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Iran: Keeping the Oil Lifeline Open

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An Intelligence Assessment

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September 1987

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An Intelligence Assessment

This paper was prepared by Office of Global Issues. It was coordinated with the Defense Intelligence Agency.

Comments and queries are welcome and may be directed to the Chief, Strategic Resources Division, OGI,

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Iran: Keeping the Oil Lifeline Open [redacted] 25X1

Key Judgments

Information available as of 3 August 1987 was used in this report.

We believe that Iran can maintain currently allowed OPEC production levels and current crude oil export levels for the next several years in the face of any likely level of Iraqi air attacks. Among Baghdad's likely options, only sustained attacks on Iran's refineries would have the potential to disrupt seriously the Iranian economy and its war effort. Thus far, Iraqi attacks on shipping in the Persian Gulf have done little to disrupt Iranian oil exports. Nevertheless, the cumulative effect of Iraqi attacks and reduced field maintenance have sharply cut Iran's excess production capacity, making a sustained increase in exports highly unlikely even in the absence of hostile action. [redacted] 25X1

Iran has shown an impressive ability to cope with increased Iraqi air attacks on its oil system during the past 18 months. Baghdad's strikes in the late summer and fall of 1986 temporarily reduced Iran's oil exports by a third and its refining capacity by three-quarters. Resourceful Iranian countermeasures, combined with Iraq's failure to mount effective followup attacks, allowed Tehran to rebuild capacity and reduce its susceptibility to long-term disruptions. Tehran has restored its exports to their preattack level, reestablished a large surplus export capacity, and rebuilt its refining capacity to about 90 percent of earlier levels before an August 1987 attack on the Tabriz refinery. [redacted] 25X1

In response to the Iraqi air campaign, Tehran has developed a strategy based on "low tech" repairs and increased redundancy to reduce vulnerability. Iran's initiatives include adding export facilities to decrease reliance on Khark Island and developing innovative ways to continue tanker loading operations at Khark despite major facilities damage. Iran has easy access to Western-made parts and services and can readily purchase needed equipment—even that manufactured in the United States. In addition, Tehran has established links that enable it to ship major pipeline equipment out of the country for repair or maintenance. All of these measures reduce the likelihood of long-term disruption. [redacted] 25X1

The simplicity of Iran's export system, despite its vast size, has contributed greatly to Iran's ability to maintain exports after numerous attacks. Built by Western contractors in the prerevolution era to handle much larger volumes, most parts of the system still have considerable excess capacity at recent flow rates of 1.7 million barrels per day (b/d). Pipelines, pump stations, control facilities, the Khark Island export terminal, and the tanker shuttle system could all absorb substantial additional damage before

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exports would be affected for more than a short period. Continued repairs, as well as additional capacity being built, will add further to the redundancy and resiliency of the system. Unless Iraqi attacks were carried out with far greater frequency than in the past, we would not expect Iranian export capacity to fall below 1 million b/d for more than 30 days. Although we believe Baghdad has the capability to increase the frequency of attacks, its willingness to do so may be diminished because Iraqi leaders are sensitive to even minor aircraft losses.

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Given the redundancy of the export system, Baghdad's best option for slowing the Iranian economy and war effort lies in shifting its operations away from the Persian Gulf and attacking the domestic supply of oil products. Tehran's refineries are clearly vulnerable to air attacks. Despite the recovery of this sector from last year's damaging attacks, Iran still must import 25 percent of its requirements and has little pipeline capacity to increase imports.

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Such a shortfall would

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have broad impact on economic and, to a lesser extent, military activities. To reduce this vulnerability, Tehran is moving ahead with plans to install additional refinery capacity at the outer edges of Iraqi air range. It would take about two years, however, before any of these facilities could be operational even if construction contracts are signed soon.

