and beyond. Such an historic opportunity to defend the honor, reclaim the future, and establish the standing of their nation as a bastion of peace is one that all Iranians—inside and outside Iran—must welcome and seize. As with elections, so too with Iran's nuclear program, it is time for Ayatollah Khamenei to recognize that the days of gambling with the lives, the votes, and the future of the Iranian people have come to an end.

As ancient civilizations and peoples whose attachment to the springs and sources of life is etched in the scripture, history, culture, and geography of the Middle East, the Iranian people and their neighbors in the region must not allow Khamenei and Ahmadinejad to convert the reflection of their faith—the hands, hearts, and faces of one another's children—into the tattered and torn shroud of scars and burns covering their own tormented image. And the U.S. Israel and international community cannot and must not fuel the fire of the wars Iran's Ayatollah seeks to ignite. Rather, they should join the Iranian people in their efforts to protect their country against the Ayatollah's macabre and murderous policies. An Ayatollah who holds Iran hostage by usurping religion to sanctify violence—nuclear or otherwise—has no legitimacy, no authority, no claim and no place in Iran's future. As with Saddam, Qadhafi and Assad, his time is up.

APPENDICES

APPENDIX 1:

ISFAHAN AND NATANZ GAUSSIAN PLUME CALCULATIONS

Basic chemical reactions for the production of UF6

Mass balance for UF6 production assuming ideal (100% efficient or stoichiometric) reactions is obtained as follows:

Inserting molecular weights and solving for masses of each compound used to produce 1 kg (2.2 lbs) of UF6 gives

$$1 \text{ kg UF}_6 \Rightarrow 0.797 \text{ kg (U}_3\text{O}_8) + 0.004 \text{ kg (H}_2) + 0.227 \text{ kg (HF)} \\ + 0.108 \text{ kg (F}_2) - 0.136 \text{ kg (H}_2\text{O)} \quad (1)$$

On a mass basis to produce 1000 kg (2,200 lbs) of UF6, the following input masses are required for equation (1)

$$1000 \text{ kg (UF}_6) = 797 \text{ kg (U}_3\text{O}_8) + 4 \text{ kg (H}_2) + 227 \text{ kg (HF)} \\ + 108 \text{ kg (F}_2) - 136 \text{ kg (H}_2\text{O)} \quad (2)$$

Observe that the reaction in equation (2) generates 136 kg (299 lbs) of H2O.

As stated in the methodology and assumptions section, for the purposes of calculating travel distances and exposed areas we are utilizing IDLH for toxicity values. The IDLH values for UF6, UO2F2, HF, F2 and other fluoride compounds as very similar and within a narrow range of values. So a combined, mean IDLH value is assumed as follows since the accurate estimation of the various mass components of the possible fluoride products is not possible in the event of an attack on Iran's nuclear fuel facilities.

IDLH for fluoride products released to the atmosphere is

$$25 \text{ ppm or } 38.8 \text{ mg (F}_2\text{)/m}^3 \text{ (air)} \quad (3)$$

The airborne dispersion and deposition of the toxic materials that could be released from an attack upon an Iranian nuclear site with UF6, HF, or F2 can be modeled using the standard Gaussian plume atmospheric dispersion and transport model (Refs 3 and 5). The atmospheric dispersion concentration is quantified in terms of the standard X/Q dispersion factors where

X (grams of toxic material/m³) liberated into the atmosphere

Q (grams of toxic material/s) released from the source.

The Gaussian plume model equation uses the following simplified equation

$$X/Q = Pd / [2^{\frac{1}{2}} \pi S_x S_y S_z] \quad (4)$$

Where

Pd = time duration of the toxic release(s)

$$\pi = 3.1415$$

Sx, Sy, Sz = dispersion coefficients for travel in (x), horizontal (y), vertical (z) directions (m)

The objective for this analysis is to provide an estimate of the distance x(m) that a toxic plume can travel from the release point to the point at which the plume exhibits a concentration equal to the IDLH value for the toxic material. The ground distance that the plume will travel until this concentration occurs is x. The value of x is contained in the dispersion coefficients as follows for distances greater than about 5 km (3.1 miles).

$$S_x = S_y = 0.13 x^{0.9} \quad (5)$$

$$S_z = 0.57 x^{0.58} \quad (6)$$

These experimental numerical values shown in equations (5) and (6) assume atmospheric stability Class D that are typical worldwide values used for ambient meteorological conditions prevalent about 2/3 of time for average weather conditions and wind speeds of about 3.1 m/s.

Solving equation (4) for x by substituting equations (5) and (6) gives

$$x^{2.38} = 13.2 Pd (Q / X) \quad (7)$$

or

$$x \text{ (m)} = 2.96 [Pd (Q / X)]^{0.42} \quad (8)$$

Equation (8) may now be used to estimate the travel distance along the ground that this toxic plume will move as a hemisphere. The toxic materials inventory estimated at Isfahan and Natanz will be used to determine the travel distance x from equation (8) as follows for each site.

The toxic material inventory at Isfahan and Natanz is estimated at 371 metric tons. Since it is not evident how this inventory is distributed between these two sites, we have assumed a range of releases of 1 to 50% percent of total inventory at each site. (Table 9)

If the military attack upon the UF6 storage and processing sites is highly successful, then the release of 50% of the UF6 that might be dispersed on the ground and into the atmosphere is shown in the following calculation.

