Iran's Ballistic Missiles

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Introduction

Last year was particularly productive for Iran's missile and space program. In February 2009 the first Iranian satellite, the Omid, was launched on the locally manufactured satellite launcher Safir. Some two months prior, in November 2008, the Iranians held the first test launch of their two-stage ballistic missile, the Sejjil, which unlike its predecessors is propelled by solid fuel. An additional test with the same missile took place in May of this year.

Iran's missile system has generated headlines since the mid 1980s, but reports have generally been clouded as a result of the secrecy shrouding the Iranian program. These have been joined by vague and at times contradictory official announcements that have helped Iran to glorify its image both for domestic and foreign audiences, in terms of performance (e.g., the missile range), manufacturing capabilities, and operational capabilities. On the other hand, Iranian spokespeople at times try to obscure Iranian intentions and even assuage fears in the international arena (e.g., that the missiles are for defensive purposes only).

However, despite the fact that some of what has been written is exaggerated, the Iranian missile threat does exist, and it is important to try to understand it as it is. This essay attempts to examine what we know about this aspect of Iranian armament programs and to separate solid information both from good estimates and from clear overstatements.

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Shehab-1 and Shehab-2 Missiles[1]

Iran began to equip itself with ballistic missiles only in the course of the Iran-Iraq War, when it received Russian-manufactured Scud-B missiles from Libya. The first operational use of them was made in March 1985. Later in the war, Iran purchased more missiles, first from Libya (and possibly also from Syria), while at the same time turning to North Korea, who apparently became its main missile provider. At the height of the war, during the "War of the Cities" (March-April 1988), Iranian forces launched 77 missiles on Iraqi cities.

Towards the end of the Iran-Iraq War, Iran, with North Korean assistance, started to manufacture its own missile, called the Shehab-1. In the meantime, the Koreans developed an improved version of the missile (called the Scud-C in the West; apparently its North Korean name was Hwasong-6), with a range of some 500 km. By 1991, the capability for manufacturing this missile had already been transferred to Iran (and also to Syria) where the missile was named the Shehab-2.

There is no definitive data about the number of Shehab-1 and Shehab-2 missiles that Iran acquired. During the entire Iran-Iraq War some 120 missiles were fired. It was estimated that by the end of the war, Iran was left with only a few, but later Iran started to accelerate the rate of production and also bought ready-made missiles directly from North Korea. Because there is no reliable information about the number of missiles manufactured and purchased, all data published on the subject is speculative. The usual numbers mentioned are 18 launchers and some 300 missiles, but other sources estimate twice as many. The numbers are apparently based on an analysis of possible war scenarios, whereby it was possible to arrive at the number of missiles likely to be fired. (If so, it seems the calculation is based on an estimate of three missiles per launcher for each day of fighting over a six-day fighting period.) This estimate is also based on the assumption that a nation would not invest resources in manufacturing a larger number of missiles than it needs. In any case, in recent years Iran has not hesitated to launch Shehab-1 and Shehab-2 missiles in military exercises, and therefore it seems it is not worried about shortages in wartime and is interested in demonstrating the abundance of missiles at its disposal.

Shehab-3 Missiles

As early as 1988, North Korea started to develop a missile with a range far greater than that of the Scud, though based on the same technology. From its earliest days Iran was likely involved in this project, and may even have helped finance it. The first prototype of the missile was spotted by American intelligence in 1990, but its first successful test took place in 1993. It would seem that already in 1994 Iran started receiving components of the missile and apparently also the technology for assembling it, and later, for manufacturing it. In Iran, the missile was called the Shehab-3. Precisely at the same time, technology for missile manufacturing was also transferred to Pakistan, where the missile was called the Ghauri.

The first Iranian test launch of the missile took place in 1998, but it was only in 2001 that Iran officially announced that it was beginning its own manufacture of it. The Iranian program, however, encountered problems, which apparently were overcome only in mid 2003.