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In contrast with the export system, Iran's production system has little excess capacity. In the oilfields, cutbacks in development drilling and well maintenance have eroded production potential. Our analysis indicates that problems with reservoirs and wells currently pose the most significant constraint on any major expansion of production and exports, probably limiting Iran's output to 3.0 million b/d or less. Although we believe that recent oil production of about 2.5 million b/d can be maintained for the next few years with current levels of field work, any curtailment of drilling and well repairs could have a dramatic effect on long-run production and export potential. We doubt that production, even with major investments, will ever recover to levels achieved during the Shah's reign.

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Introduction

Oil, long the mainstay of the Iranian economy, remains the financial underpinning of the Islamic regime and its war effort against Iraq. Production began in the early 1900s and built to a peak of more than 6 million barrels per day (b/d) in 1974 under the Shah. Although struggling to cope with Iraqi attacks against oil facilities, Iran managed to produce nearly 2.5 million b/d of crude oil in the first half of 1987—slightly above the level permitted under the OPEC agreement. Oil exports ran at about 1.7 million b/d during that period and accounted for nearly 94 percent of Iran's total foreign exchange revenues. Intensified Iraqi air attacks and loss of considerable capacity since the start of the war have forced Tehran to devote more effort to keeping its oil lifeline open.

The Oil Lifeline

With extensive Western help, the Shah built a highly integrated combination of facilities for oil production, refining, importing, and exporting (figure 1):

- Crude production facilities include oil wells, saltwater removal equipment, gas-oil separation plants (GOSPs), and gas handling equipment. These facilities serve both export and domestic systems.
- Crude export facilities include export terminals, pipelines, and booster pump stations.
- Oil product facilities include refineries and product import facilities, as well as pipelines and pump stations that serve these facilities.

Despite its vast size, the Iranian oil system is fairly simple in design. Crude oil is collected from wells in onshore fields in southwestern Iran by small-diameter gathering lines, which feed centralized production units where oil and natural gas are separated and saltwater is removed. After leaving the production units, oil flows in a southeasterly direction through larger trunklines to Khark Island for export or is sent to refineries in the north for further processing and domestic distribution (figure 2). Nearly all of Iran's exported crude is shipped through Khark Island. Most of it is shuttled via an Iranian tanker fleet to storage vessels at Larak Island, where Iranian customers can lift crude relatively free from risk of Iraqi attack. All but one offshore field in the northern Persian Gulf have been shut in since early in the war, and most offshore production in the southern Gulf has been interrupted by Iraqi airstrikes on oil platforms late last year.

Figure 1
Iran's Oil System

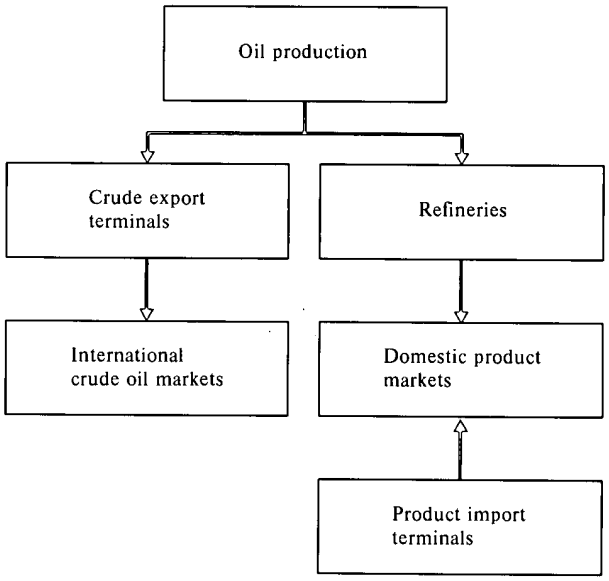

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Figure 2
Major Oil and Gas Facilities in Iran

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Table 1
Major Recent Air Attacks on the Iranian Oil System