$$Pd(s) Q(g/s) = 6.01 \times 10^7 \text{ g of toxic fluorine materials}$$

$$X = 0.0388 \text{ g/m}^3 \text{ average IDLH for these toxic materials}$$

$$Pd(Q/X) = 1.54 \times 10^9 \text{ m}^3$$

Gaussian Plume Calculations for Military Strikes on Iranian Nuclear Infrastructure							
% 371 (MT) of UF6 Released to Atmosphere	Fluorine in Airborne Compounds (g)	Fluorine at >= 25 ppm		Fluorine at >= 25 ppm		Chlorine at >= 10 ppm	
		Travel distance (km)	Area (=L L/2) (sq km)	Travel distance (miles)	Area (=L L/2) (sq miles)	Travel distance (km)	Area (=L L/2) (sq km)
		IDLH Fluorine		IDLH Fluorine		IDLH Chlorine *	
		X(IDLH) = 25 ppm		X(IDLH) = 25 ppm		X(IDLH) = 10 ppm	
1	1.20E+06	4	8	3	5	5	13
5	6.01E+06	8	32	5	13	9	41
10	1.20E+07	11	61	7	25	12	72
20	2.40E+07	15	113	9	41	16	128
25	3.00E+07	16	128	10	50	18	162
50	6.01E+07	21	221	13	85	24	288

Table 9

And a travel distance from the release point of the toxic materials is

$$x(m) = 2.96 [Pd(Q/X)]^{0.42} = 21 \text{ km (13 miles)}$$

Notes:

1: IDLH - Immediately Dangerous to Life and Health (U.S. NIOSH)
 *Since Chlorine use is widespread compared to Fluorine and toxic health effects are similar, the IDLH effective distance and area data for Chlorine are also presented for comparison

Consequences of Radiation Exposures from UF6

The UF6 materials used in the Iranian Nuclear Program Iran pose both chemical toxicity and radiological risks to humans. The chemical toxicity effects are evident immediately upon release of fluorine compounds into the environment. The radiological effects appear over long periods of time associated with the radioactive decay properties of the radioactive materials. The long-term radiological risk to humans from the uranium in the UF6 after fluorine in the UF6 has dissipated and uranium compounds are now dispersed within the environment. Uranium is a very long-lived alpha emitter (half-life of U-235 is 704 million years and U-238 is 4.5 billion years) with long sequences of other radioactive daughters that pose significant health hazards. These radioactive products associated with U are deposited within the body through breathing and ingestion poses both long-term cancer risks.

The risk associated with the deposition of U and its radioactive daughters on soil can be estimated from the total inventory of UF6 reported. A RESRAD (Ref 4) analysis shows that 8.4 grams of uranium deposited per square meter of land surface area poses a radiation exposure of about 1 milliSievert/year (or 100 millirem/year) from all pathways producing human radiation exposure. This level is generally considered the maximum allowable additional dose to the public from surface-deposited radiation above natural background radiation exposures. The land area that could be contaminated at

this level from the eventual release to the environment of 371 Metric Tons is given by

$$371 \times 10^6 \text{ g UF6} \times (0.676 \text{ g U/g UF6}) / [8.4 \text{ g U/(sq m land area)}] = 30 \text{ sq km (11.6 sq. miles)} \tag{9}$$

About 30 sq km (11.6 sq. miles) of land could be contaminated for centuries from this deposition of uranium on adjacent land. This contaminated land must either be abandoned for human use or extensive cleanup performed including removal of all surface materials (soil, water, etc.) at very large economic expenditures.

References:

1. "Implementation of NPT Safeguards Agreement and relevant provisions of Security Council resolutions," IAEA Report to the Board of Governors, 18 February 2010: 6.
2. IDLH values provided in the CDC-NIOSH Pocket Guide to Chemical Hazards, 18 Nov 2010, www.cdc.gov/niosh/npg/. IDLH is an acronym for "Immediately Dangerous to Life or Health," and is defined by U.S. National Institute for Occupational Safety and Health (NIOSH) as exposure to airborne contaminants likely to cause death or immediate or delayed permanent adverse health effects. NIOSH is the United States federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the Centers for Disease Control and Prevention (CDC) within the U.S. Department of Health and Human Services.
3. "Airborne Release Fraction/Rates and Respirable Fractions for Nonreactor Nuclear Facilities," DOE Handbook, DOE-HDBK-3010-94, December 1994.
4. RESRAD is a computer code developed by U.S. Department of Energy to evaluate human health and ecological risks resulting

from residual radioactive and chemical contamination. The RESRAD code has been widely used in the United States and abroad for assessing environmental radiation risks.

5. "Development of a Computer Model for Calculation of Radioactive Materials into the Atmosphere after an Accident," UCRL-CR-129075, November 1997.
6. Deichmann, W. and H. Gerarde, "Hydrofluoric Acid," Toxicology of Drugs and Chemicals, Academic Press, NY, NY, pg. 317-318, 1969.

APPENDIX 2:

AGGRAVATING FACTORS: OPERATIONAL AND ORGANIZATIONAL

Poor Governance

As with other aspects of the Iranian economy and industry, virtually every aspect of Iran's nuclear program reflects serious problems of governance. Whether leadership and diplomacy, military and civil defense, international cooperation and supervision, standards and design, site selection and design, security and prevention, or response and recovery, there is very little reason for confidence in the Islamic Republic's management of Iran's nuclear program. Iran's leaders have not only done virtually everything in their power to shatter the international community's confidence in Iran's nuclear program and promises, they have, at the same time, ignored their legal, political, and religious obligation to protect and prepare the Iranian people against the risks of attack. Such a flagrant violation of responsibility and trust is apparent in many dimensions of Iran's nuclear program.

Iran's Defensive Capabilities: The S-300 Mirage

The day after Iran and Russia inaugurated the Bushehr Nuclear Plant on August 21, 2010, Iranian President Mahmoud Ahmadinejad told the al-Jazeera network that "Israel's too weak to attack Iran's nuclear facilities."¹⁹⁵ He added that Jerusalem did not have "the courage to do it...and I do not think its threat is serious."¹⁹⁶

As for the possibility of a U.S. military strike, the Iranian president was equally dismissive. He told al-Jazeera that "America is not interested in sparking a military confrontation" and that "there are no logical reasons for America to carry out such an act." He ended by questioning America's military credibility before his Arab audience: "Do you believe that an army that has been defeated by a small army in Iraq can enter into a war with a large and well-trained army like the Iranian army?"¹⁹⁷

The irony is that Iran's leaders have not taken adequate defensive measures to protect the Iranian people against the consequences of their offensive rhetoric and conduct. What makes Khamenei's nuclear policies and Ahmadinejad's provocations—the gamble—so dangerous to the Iranian people is that they have systematically undermined Iran's national security by eroding Iran's diplomatic influence and military power. The Iranian military's ability to defend Iran's nuclear sites against military strikes is negligible. Iran's Air Defense system has become largely outdated.¹⁹⁸ In the event of a strike, there would be a considerable early-warning delay due to Iran's

195 "Ahmadinejad: Israel is too weak to attack Iran's nuclear facilities," Haaretz, 22 August 2010.