In 2004, a different model of the Shehab-3 missile was publicly unveiled for the first time. Externally, the missile had a different nose section, resembling a baby bottle. Contradictory reports in the Iranian media attributed different ranges to the missile, varying from 1,500 to 2,000 km. In the professional literature, this missile was named the Shehab-3A or Shehab-3M (these appellations were given to the missiles by researchers outside of Iran; this essay will use the term Shehab-3M). In September 2007, a missile, called the Ghadr-1 (or Qadr-1) by the official announcer, was displayed in a parade. The announcer declared that the missile had a range of 1,800 km. However, it appeared identical or almost identical to the Shehab-3M. (Since then, Iranian spokespeople have not used this term; opposition elements have used "Ghadr" for other missiles.)

The Shehab-3 has a mobile launcher, apparently locally manufactured, and built on the rear platform of a semi-trailer. A thorough examination of the photographs published by official Iranian sources reveals that there are at least five variations of this launcher. As with the Shehab-1 and 2, what we do not know about the Shehab-3 exceeds what we do. In addition to questions about the manufacturing of the missile, the number of missiles and launchers made to date is a matter of conjecture. Most sources estimate that there are up to six operational launchers, while the number of missiles is estimated at several dozen. In this case too there are sources that estimate much higher numbers, but neither the low nor the high numbers rest on concrete information.

In addition, in the case of all models of the Shehab-3, there are many questions about its actual performance. The standard claim for the range of the Shehab-3 is about 1,300 km, and for the Shehab-3M about 1,500 km. Very few researchers have actually undertaken an in-depth technological estimate of the missile on the basis of the little bits of available information. These researchers have estimated that if the warhead weighs 1,000 kg, the range of the Shehab-3 cannot exceed 930 km, and that of the Shehab-3M – 1,100 km. Decreasing the weight of the head to 500 kg would increase the range by only 200 km, i.e., 1,100 and 1,300 km, respectively.[2]

The Sejjil[3]

Published information about the development of solid fuel ballistic missiles has been around for over a decade. Initial reports were about "exchanging the Shehab engine," but at a later stage reports surfaced about the development of a solid fuel-propelled ballistic missile called the Ashura. At the same time, Iranian opposition elements reported on the existence of two missiles, the Ghadr-101, a single-stage missile, and the Ghadr-110, a two-stage missile. The names and the existence of these missiles have no confirmation from any other source.

In November 2008, the first test launch of a missile now called the Sejjil took place; a second test was held in May 2009. In both cases, official Iranian media published photographs of the launch, from which it is possible to conclude the following: the missile is a two-stage missile propelled by solid fuel; its dimensions, based on the photographs, seem very much like those of the Shehab-3; and the launch vehicle strongly resembles that of the Shehab-3. An in-depth technical analysis undertaken by scientists on the basis of the photographs concludes that the missile is capable of carrying a payload of 1,000 kg to a range of up to 2,200 km. Decreasing the warhead to 500 km would allow it a range of close to 3,000 km.

The missile is at present in development, and to date has undergone only two tests. In my estimation, some five years are needed to complete the missile's development and to introduce it into operational status.

As it enters active service, it will gradually replace the Shehab-3, which by then will be outdated and will gradually be phased out of service.

Other than the data supplied by the opposition regarding the existence of the Ghadr-101, there is no information about the development of a mid-range ballistic missile that would gradually replace the Shehab-1 and 2 as the operational missile for ranges of up to 500 km. Operational logic, however, requires the development of such a missile, and it is safe to assume that is has been developed in tandem with the two-stage Sejjil. In other words, I estimate there is a missile that is the first stage of the Sejjil without the second stage, or that such a missile is being developed.

BM-25

According to reports, in 2005 Iran received 18 missiles called BM-25 from North Korea, which were actually Russian missiles of the R-27 model (a model called the SS-N-6 in the West). This was a ballistic missile, with a 2,500-3,000 km range, meant to be launched from submarines. The missile was in use in the USSR in the 1960s, but was withdrawn from service. Based on these reports, North Korea obtained a number of such missiles and transferred some to Iran.

The reports were not verified by other independent sources, and it is also not known whether the missile has been modified for launching from a ground-based launcher or has been introduced into operational service in Iran. Uncharacteristically, Iran has not reported the existence of this system in service. The standard assessment has been that the missiles were purchased in order to serve as models for reverse engineering processes, by which Iranian (and North Korean) engineers were hoping to acquire more advanced technologies than those they already have.