	Facility	Damage	Recovery Time
1986			
May	Gorreh booster pump station	Pumps	Damage bypassed in two weeks.
	Tehran (Shahr-e Rey) refinery	Major equipment	Fully repaired in six months.
July	Bakhtaran refinery	Extensive	Remains shut down.
August	Esfahan refinery	Major equipment	Fully repaired in three months.
	Khark Island export terminal	T-jetty; four additional berths unusable	Repairs ongoing. Capacity reduced to 3.8 million b/d.
September	Refinery feed pump stations	Major pump	Bypassed and partially repaired in three weeks.
	Tabriz refinery	Major equipment	Partially repaired in two months. Now fully restored.
	Khark Island export terminal	Closed northern end of T-jetty	Restored use of two berths in two weeks. Capacity reduced to 3 million b/d.
October	Shiraz refinery	Major equipment	Fifty percent restored. Could be fully repaired by late 1987.
1987			
August	Tabriz refinery	Major processing equipment and pipeline	Shut down for at least two months.

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Iraq's 1986-87 Air Campaign

Since May 1986, Iraqi air attacks on the Iranian oil system have become more numerous and effective as Baghdad modified its tactics and increased its capabilities (table 1). With few exceptions before May 1986, Iraq's airstrikes were limited to high-speed, high-altitude bombing tactics. In 1986 Iraqi aircraft began lower altitude, slower attacks using more sophisticated weaponry, such as laser-guided munitions, which dramatically increased their effectiveness. Iranian oil installations at Khark Island were severely damaged in six low-level attacks since June 1986, and several important pump stations onshore were damaged. All six Iranian refineries have been hit, and facilities at all major operating oilfields have sustained at least minor damage. Iraq, however, has not maintained sufficient pressure to cripple Iran's economy by halting exports or shutting down refineries for a prolonged period.

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Iran's Response Strategy

The Iraqi air campaign of 1986 forced Tehran to adopt a more responsive and resourceful strategy to preserve its oil system. During the early years of the war, the large redundant capacity Iran inherited in oil production and export facilities enabled Tehran to rely almost entirely on unused capacity to offset losses caused by war damage. Over the years, much of this surplus capacity has been whittled away by successive Iraqi attacks, lack of maintenance, and cannibalization. Although the redundancies and broad capabilities built into the initial system—especially compared with current low flow rates—continue to provide Tehran with many options to keep its oil flowing, Tehran increasingly is having to work harder and more creatively to maintain the resiliency of its system.

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Key elements of Tehran's strategy are a number of "low tech" countermeasures to reduce the system's vulnerability and add redundancy to lessen the impact of damage:

- *By burying pipelines and controls*, Iran has reduced the exposure of many relatively easy targets as well as the risks of spreading fire or collateral damage.

- *By adding equipment and pipelines that increase redundancy and flexibility*, Iran has reduced its dependence on key chokepoints in the oil system. For example, Tehran has undertaken a major reconfiguration of the flow control manifold at Ganaveh, in part to accommodate new single buoy moorings off the coast that will increase export capabilities and reduce dependence on Khark Island.

- *By enhancing its repair and replacement capabilities*, Iran is also able to mitigate the impact of damage. Tehran has increased its inventory of spare parts and made use of innovative techniques that reduce downtime, especially at Khark, which has borne the brunt of Iraqi air attacks and where every tanker loading berth has been out of service at some time.

- *By installing antiaircraft weapons and building safety carriers for personnel and equipment*, Tehran is attempting to improve protection for critical components. Key equipment at refineries and pump stations is being surrounded by 3-meter-high barriers to protect workers and reduce potential damage from flying debris or truck bombs.

The refining sector has posed a particular challenge for Tehran. The loss of the Abadan refinery early in the war eliminated Iran's surplus refining capacity and forced Tehran to respond quickly. Iran accelerated the completion of the Esfahan refinery, added components to other refineries, and expanded arrangements to use spare refining capacity in other countries. When Baghdad recently began targeting Iran's refineries more systematically, Iran increased its capacity to import products and took steps to add refining capacity.

Tehran's Access to Western Equipment and Services

Access to Western oil equipment is critical to Tehran's survival strategy and has not presented problems Spare pumps and possibly spare tanker mooring buoys have been stocked, Kala—the London-based purchasing arm for the National Iranian Oil Company (NIOC)—has had authority since 1985 to purchase equipment and spare parts from any source, including US manufacturers. Typically, the process of purchasing equipment is slow, which has led NIOC to stockpile spare parts and even large equipment items in anticipation of war damage. In emergencies, the acquisition process has been improved by streamlining internal procedures, buying used equipment, and authorizing expensive airlifts.