196 Ibid.

197 Ibid.

198 Anthony Cordesman and Abdullah Toukan, "Study on a Possible Israeli Strike on Iran's Nuclear Development Facilities," Center for Strategic and International Studies Report, 14 March 2009, <<http://csis.org/publication/study-possible-israeli-strike-irans-nuclear-development-facilities>>.

antiquated, semi-automated C4I Battle Management systems. As for Iran's combat aircraft, largely a legacy of the Shah, most analysts predict a long response/scramble time, low operational readiness, low sortie rate, and a high loss rate.

To make matters worse, foreign policy miscalculations have seriously crippled the Iranian military's defensive capabilities. Russia's decision to renege on a deal to upgrade Iran's obsolete air defenses with S-300 ground-to-air missiles has effectively turned Iran's nuclear sites into sitting ducks. Having threatened Israel with destruction, taunted the United States into attacking Iran's nuclear program and military, denied the possibility of a military threat, and accused his own ally, Russia, of selling Iran out to Satan, the President finds solace by telling a cheering crowd in Bojnourd that "the Iranian people don't need missiles to defend themselves."¹⁹⁹

In fact, far from securing Iran against foreign powers or acting as a deterrent against a nuclear attack, the Islamic Republic's foreign policy and nuclear rhetoric can erode Iran's national security by increasing the risks of proliferation in the Middle East. The possibility of Shia Iran using its nuclear weapon to impose its will on weaker Sunni states creates a clear incentive for oil rich Gulf nations to counter the Islamic Republic's real or imaginary nuclear arsenal with their own nuclear weapons. Should al-Qaeda or other religious fundamentalists with strong anti-Iranian and anti-Shia sentiments take over any of these small states, the risks of a nuclear attack on Iran would be far greater than the risks posed by the Israeli or American nuclear arsenal. In this sense, far from constraining Iran's security, a powerful nonproliferation regime that would establish confidence about the peaceful nature of nuclear programs in the Middle East would be in Iran's interest.

Lack of International Supervision: The Regulatory Black Hole

The Islamic Republic's policies have not only increased the risks of military strikes, they have also diminished the capacity of domestic and international bodies to ensure the safety and security of Iran's nuclear program. While, before Fukushima, Iranian officials claimed to be following Japanese standards for their nuclear program, after Fukushima the Iranian public was fed false assurances about Iran's nuclear capabilities. For example, Iranian nuclear physicist Seyed Mahmoud Reza Aga-Miri, Iran's representative to the SESAME (Synchrotron Radiation Light for Experimental Science and Applications in the Middle East) project, *told Fars News Agency*, "Iranian experts can easily tackle this [Fukushima] disaster and solve Japan's problem. This shows that maybe Iran's practical capabilities are higher than Japan's."²⁰⁰

Iran's claims that its nuclear plants comply with the highest up-to-date standards simply do not make sense. As Nima Gerami points out in the Bulletin of the Atomic Scientists, the International Atomic Energy Agency (IAEA) "emphasizes that Iran does not, in fact, follow some important safety protocols." As Gerami points out, Iran is "the

199 "Ahmadinejad Slams Russia for Selling Out to Satan," Al-Arabiya via Agence France-Press, 3 November 2010, <<http://www.alarabiya.net/articles/2010/11/03/124756.html>>.

200 Nima Gerami, "Nuclear Safety in Iran, Post-Fukushima," Bulletin of the Atomic Scientists, 3 August 2011, <<http://thebulletin.org/web-edition/op-eds/nuclear-safety-iran-post-fukushima>>.

only country in the world with significant nuclear activities not to sign the 1994 Convention on Nuclear Safety (CNS), a crucial system of peer review and mutual oversight. (Israel, India, and Pakistan, all outside the Nuclear Non-Proliferation Treaty, have signed the CNS. India and Pakistan have both ratified.)²⁰¹

An international team of nuclear safety experts from the IAEA did visit Iran from February 20 to March 2, 2010, for an Integrated Regulatory Review Service (IRRS) mission which included a technical visit to the Bushehr Nuclear Power Plant site (BNPP-1). Olena Mykolauchuk, IRRS team leader and head of the State Nuclear Regulatory Committee of the Ukraine—no stranger to nuclear disasters—reportedly commended her Iranian counterparts for “demonstrating significant progress of INRA as a nuclear regulatory authority.”²⁰² Philippe Jamet, director of the IAEA’s Nuclear Installation Safety Division, added that through such review missions “both Iran and the international experts contribute to enhancement of nuclear safety and worldwide experience sharing.”²⁰³

Yet while praising “INRA’s dedicated staff and conscientious staff” for their recognition of the importance of “the value of peer reviews and international cooperation regarding nuclear safety,” the IAEA made it very clear that the “the mission was an objective peer review based on IAEA safety standards and “was neither an inspection, nor an audit.”²⁰⁴ Beyond the niceties, the IAEA peer review’s recommendations and suggestions to improve the regulatory effectiveness of INRA were as follows:

- The government should support the prompt enactment of a law establishing INRA as an independent nuclear regulatory authority, as well as provide it with all authority and resources needed to carry out its functions.
- The government is encouraged to join the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.
- INRA should replace the existing set of ad hoc regulatory requirements with a comprehensive set of national safety regulations.
- The number and expertise of technical staff should be increased and career incentives should be established to attract and retain them.²⁰⁵

Although, in 2010, the IAEA’s IRRS mission to the Bushehr plant recommended that Iran take these crucial steps to develop a comprehensive system of national nuclear safety regulations, Iran has yet to sign the Convention on Nuclear Safety.