Safir

In February 2009, Iran launched its first homemade satellite using the Safir satellite launcher, also locally manufactured. This was the climax of an effort Iranian spokespeople had talked about for years: the desire to acquire independent satellite launch capabilities. The successful launch of the satellite was preceded by a number of tests – of sub-orbital rocket launches – in February 2007, February 2008 (when the Iranian media called the missile the Kavoshager, though the name may have indicated the payload rather than the missile), and again in August 2008. At that time, the satellite launcher was also put on public display, the name used was Safir, and photographs were published.

The Omid satellite itself was a small research satellite, carrying communications equipment, telemetry, and long distance sensors. It entered orbit at altitudes of 252.7-384.5 km in a trajectory with a 55-degree incline, and circled the earth every 90.8 min. In late May 2009, the satellite completed its mission, and probably reentered the atmosphere where it was incinerated.

Based on analyses of photographs and video clips, it seems that the launcher is propelled by liquid fuel. According to every indication, its first stage is based on the Shehab-3/No-Dong technology, whereas its second stage, also propelled by liquid fuel, is much shorter, and propelled by an engine with two combustion chambers – very different from the engine of the Scud and its clones. In the estimation of some researchers, this was the Russian R-27 (otherwise known as the SS-N-6 or BM-25) missile's vernier motor – a small motor used to steer the missile. Because this engine uses more energetic fuels, it was enough to propel the Omid satellite – probably weighing no more than 20 kg – into a low earth orbit. On the basis of this estimate, Iran (and North Korea) acquired the old missile in order to use its engine as is (which does not exclude the possibility of attempts at reverse engineering in order to arrive at independent manufacturing of those parts).

The Safir satellite launcher is part of Iran's ambitious satellite program. Iran intends to launch other satellites into space, both indigenous and foreign, using both local satellite launchers and launchers bought from foreign suppliers. The Safir is a notable technological achievement, but it represents the peak of the technology it uses. It cannot carry into space satellites weighing more than 20-30 kg. If Iran intends to launch other satellites, the current launcher will limit the possibilities. Heavier satellites will require the development of a different satellite launcher based on more advanced technology.

Many experts have dealt with questions focusing on possible uses of the Safir as a missile for operational purposes, specifically, as a surface-to-surface missile with a greater range than the Shehab-3. In my estimation, such a discussion is futile. A satellite launcher is launched from a fixed launch pad and is assisted by a launch tower. Preparing it for launch is a long project. It is hard to imagine it as a missile in any kind of operational scenario. It is inflexible and cannot be hidden, is vulnerable to preemptive attack, and in current scenarios does not bestow any sort of operational advantage. It is also safe to assume that the satellite launcher is under the purview of a non-military institution.

The Technology

Engines. This year Iran proved its capabilities with two-stage systems, both liquid fuel and solid fuel technology. However, a close look at the achievements reveals their limitations, especially with regard to all the liquid fuel missiles launched to date, which were all based on Scud technology. We know nothing about any Iranian or North Korean success in designing a new engine or in constructing a different engine, not to mention engines propelled by more energy efficient fuels.

The Shehab engine is identical to the Scud engine, except that it is about 1.5 times larger. A development process of this sort has no precedent in the history of rocket engine development. In fact, the difficulty this entails is so great that some researchers have estimated that the photographs of the engine displayed were doctored, and that the missile uses a foreign-bought engine, apparently from Russia. In either case, it is still an engine based on proven technologies from the 1950s. Currently, Iran does not have the technology to launch missiles to greater distances or to carry heavier satellites.

Guidance systems. Does the Shehab-3 use a Scud-generation guidance system or does it have a more advanced one? Concrete information is unavailable, but Iran's success in launching the Omid signals that is has access to more advanced systems than those of the Soviet Scud. Thus it is safe to assume that the ballistic missiles have also benefited from this capability and they are capable of attaining greater precision than the Scud. Still, these are inertial guidance systems, operating only during the acceleration stage. There is no information about the existence of guidance systems for the final steering stage, or about the existence of steering capabilities of the penetrating body during the penetration stage.