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Iran also has had few problems obtaining Western services.

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Erosion of Productive Capacity

Iran's oil production potential has eroded substantially since the beginning of the war, largely from deteriorating subsurface conditions and declining well capabilities rather than from damage inflicted by the war (figure 3). Iran's reservoirs and wells are in poor condition and are probably getting worse. We believe that reservoir and well problems currently limit the maximum production capability of Iran's onshore oilfields to about 3 million b/d. Iran's reservoirs suffer severely from

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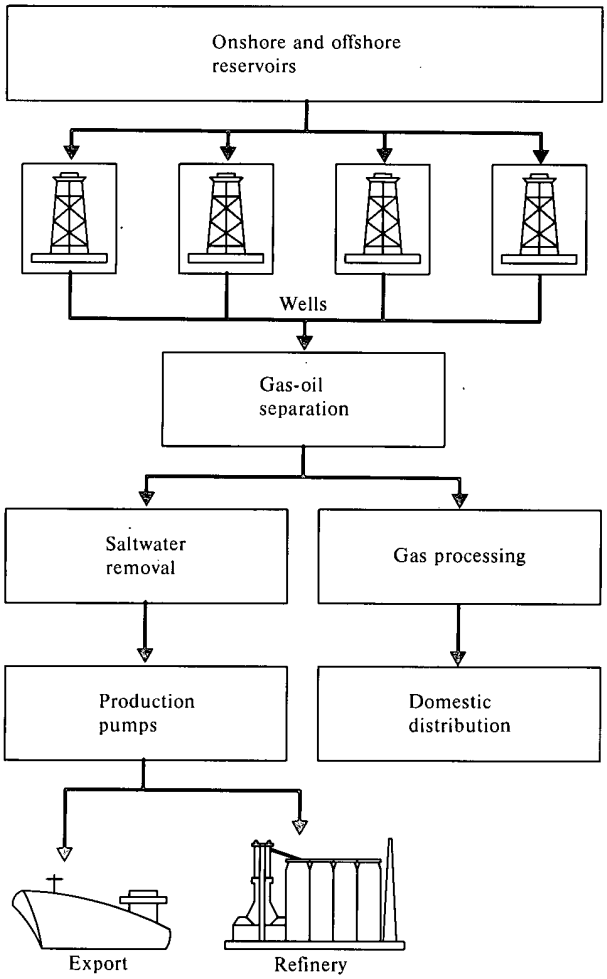
Figure 3
Iran: Crude Oil Production Subsystem



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inadequate maintenance and the postponement of gas injection plans developed in the late 1970s. Moreover, new wells must be drilled continuously to offset lost production from older wells—about four months is required to complete one well—and existing wells need constant attention.

Iranian Production Outlook

We doubt that Iran will ever approach production levels achieved during the Shah's regime, even with a sizable financial commitment and continued access to Western equipment and services. Oil production fell sharply from 5.2 million b/d in 1978 to less than 3 million b/d following the fundamentalist revolution and to below 1.7 million b/d in the early months of the war with Iraq. In 1987 production has averaged nearly 2.3 million b/d. Iran would have to expend considerable resources to reverse its decline in production capability and boost output substantially over the next decade. We estimate that in the production area alone more than $1 billion would be needed to repair collapsed well casings, corroded tubing, and downhole equipment and to contend with reservoir pressure losses. 25X1

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We believe that it could take as long as 10 years to expand production to about 4 million b/d. 25X1

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unless this minimal level of activity is maintained, production could decline 25X1 25X1

Although the extent of deterioration in Iran's reservoirs is unclear, we believe that even serious damage and recent budget cuts—because of the decline in oil prices and the economic drain of the war—will not prevent Tehran from producing at its current OPEC ceiling of 2.4 million b/d at least for the next few years. Budget cuts that further reduce drilling and maintenance could quickly change this outlook. 25X1