What is fairly clear from the IAEA’s peer review alone is that Iran is developing its nuclear program without establishing an nuclear regulatory authority, or granting it the necessary authority, resources and staff to carry its functions, that Iran lacks a comprehensive set of national safety regulations, and that Iran has not joined key con-

201 Ibid.

202 “International Experts Conclude IAEA Peer Review of Iran’s Safety Regulation of Bushehr NPP,” IAEA press release, 2 March 2010, <<http://www.iaea.org/newscenter/pressreleases/2010/prn201003.html>>.

203 Ibid.

204 Ibid.

205 Ibid.

ventions on nuclear safety. The main national laws and regulations concerning nuclear power remain the Atomic Energy Act of 1974 and the Radiation Protection Act of 1989.²⁰⁶

The limited nature of Iran’s technical cooperation projects with the IAEA for the 2009–2011 cycle points to “an environmental radiological monitoring of the Isfahan UCF site surrounding in normal and emergency situation and characterizing pathways of exposure to individuals and the public (IRA2007016),” but beyond a technical document on monitoring environmental radiological threats and pathways around the Isfahan site, there is very little in the 16 initiatives listed by the IAEA that addresses emergency response preparations” (to suggest technical documentation, let alone mobilization or preparation for the medical, economic and environmental consequences of nuclear catastrophe at Isfahan and elsewhere).²⁰⁷

The Islamic Republic’s policies have not only increased the risks of military strikes, they have also diminished the capacity of domestic and international bodies to ensure the safety and security of Iran’s nuclear program. While before Fukushima, Iranian officials claimed to be following Japanese standards for their nuclear program, after Fukushima the Iranian public was fed false assurances about Iran’s nuclear capabilities. Iranian nuclear physicist Seyed Mahmoud Reza Aga-Miri, Iran’s representative to the SESAME (Synchrotron Radiation Light for Experimental Science and Applications in the Middle East) project, *told Fars News Agency*, “Iranian experts can easily tackle this [Fukushima] disaster and solve Japan’s problem. This shows that maybe Iran’s practical capabilities are higher than Japan’s.”²⁰⁸

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206 International Atomic Energy Agency Iran factsheet, March 2009, <www.pub.iaea.org/MTCD/publications/PDF/cnpp2009/countryprofiles/Iran/Iran2008.htm>.

207 Ibid.

208 Nima Gerami, “Nuclear Safety in Iran, post-Fukushima,” *Bulletin of the Atomic Scientists*, 3 August 2011, <<http://thebulletin.org/web-edition/op-eds/nuclear-safety-iran-post-fukushima>>.

209 Ibid.

210 Ibid.

What is fairly clear from the IAEA's peer review alone is that Iran is developing its nuclear program without establishing an nuclear regulatory authority, or granting it the necessary authority, resources and staff to carry its functions, that Iran lacks a comprehensive set of national safety regulations, and that Iran has not joined key conventions on nuclear safety. The main national laws and regulations concerning nuclear power remain the Atomic Energy Act of 1974 and the Radiation Protection Act of 1989.²¹¹

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Management Problems: Lack of Standards

It is impossible to manage Iran's nuclear fuel cycle without a clear set of standards. Yet, in a paper on the Iranian Nuclear Fuel Cycle Experience presented at the World Nuclear Association's Annual Symposium, Dr. M Ghannadi-Maragheh, vice-president of the Atomic Energy Organization of Iran (AEOI), shows how much of Iran's nuclear fuel cycle remains incomplete. Indeed his paper has gaping holes in areas such as safeguards, quality control, waste disposal, and medical treatment. Iran's Atomic Energy Organization appears to have no standards or is only just beginning to define standards for crucial areas of the nuclear fuel cycle. Where standards do exist, they are often no more than ISO translations prepared by the Institute of Standards and Industrial Research of Iran. Or they are incompatible. For example, according to Ghanadi-Maragheh, "Russian design of (Yellow Cake Production) for constructing of plant and equipment was not familiar to non-Russian contractors—as Western designs are—and Russian documents and drawings were not according to Iranian standards."²¹³ While one cannot judge an entire organization based on the quality of its leadership, Ghannadi-Maragheh's paper provides a glimpse into a hopelessly disorganized nuclear fuel cycle defined by negligence, amateurism, and lack of professionalism at the highest levels of the AEOI. The absence of standards, lack of process, and poor integration of Iran's fuel cycle points to fundamental organizational and management problems—a poor organization of knowledge, definition of roles, distribution of authority, and division of functions within the AEOI, and, consequently, negligence of some of the most crucial sectors of Iran's nuclear program, including the management of Russian and other foreign contractors.

211 International Atomic Energy Agency Iran factsheet, March 2009, <www.pub.iaea.org/MTCD/publications/PDF/cnpp2009/countryprofiles/Iran/Iran2008.htm>.

212 Ibid.

213 M. Ghannadi-Maragheh, "Iranian Nuclear Fuel Cycle Experience," presented at the World Nuclear Association Annual Symposium, 3-5 September 2003.