Solid fuel technology. Solid fuel missile technology differs in essential ways from liquid fuel technology, and therefore involves a very different type of expertise. The engineering problems in production involve precise casting of the fuel, with uniformity and composition critical to the missile's performance. Because of this, the difficulty grows exponentially the larger the missile. Therefore, the capability of manufacturing short range artillery rockets is very far from that of manufacturing long range ballistic missiles, even though the type of propellant is the same.

Iran was exposed to solid fuel technology when it started to manufacture the Oghav artillery rocket, apparently a version of a Chinese rocket, back during the Iran-Iraq War. During the 1990s, Iran developed a large number of artillery rockets with increasing diameters and ranges (the largest of which was the Zelzal-2 with a diameter of about 61 cm). It apparently also advanced from dual-based engines to engines using composite fuel. Such technology requires extremely meticulous quality control during the manufacturing process, but allows for the production of engines with large diameters.

With the launch of the Sejjil, Iran proved that it has the technological capacity to manufacture a two-stage engine with a diameter of about 1.25 m. (The Sejjil's diameter is estimated to be similar to that of the Shehab-3.) As with other missiles, the question remains whether this is the result of Iranian development or imported technology.

Indigenous Manufacturing Capabilities

It is well known that when Iran started to launch missile manufacturing processes it had to import numerous components that could not be made in Iran. In particular, it was estimated that Iran was incapable of manufacturing the missile engines or guidance systems. Today there is no definitive information on the subject; there are those who doubt Iran's capabilities of manufacturing its engines and guidance systems (especially the gyro systems). The tendency is to compare Iran's' capabilities to what Iraq possessed in the past, but it seems that for a long time Iran has demonstrated far greater capabilities. In my estimation, Iran is currently capable of manufacturing the engines at home.

As for the gyro systems, when Iran put the guidance system of the short range Fatah-A110 missile on public display; it showed a small gyro with only one degree of freedom, insufficient for a full inertial guidance system. There were those who viewed this as the outer limit of Iranian capability, and therefore concluded that for guidance systems Iran is dependent on imports or at least on imports of their critical components. By contrast, others feel that Iran has the capability of also fully manufacturing the guidance systems at home. It is likely, however, that Iran still needs many items that can be obtained only outside of Iran, such as electronic components and certain metals, but they have no trouble attaining them.

North Korean Assistance

The improved Scuds and the No-Dongs were developed in North Korea, where engineers were successful in both reverse engineering and in introducing improvements and expansions. Nearly two decades have passed since then, and Iran is much less dependent on North Korea. In fact, it may be that by now the flow of technology has reversed. Examples of this are the Shehab-3M and the success of the Safir satellite launcher.

Furthermore, it is a commonplace that the technological and scientific knowledge of a country is closely linked to the relationships that the country's scientific elite has with science communities around the world. While North Korea has remained a sealed society, Iran has never been cut off from the world, and in particular, from the world of technology. Under these circumstances, it has a better basis for generating scientific and technological achievements than North Korea.

Chinese Assistance

Solid fuel technology could not have reached Iran from North Korea, which itself lacks it. Thus the most probable source of assistance was China. China sold arms to Iran as early as the Iran-Iraq War, when Chinese assistance included artillery rockets as well as sea-to-sea missiles, all propelled by solid fuels. In the early 1990s, China began to market the M-9 (known in China as the DF-15) and the M-11 (known in China as the DF-11) missiles in the region. There is no definitive information about the sale of these missiles to any nation in the region, but hypotheses have been raised about the missiles being sold to Pakistan and Iran. When Pakistan publicly displayed the Shaheen-2 and Ghaznavi missiles, some claimed they were identical to the Chinese M-9 and M-18 missiles. (An examination of photographs of the Sejjil shows that it does not resemble the Pakistani missile.)

It is likely that Iran was in need of external assistance in order to adopt the technology, and China is of course the most probable source for this technology. The questions remaining are: were the Sejjil engines cast in an Iranian factory or were they imported in toto? Does Iran have the capability of casting such engines? And is this capability dependent on the presence of foreign experts, or has Iran overcome the problems and adopted the technology fully?