Iran's onshore production processing capacity remains more than 6.5 million b/d, in our judgment—reduced from 1985 levels of nearly 8 million b/d but still more than double current production levels. We believe that 34 oilfield processing areas remain in service out of 48 originally constructed. Only five of these have been totally or partially shut down because of war damage; 25X1

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Gas System Shortcomings Preclude Early Resumption of Exports

Despite recent press attention to increased contacts between Soviet and Iranian officials on the resumption of natural gas trade, we believe that the potential for boosting revenues by exporting gas to the Soviet Union is slight until the war is over. In the 1970s, Iran exported an average of nearly 10 billion cubic meters (bcm) per year of associated natural gas to the Soviet Union through the IGAT I pipeline from oilfields in the south. Planning for even higher exports and added domestic requirements, Tehran and Moscow embarked on a major cooperative project to construct a second pipeline to the Soviet border from the giant Kangan gasfield in southern Iran that would deliver 17 bcm annually to Western Europe. Exports stopped in March 1980, however, when the Soviets balked at Tehran's demands for a fourfold gas price increase. Iran claimed that it lost $130 million a year from Soviet gas trade.

Even if a major breakthrough in Soviet-Iranian relations led to an agreement to resume exports, gas produced as a result of current Iranian oil production would not be sufficient to support gas exports at previous levels—nearly 7 million b/d of oil production would be required to produce 8 bcm per year of gas for export. A number of expensive and time-consuming projects first need to be undertaken, such as completion of the Kangan gas facility to process nonassociated gas, completion of the IGAT II pipeline and installation of compressor stations needed to move the gas from southern Iran, and repairs to compressors and pipelines along the IGAT I pipeline to the Soviet border. Tehran might also insist that gas facilities in the oilfields damaged as a result of the war be repaired before exports resume to ensure that increasing domestic demands served by the IGAT I pipeline are met. Leadtimes to complete these projects, if done simultaneously, could exceed a year. 25X1

In addition, Iran should give high priority to reinstituting a costly gas injection program to prevent oil reservoir damage, in our view, before exports are considered. Such a program could cost about $5 billion and take more than four years to complete, but without it Iran faces the prospect of more rapid depletion of its oil resources and erosion in oil productive capacity. 25X1 25X1

the others were shut down because of low oil production, were never put in service, or have been cannibalized for parts. Over half of the 34 oilfield processing areas are in four major onshore oilfields—Marun, Agha Jari, Ahvaz, Gachsaran—and account for 70 percent of Iran's current oil production of 2.5 million b/d.

Iraqi aircraft have damaged equipment at nearly 30 percent of onshore processing facilities. Bomb damage, however, is scattered throughout the facilities, suggesting that Iraqi pilots may not have been aware of the location of the critical pump houses or were not concerned with accuracy. In many cases, damage was limited to gas compression equipment, which could affect gas supplies available for domestic consumption and possibly for reinjection to support long-term oil production, but has no immediate effect on crude exports or refinery supplies. 25X1