Earthquakes: Fukushima Redux

As with Japan's Fukushima nuclear plant, the Bushehr nuclear plant sits in a seismic zone along the fault lines of the Arabian and Eurasian continental plates. In 2002, a 4.6 magnitude earthquake hit Bushehr. More recently, the Iranian Seismological Center detected a 5.2 magnitude earthquake on March 5, 2011, in the Kohgiluyeh and Boyer-Ahmad province and a 4.8 magnitude earthquake on May 8, 2011, in Bushehr province.²¹⁴

President Ahmadinejad's belated efforts to relocate residents of the villages near the Bushehr nuclear facility have failed, and there is little evidence to suggest that the Iranian military and provincial governments have the financial, military, logistical, medical, and communications and control facilities necessary to detect, monitor, and treat radiation and chemical toxins released near urban centers. Iran's neighbors are also worried. Kuwaiti geologist Dr. Jassem al-Awadi has warned that in the event of an earthquake, "the ominous results will be similar to those of the Chernobyl disaster for the whole region."²¹⁵ According to al-Awadi, an earthquake could spark massive fallout that would reach Kuwait and other Gulf Cooperation Council states. With Kuwait only 276 km (171.4 miles) from Bushehr, he expressed doubts about whether the IAEA has been imposing its safety standards at the plant. According to Dina Esfandiary, a research assistant at the International Institute for Strategic Studies (ISIS), Bushehr, unlike Chernobyl, has had some design upgrades, including a containment dome built out of reinforced concrete, but radiation could escape if an earthquake damaged the Bushehr plant's containment dome. According to Esfandiary, "Bushehr is located on the coast; any accident would directly affect Iran's neighbors, particularly Kuwait, the UAE and Saudi Arabia, due to the winds in the Gulf region blowing from East to West."²¹⁶

In addition, the Persian Gulf's water supplies would also be disrupted because of the nature of coastal currents circling counter clockwise.²¹⁷ The contamination of the Persian Gulf would pose an immediate risk to Arab states as they rely on desalination plants for their fresh water. Essentially, an accident at Bushehr would contaminate their water supply.

Design and Parts: Resurrecting Obsolete Technology

While the meltdown of the reactors at Fukushima was caused by the disruption of the cooling systems at Fukushima due to the external shocks from an earthquake and a tsunami, the risks of a man-made disaster at Bushehr are much worse than those from a massive natural disaster. As a hybrid nuclear plant that combines German design from the 1970s with Russian technology from the '90s adopted for Iran,

214 "Recent seismicity map of Iran," Iranian Seismological Center accessed 8 July 2011, <www.irsc.ut.ac.ir>.

215 "Kuwait Warns of Bushehr Disaster: Reactor is in Earthquake Zone," World Tribune, 1 October 2010, <http://www.worldtribune.com/worldtribune/WTARC/2010/ME_iran0964_10_01.asp>.

216 Dina Esfandiary, "Bushehr plant can resist quake, but still endangers Gulf," International Institute for Strategic Studies, 4 April 2011, accessed 8 July 2011, <www.iiss.org/whats-new/iiss-in-the-press/april-2011/bushehr-plant-can-resist-quake-but-still-endangers-the-gulf/>.

217 Ibid.

Bushehr is flawed at the level of conception, design and operation. As late as February 28, 2011, the Russian operators of the plant were forced to remove the nuclear fuel to “thoroughly clean the reactor core and the primary cooling system to remove metal shards left by the cooling pumps failure.”²¹⁸ Iran’s state-run Mehr news agency quoted Alexander Sadonikov, Russia’s Ambassador to Iran, as stating that the delay was necessary since it is better “to prevent unwanted consequences rather than to regret it later.”²¹⁹

The failure of Bushehr’s cooling pump is not a function of natural disaster, but rather potentially deadly technological flaws. Originally a joint venture with Siemens AG and AEG Telefunken in 1975, Iran planned to build two pressurized water reactors subcontracted to ThyssenKrupp AG based on the design of the German Biblis Nuclear Power Plant. The first reactor at Bushehr was scheduled for completion in 1980, and the second, in 1981. Dogged by more than 30 years of delay, abandoned after the revolution of 1979, damaged during the Iran-Iraq war in the 1980s, subjected to a hot and humid climate in which even stainless steel can rust, Iran signed a contract with Russia’s Ministry for Atomic Energy to revive the plant in 1995 by installing the V-320 915 MEE VVER 1000 pressurized water reactor. The project was scheduled for completion in 2001 and then, after yet another series of delays the Russians blamed on the lack of experience of Iranian subcontractors, the completion date was rescheduled for September 2007.

These delays speak volumes about the technical challenges of assembling a nuclear plant out of a collage of old, rusted and incompatible parts, under embargo conditions that have made it virtually impossible for Iran to tap into German expertise and documentation about more than 80,000 pieces of equipment and spare parts. Russian experts have thus had to graft the existing German stock with Russian technology, a costly process that has required constant additional testing and monitoring of the plant. In a joint press conference held February 26, 2009, with the Russian head of Rosatom, former Soviet prime minister Sergei Kirienko, Reza Aghazadeh, the head of the Atomic Energy Organization of Iran, explained the reason for delays at Bushehr quite succinctly. According to Aghazadeh, “24% of the parts and equipment used at the Bushehr power plant are German, 36% Iranian, and 40% Russian.”²²⁰ Expressing his satisfaction with the technical progress at the plant, Aghazadeh said that, “one must admit that changing the technology of a western reactor to a Russian one poses many difficulties, and naturally, this is the first nuclear plant of its kind and this nature to be put to use.”²²¹ Kirienko agreed. He stressed that the Siemens technology at the plant was more than 30 years old, and that it was necessary to carry out extensive experiments and tests in a responsible manner. As he put it:

“Until now, no one has succeeded in operationalizing such a plant, and, actually, completing the Bushehr nuclear plant is not the same as constructing a new plant but rather it is completing a plant that has been constructed by a company from another company, and

consequently, we have had to make extremely important technical decisions about it.”²²² When pressed to explain a decade of delays, the Russian nuclear boss wryly added that: “Of course, it is 35 years past the deadline.”²²³

In a post-Fukushima world in which Germany is looking to decommission 17 nuclear power stations, including its Biblis reactor in Hesse built in 1975, Iran’s approach to nuclear power seems to hinge on the denial of fact and distortion of truth. Rather than putting safety first, the head of Iran’s Atomic Energy Agency, Aghazadeh, claims that he expects the Bushehr nuclear reactor, one based on the Biblis design, and under construction since 1975, to generate power for another 50 years—an absurd proposition given that most nuclear plants that are correctly maintained have a 30- to 40-year lifecycle. The fact that Bushehr has experienced problems with its cooling system before launch due to shards, and has required years of additional testing, is a clear warning about the liabilities ahead.