Another type of assistance, also likely with Chinese roots, lies in the guidance systems. China has great capabilities in the field of guidance systems, and if Iran is acquiring the guidance systems for its missiles rather than manufacturing them at home, China is almost certainly the most important source.

Russian Assistance

Another open question concerns Russian aid to the Iranian missile program. Officially, there is no such assistance, and it is indeed likely that if such assistance does exist, the government either does not know about it or is turning a blind eye. There are those who are convinced that neither Iran nor North Korea is capable of developing the No-Dong/Shehab-3 engine without the help of Russian experts.

In addition, highly reliable information indicates that during the 1990s Iran was able to obtain RD-124 engines developed at the end of the 1950s, serving the Russian R-12 missile (also known by its American name, the SS-4). Other assistance apparently took the form of supplying Iran with the R-27 missile via North Korea. How these missiles found their way from Russia to North Korea, and whether the Russians knew about their transfer to Iran are open questions, especially in light of the fact that Russia committed itself to destroying these missiles as part of the INF agreements with the United States in 1987. However, it is hard to believe that the missiles came to North Korea and from there to Iran without the agreement – or at least studied ignorance – on the part of the Russian authorities.

Conclusion

When discussing the Iranian missile threat it is important to remember that there is very little solid information, and much of the information appearing daily in the media is based on more or less reasonable estimates.

The existence of the Shehab-3 is a documented fact. Tests carried out with this missile (ten to date) were followed by Western intelligence services, even though the information gathered by the services was never published. The range of the missile and its payload capacity are a matter of speculation, but at least here the range of uncertainty is fairly clear: a range of 900 to 1,500 km and a payload capacity of 500 to 1,000 kg (varying according to the different models of the missile).

In estimating the current threat, the number of missiles in storage is an important variable, as is Iran's capability of manufacturing them domestically. Here, the range of uncertainty is quite wide: from a few missiles according to the most skeptical to several hundred according to the most alarmist, and from zero manufacturing capability or great dependence on imports, to almost unlimited capability of production at home.

In addition, satellite launching capability is another proven fact, including the existence of a dual-stage launcher with liquid propulsion, and this would seem to indicate the existence of the necessary technologies for launching satellites in the fields of propulsion, steering, and guidance. Uncertainty remains with regard to Iran's capability of manufacturing these technologies indigenously and independent of foreign assistance, and its capability of retooling the missiles to become operational ballistic missiles. Here, speculation outweighs solid information.

As for the solid fuel missiles, the existence of an experimental two-stage missile with solid fuel propulsion is, again, a proven fact. However, even according to the most pessimistic forecasts, this missile is still in development, and it will be several years before it can become operational. It is almost certain that when the time comes the same questions about independent manufacturing will arise, as well as questions about the number of missiles liable to be part of Iran's active order of battle.

When a nation attempts to deal with an external threat, relying on ominous estimates is only logical. At the same time, it is important to remember that just as there is a price for relying on rosier estimates (if I have failed to prepare, my enemy can hurt me), relying on the dire ones also carries a cost (which I paid by spending on constructing defenses against what turns out to be a nonexistent threat). It is also clear that should a decision be taken to invest in defenses, decision makers will tend to prefer the pessimistic estimates and publicize those rather than the conservative assessments. However, researchers and intelligence personnel must not allow this pressure to color their work.

Notes

1 The missile's name is often spelled "Shahab" or "Shihab." Consultation with speakers of Farsi convinced me that the spelling "Shehab" is the best representation of the actual pronunciation.

2 The sources for the technical analysis are: Charles P. Vick, www.globalsecurity.org; Theodore Postol, *Technical Addendum to the Joint Threat Assessment on the Iran Nuclear and Missile Potential*, The East West Institute, May 2009 at www.ewi.info/; Robert H. Schmucker, *Iran and Its Regional Environment*, Second Transatlantic Conference, Berlin, March 2006 at www.hsfk.de; and Norbert Brügge, *Space Launch Vehicles* at www.b14643.de/Spacerockets_1/.

3 There are at least six different transliterations of the missile's name in different sources.