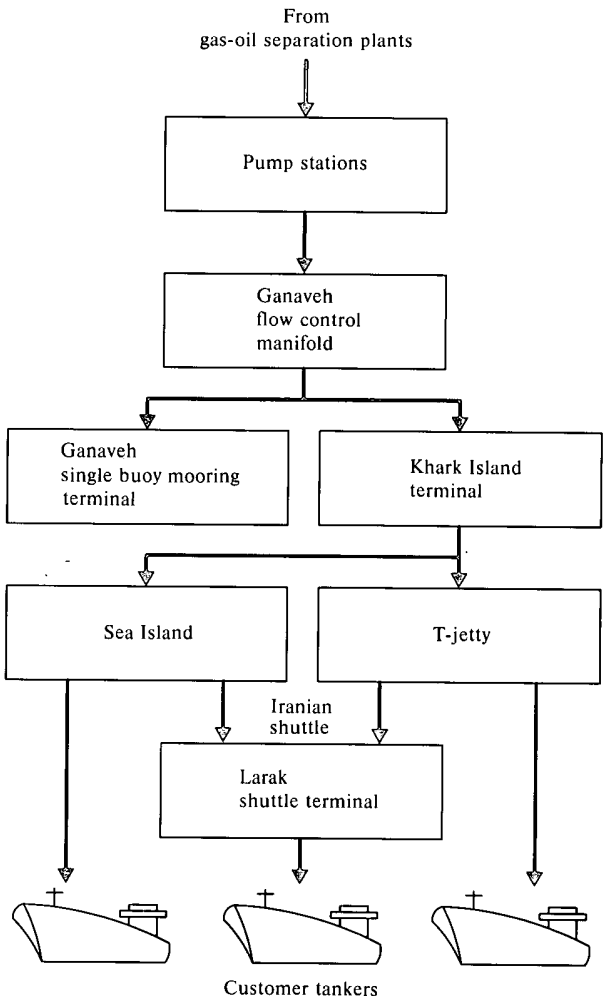
Iran's onshore oil production facilities are among the least vulnerable parts of the oil system to air attacks because they are scattered throughout southwestern Iran and have considerable redundant capacity. Over half of the nearly three dozen operating gas-oil separation plants would have to be destroyed to drop production below Iran's current OPEC quota of 2.4 million b/d. 25X1 25X1 25X1 25X1 25X1 25X1

Damage to other equipment within the processing area would not impede production significantly.

In our judgment, a continuous and intense Iraqi air campaign that simultaneously destroyed the oil pump houses at gas-oil separation plants in the four major oilfields would be needed to restrict severely Iranian oil production. Although Iran has received replacement pumps [redacted] a loss of this magnitude could limit production to about 1 million b/d—less than half of current output—for several months. Undamaged fields capable of producing more than 2 million b/d before the war probably are now incapable of producing near that rate because of the lack of use and maintenance. [redacted]

Offshore production accounts for only about 5 percent of Iranian oil exports—down from about 10 percent in late 1986. Only two of Iran's 20 offshore oilfields in the Persian Gulf are operating—Fereidoon in the north and Sirri in the south. Fereidoon production is moved through underwater pipelines to Khark Island, where it is exported and is normally counted with other exports from Khark. Sirri oilfield production is fed through underwater pipelines to Sirri Island, where it is exported or moved by tanker to the Lavan refinery. Until late 1986, oil was also produced from Sassan, Rostam, and Rakhsh fields in the southern Gulf. This production served processing and export facilities at Lavan Island, but an Iraqi attack at Rostam and Sassan platforms in November 1986 stopped production at all of these fields. [redacted] Sassan—capable of producing as much as 130,000 b/d—suffered severe damage and will need major reconstruction. [redacted]