Inappropriate Fuel Design: The Arak Anomaly

Iran’s leaders regularly use Iran’s nuclear program for publicity stunts that come at the price of eroding confidence in the actual operation of the plants. Design anomalies at Iran’s heavy water reactor plant at Arak, under construction since 2004, is a case in point. According to a report by the Institute for Science and International Security, the Arak reactor fuel assembly unveiled by President Ahmadinejad during his spring 2009 site visit are “of a surprising shape for a small 40 megawatt-thermal heavy water reactor and raise questions about whether it is indeed a fuel assembly for this reactor.”²²⁴ According to ISIS, the fuel element resembles those used in an RBMK (Reaktor Bolshoy, Moshchnosti Kanalniy) Soviet-era reactor (similar to Chernobyl), “a descendant of the large Soviet plutonium reactors built in the 1940s and 1950s.”²²⁵ Although the ISIS study considered it highly unlikely that like the RBMK, the Arak reactor was also designed for on-line refueling, they were left puzzled: “Even if this fuel assembly is intended for the Arak reactor, why would Iran seek to build a heavy water reactor around such an inappropriate fuel design?” They offered two possible explanations: One was that NIKIET, a Russian nuclear design institute with extensive experience designing the RBMK graphite-moderated power reactors and the VVER family of pressurized light water reactors, including the Iranian Bushehr reactor, could have helped Iran build the Arak reactor. Yet they added that “NIKIET has no known experience in heavy water moderated reactors of which only a few have ever been built in Russia.”²²⁶ The other possibility was that “Iran could have displayed a RBMK uranium oxide fuel assembly for publicity purposes, allowing Ahmadinejad to proclaim that Iran had “mastered” this important step of the reactor’s

218 Peter S. Green, “Failure at Iran’s Bushehr Nuclear Plant Raises Concerns about Safety,” *The Washington Post*, 7 March 2011.

219 Ibid.

220 “ASR-Iran News Analysis,” <<http://www.asriran.com/fa/pages/?cid=66101>>(Persian).

221 Ibid.

222 Ibid.

223 Ibid.

224 David Albright, Paul Brannan and Robert Kelley, “Mysteries Deep Over Status of Arak Reactor Project,” 11 August 2009, <<http://www.isisnucleariran.org/assets/pdf/ArakFuelElement.pdf>>.

225 Ibid.

226 Ibid.

fuel cycle.”²²⁷ ISIS’s examination of photographs from Ahmadinejad’s visit to the Fuel Manufacturing Plant at Esfahan during which he declared the plant operational also exposed glaring inconsistencies as “images from the tour indicate that much equipment is missing.”²²⁸

Contaminated Supply Chain: The Smuggler’s Haven

The Islamic Republic’s failure to build confidence in Iran’s nuclear program has had a dramatic impact on the quality, security and progress of Iran’s nuclear program. The 30-year delay in starting Bushehr, and the delay, cost, and safety concerns that plague the plant to this day reveal Iran’s plight. Rather than procuring nuclear parts from reliable sources such as Germany’s Siemens corporation, embargos and sanctions have forced Iran to turn to the dubious chain of nuclear junk dealers operating out of Pakistan and the United Arab Emirates. For all intents and purposes, Iran’s Atomic Energy Organization has had to become part of an illicit and informal nuclear underground, with all the associated problems related to quality, price, and security of smuggled parts originating from dubious sources. While enrichment technology is generally not sold to non-nuclear weapons states, the purchase of used nuclear equipment—including contaminated centrifuges—in the black market casts doubt on the Atomic Energy Organization of Iran’s planning, procurement, and quality control standards. It also exposes Iran’s nuclear program to grave security risks associated with double agents.

Abdul Qadeer Khan reportedly told investigators that the contaminated centrifuges found in Iran by the International Atomic Energy Agency were “broken and used centrifuges” sold as “scrap” to a Karachi-based company, ALCOP.²²⁹ An associate of Khan reportedly bought the centrifuges from ALCOP and sold them to Iran. Iran reportedly paid 2 million Pakistani rupees (about \$30,000) for contaminated Pakistani junk that not only jeopardized the safety and security of Iran’s nuclear program but also the credibility of Iran’s claims about the nature of its nuclear program. When one considers the fact that Iran was reported to have paid the same intermediary more than \$3 million for the whole lot, the grave dangers posed by the Iranian leadership and parliament’s failure to hold the Atomic Energy Organization of Iran accountable for purchasing nuclear junk at exorbitant prices becomes obvious. Iran has essentially degraded and delayed its own nuclear program by abandoning legitimate nuclear suppliers to settle for scrap purchased from questionable sources in the Pakistani black market.

Ideological Constraints: Diminished Expertise

The ideological subjugation of the Atomic Energy Organization of Iran, and the lack of independence of Iran’s Nuclear Regulatory Authority, points to the absence of an institutional framework for checking and monitoring Iran’s nuclear program. The rise of religious and political apparatchiks whose primary concern is propaganda has come at the

expense of Iran losing the professional depth, scientific expertise and the international cooperation necessary for building trust and relationships that are critical components of developing the expertise.

Iran’s development of its nuclear industry under a veil of secrecy means that there is no process for checking the claims or supervising the operations of the Atomic Energy Organization of Iran. It is not at all clear who is promoted to what position in the organization according to what level of scientific expertise, financial acumen, or management experience. The lack of transparency, accountability, and supervision has had serious repercussions in terms of ensuring compliance with international safety standards. Scientists who do point out problems with the design, construction, procurement, operation, and organization of Iran’s nuclear program expose themselves to retribution for pointing out the obvious. A grotesque political culture premised on nuclear xenophobia and paranoia has not only arrested, delayed, and damaged Iran’s nuclear development, it has transformed Iran’s nuclear program into a national and religious symbol whose management, operations, quality and security cannot be questioned.