Figure 4
Iran: Crude Export Subsystem



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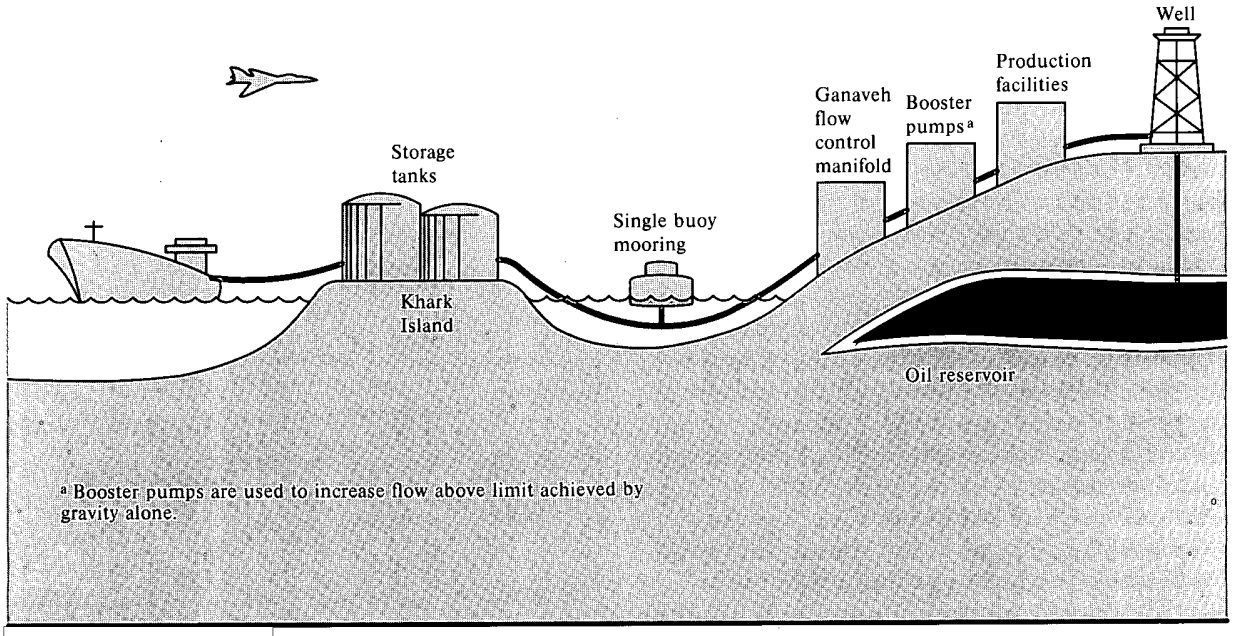
Resilience of the Export System

Although all components of the Iranian export system (figure 4) have been damaged, the system can easily handle Iranian exports, which range between 1.5 million and 2 million b/d. Crude oil from onshore production flows southeasterly downhill into the heart of Iran's export system, consisting of pipelines, booster pump stations, the Ganaveh flow control manifold, the Khark Island export terminal, and a tanker shuttle system. The system is being used at only about 25 percent of its original design capacity, but Tehran has been forced to react more vigorously to Iraqi attacks in recent years because of the cumulative damage inflicted by repeated strikes. The lack of a continuously aggressive Iraqi air campaign and the success of Iran's constant repair effort have enabled Tehran to maintain exports except for a few months of reduced export capability. [redacted]

Figure 5
Iran: Gravity Flow System



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Getting Oil to Khark Island

Facilities feeding crude oil to Khark Island have been attacked on numerous occasions but could absorb considerably more damage before exports would be affected. Many already have sustained substantial damage, but quick repairs have restored some lost capacity, and such preventive measures as burying pipelines and manifolds reduce vulnerability to further attacks. The delivery system benefits greatly from considerable redundancy originally built into the system and from a gravity flow capability (figure 5) that limits the need for pumps only when high export levels are desired or under abnormal operating conditions.

The pipelines in the onshore export system are largely undamaged and are not a limiting factor in determining export capacity. We believe that under the current operating procedure only one or two of the six major pipelines leading to the export terminal at Khark Island are being used to move crude oil.

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The remaining two pipelines may be assigned to feed a new single buoy mooring floating oil loading terminal (SBM). If all six pipelines are used, our analysis shows that oil can flow without any pumping at a rate of more than 4 million b/d from the onshore production areas to Khark Island. If only two of the smaller pipelines are used, the gravity flow rate is reduced to slightly over 1 million b/d, suggesting that Iran probably requires booster pumps to sustain current export levels of 1.5 to 2 million b/d.

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Booster pump stations are located along the main export pipeline corridor at Ahvaz, Omidiyeh, and Gorreh. Iraqi air attacks in 1986 damaged the Omidiyeh and