In the aftermath of Fukushima, Japan’s cooperation with other advanced nuclear states meant that Japan could instantly draw on a deep global reservoir of knowledge, expertise and equipment. Thus, in the nuclear industry as in other industries, it is interdependence—not dated and paranoid ideologies premised on national independence—that enhances standards, ensures quality, drives productivity and delivers progress. The excessive and unnecessary politicization of Iran’s nuclear program under the guise of developing “indigenous” science is absurd, risky, and entirely unnecessary given that virtually all other Iranian industries—from oil to automotive, pharmaceutical to agriculture—rely on discoveries and technologies that originate in other countries. What should guide the development of Iran’s nuclear program is not any religious or political ideology, but quality, safety, functionality, maintenance and other basic scientific and economic values that establish trust in a product.

Security and Sabotage: The Stuxnet Precedent

Beyond the dangers of working with obsolete and incompatible technology, Iran’s nuclear plants lack adequate security and are vulnerable to sabotage. The vulnerability of Iran’s nuclear program led Dmitry Rogozin, Russia’s ambassador to NATO, to warn that the computer virus that had attacked the Russian-built nuclear plant at Bushehr could have led to a nuclear disaster on the scale of Chernobyl.²³⁰ Demanding a NATO investigation into the incident, Rogozin said that a virus had hit the computer systems at Bushehr. Comparing the computer virus impact to an explosive mine, he said that “this virus, which is toxic, is very dangerous, and could have serious implications...these ‘mines’ could lead to a new Chernobyl.”²³¹

Rogozin’s claims prompted the acting director of the Iranian Atomic Energy Commission, Mohammad Ahmadian, on February 4 to call for an investigation to verify Rogozin’s claims about major damage to Bushehr. Yet, despite the concern of the Russian government about the threat to Bushehr, vice-president Ali Akbar Salehi,

227 Ibid.

228 Ibid.

229 “Pakistan’s Khan says centrifuges sold to Iran as scrap,” Associated Press, accessed 28 December 2010, <http://www.breitbart.com/article.php?id=D91J2F800&show_article=1>.

230 “Russian’s Nato envoy: Iran-bound Stuxnet worm could have caused Chernobyl,” Reuters, 26 January 2011.

231 Ibid.

denied that the month-long delays at Bushehr were due to Stuxnet. He claimed that “during a washing process prior to loading the actual nuclear fuel, a small leak was observed in a pool next to the reactor and was fixed.”²³²

The Institute for Science and International Security reported that Symantec, the computer security company, had established that the Stuxnet virus “first infected four Iranian organizations in June and July 2009, and that in March, April, and May 2010, two of the original organizations were infected again.”²³³ Symantec tracked 12,000 collateral infections and concluded that the worm had targeted “the domestic portion of Iran’s supply chain for industrial control systems,” including the Siemens 315 and 417 programmable logic controllers (PLC). It would change the frequency of the converters controlling the speed of the centrifuge rotors. The Stuxnet virus malware targeted about 1000 IR-1 centrifuges out of about 9,000 deployed at the Fuel Enrichment Plant at Natanz, that the attack would last about seven minutes in a cycle that would be repeated every 35 days, and that the code would disable alarm and warning systems while sending false data to the command and control centers to conceal the sabotage.²³⁴

Stuxnet did much more than buy time by reducing Iran’s capacity to produce enriched uranium. It demonstrated the ability of foreign intelligence to launch a precise cyber-attack premised on being able to reproduce code based on having access to the most intricate operational details about Iran’s nuclear sites and equipment. It exposed a gaping breach in the security of Iran’s nuclear program. Foreign intelligence agencies had not only hijacked the command and control systems of Iran’s nuclear plants without being detected, but were able to penetrate Iran’s nuclear sites and nuclear establishment with malware by infecting Windows machines using USB keys. While it could not identify the authors of Stuxnet, ISIS concluded that “Stuxnet’s elaborate nature and its updating show a firm determination to sabotage Iran’s nuclear program.”²³⁵

Assassinations and Disappearance: Endangered Scientists

Finally, the Islamic Republic’s failure to protect Iran’s leading nuclear scientists and engineers from becoming suspects and targets in a deadly game of nuclear poker is cause for concern. On July 23, Daryoush Rezaiejad, a 35-year-old academic working for the Iranian Defense Ministry, was shot in the neck and killed. Last November, Majid Shahriari, a member of the engineering faculty at Shahid Beheshti University in Tehran, was assassinated. Fereidoun Abbasi, another professor at Shahid Beheshti hailed as Iran’s academic of the year, was wounded in an attack. Both were members of the “Nuclear Society of Iran.” Abbasi’s name appeared on the UN Security Resolution 1747 of March 24, 2007, describing him as a “senior ministry of defense and armed forces logistics scientist with

links to the Institute of Applied Physics, working closely with Mohsen Fakhrazadeh-Mahabadi, believed by Western intelligence to be in charge of the Iranian nuclear weapons program.”²³⁶ In January 2010, Massoud Ali Mohammadi, a particle physicist and supporter of the opposition movement, was blown up outside his home. In December, another nuclear scientist, Ardeshir Hassanpour, reportedly died from a gas poisoning incident. Rumors were that he was killed by Mossad. Another nuclear physicist, Shahram Amiri, was reportedly abducted on a pilgrimage to Mecca that June, and in 2007, Ali Reza Asghari, a high-ranking Revolutionary Guard general, reportedly vanished after checking into a hotel in Istanbul.²³⁷ In January 2012, another Iranian nuclear scientist, 32-year-old Mostafa Ahmadi Roshan, was killed in Tehran when his bomb-rigged car exploded (Figure 40).

Yet instead of creating a safe and secure environment for Iran’s nuclear scientists and engineers, the cloud of suspicion and secrecy surrounding Iran’s nuclear program converts Iran’s best minds into pawns in a game of nuclear poker in which they have become obvious targets of foreign intelligence agencies or hostages of Iran’s clumsy security establishment. Instead of taking steps to protect Iran’s best and brightest minds, the Islamic Republic treats them, their families, and the rest of Iran’s nuclear officials and workers as sacrificial chips.

As if assassinations and disappearances had not done enough damage to Iran’s nuclear program, accidents have also taken their toll. Rosatom declared that five of the Russian experts involved in the construction of the Bushehr nuclear plant were among the 44 passengers who died in a Tu-134 plane crash in Petrozavodsk. According to Amir Oren of Haaretz, the experts including lead designers Sergei Rizhov, Gennadi Benyok, Nicolai Tronov and Russia’s top nuclear technological expert, Andrei Topinov, had all worked on Bushehr through Hydropress, one of the main companies responsible for Bushehr’s construction.²³⁸ Given that so much of the Bushehr plant has been about technical improvisation, it will be very hard to replace the Russian experts with firsthand knowledge of Bushehr’s technical peculiarities.



Figure 43: Mostafa Ahmadi Roshan and son (Photo: AFP/Getty Images)

232 John Leyden, “Iran nuclear plant shutdown due to leak,” *The Register*, 5 October 2010, <www.theregister.co.uk/2010/10/05/stuxnet_unrelated_nuke_plant_leak/>.

233 David Albright, Paul Brennan, and Christina Walrond, “Stuxnet Malware and Natanz: Update of ISIS December 22, 2010 Report,” *Institute for Science and International Security* (report), 15 February 2011.

234 Ibid.

235 Ibid.

236 Julian Borger, “Who is killing Iran’s nuclear scientists,” *Julian Borger’s Security Blog* via *The Guardian*, 29 November 2010, <<http://www.guardian.co.uk/world/julian-borger-global-security-blog/2010/nov/29/iran-nuclear-weapons->>.

237 Julian Borger and Saeed Kamali Dehghan, “Allegations fly over Iranian scientist’s assassination,” *The Guardian*, 12 January 2010, <<http://www.guardian.co.uk/world/2010/jan/12/iran-scientist-assassination-allegation-west->>.

238 Amir Oren “Nuclear experts killed in Russian plane crash helped design Iran facility,” *Haaretz*, 23 June 2011, <<http://www.haaretz.com/news/diplomacy-defense/nuclear-experts-killed-in-russia-plane-crash-helped-design-iran-facility-1->>.

APPENDIX 3:

THE NATURE OF THE STRIKES: THE NUCLEAR OPTION

The use of tactical nuclear weapons to destroy Iran's nuclear facilities is highly unlikely but such use has been considered. We find it important to present the background surrounding this issue and provide the reader with estimated potential casualties if such a scenario is played out.

On April 9, 2006, *The Washington Post* reported that “the Pentagon and CIA planners have been exploring possible targets such as the uranium enrichment plant at Natanz and the uranium conversion facility at Isfahan.”²³⁹ The report added that “Pentagon planners are studying how to penetrate eight-foot-deep targets and are contemplating tactical nuclear devices.”

In an article published in *The New Yorker*, Seymour Hersh confirmed that the Pentagon's Iran plans included the use of tactical nuclear weapons—a remarkable revelation as it implied the use of nuclear weapons for tactical combat purposes as a substitute for conventional weapons.

As Hersh put it, ensuring the destruction of Iran's nuclear facilities meant reassessing the military effectiveness of conventional weapons. “The elimination of Natanz would be a major setback for Iran's nuclear ambitions, but the conventional weapons in the American arsenal could not ensure the destruction of facilities under 75 feet of earth and rock, especially if they are reinforced with concrete.”²⁴⁰

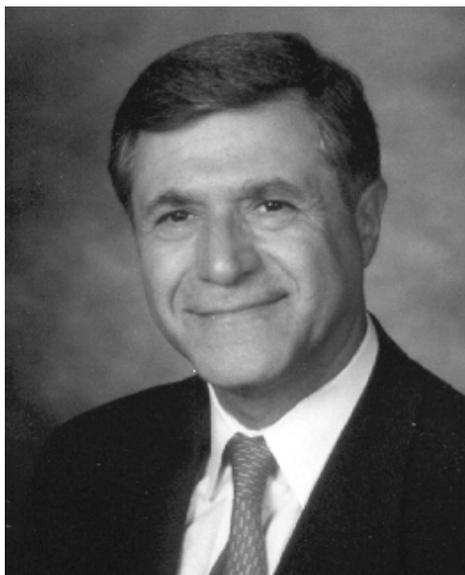
²³⁹ Peter Baker, Dafna Linzer and Thomas E. Ricks, “US Is Studying Military Strike Options on Iran,” *The Washington Post*, 9 April 2006.

²⁴⁰ *Ibid.*

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Khosrow B. Semnani was born in 1947 in Mashaad, Iran. Mr. Semnani, a Utah resident and naturalized citizen, completed his early education in Iran, later studied English in England, and earned dual Bachelor of Science Degrees in Chemistry and Physics from Salt Lake City's Westminster College in 1972. He later earned a Masters of Engineering Administration Degree from the University of Utah in 1977.

After several years of working in the mining and manufacturing industries he developed the first commercial toxic chemical and hazardous material disposal facility in the state of Utah. The Grassy Mountain facility has received, processed, and stored millions of cubic feet of highly dangerous and toxic chemicals and is currently owned and operated by the Clean Harbors Corporation.

In 1988 he licensed and developed Envirocare of Utah, the first U.S. commercial low-level nuclear waste disposal facility in the United States. This facility became the largest operation of its kind in the U.S. and for the next 17 years Envirocare safely received, processed, and disposed of radioactive and toxic chemicals from the EPA, Department of Energy, Department of Defense, nuclear power plants, and government research facilities. In 2005, Mr. Semnani sold Envirocare of Utah to a consortium of private investment firms, which later became Energy Solutions, Inc. As a physicist, he has excellent knowledge and understanding of the effects of chemical and radioactive materials on human health and the environment. Mr. Semnani was awarded an Honorary Doctorate of Science degree from Southern Utah University in May 2005 for his outstanding work in the field of nuclear waste management.

Mr. Semnani is currently engaged in international investments and worldwide philanthropic work. He lives in Salt Lake City with his wife of 29 years, Ghazaleh, with whom he has three sons.