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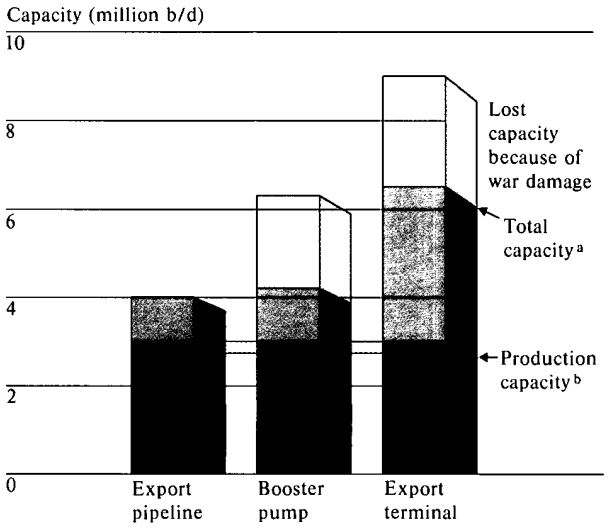
Gorreh booster pump stations, reducing the export capacity through these stations and all six available pipelines to Khark from a prewar level of about 6.3 million b/d to about 4.2 million b/d, which still provides a large surplus pumping capacity at current export levels. We estimate that, by using its remaining pumps, Tehran could push as much as 3 million b/d through the two export pipelines that we believe are in operation. Because plenty of pumping capacity appears available, repairs to these facilities may not be a top priority [redacted] the pipes and valves around the Omidiyeh booster station are being buried to limit further damage. [redacted]

The flow control manifold at Ganaveh—controlling crude fed to the Khark export terminal—was damaged by Iraqi aircraft in January 1986 but has been repaired and is not currently limiting production or exports. The manifold was originally designed to direct flow of Iranian light and heavy crude oils from the producing fields in southwestern Iran through a series of valves to any of the six pipelines that feed Khark Island. In the last year, however, it has undergone major modifications and soon will be capable of directing flow to a new SBM export terminal as well as direct flow to Khark Island. [redacted]

The Status of Khark Island

The Khark Island terminal, which handles 98 percent of all Iranian exports, has reportedly been attacked more than 150 times since August 1985 but still has more than adequate capacity to support Iranian export contracts and spot sales. Khark Island was built in stages, and, when completed, consisted of 14 loading berths and 45 storage tanks. War damage, however, has reduced the number of functioning storage tanks to 31 and at one time or another has disrupted the use of all 14 tanker loading berths. Repairs have restored seven berths; Khark Island now has the capability to operate five berths on the eastern T-jetty and two on the western Sea Island. Current sustainable capacity at Khark Island is about 4.5 million b/d, according to our calculations—well above limits imposed by production capacity (figure 6). [redacted]

Figure 6
Iran: Export Facility Capabilities Versus Production Capacity



[a] Combined capacity from Ganaveh and Khark Island.
[b] Normally about 600,000 to 700,000 b/d of production is used for domestic requirements.

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[redacted]

Iran's strategy to reduce its vulnerability to losses of crude exports for long periods is most apparent at Khark Island [redacted]. In particular, we believe that the T-jetty is now even less vulnerable to disruptions lasting more than 30 days with Iran's use of floating hoses as an alternative to a conventional loading berth. Even if the T-jetty at Khark Island were destroyed, several floating hose arrangements from the onshore pipeline corridor could be set up to export about 1 million b/d. Most pipelines leading from the storage area to the T-jetty are now buried, leaving only a new control center exposed, but this could be repaired or replaced in less than a month. The oil storage tanks on Khark are useful in the loading operation but are not critical. Alternative loading procedures could be used in an emergency, although these procedures would reduce effective capacity.

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Measuring Khark Island's Capacity

The question of Khark Island's export capacity, like that of any other export facility, can be dealt with on two levels:

- *As a* mechanical capacity*—the volume that could be achieved if the equipment is opened fully and allowed to flow continuously.*
- *As a* sustainable capacity*—the volume that practically can be maintained over an extended period, taking into account all factors that commonly restrict the flow.*

Before the war started, Khark's sustainable loading capacity for 30 days was about 9 million b/d, compared with a mechanical loading rate of more than 38 million b/d. Sustainable capacity was limited by aspects of loading operations that typified any major export terminal. Customers arrived on irregular schedules, requesting cargoes of various sizes and at varying receiving rates. Loading times at the two different types of facilities—the Sea Island on the west and the T-jetty on the east—varied with tanker sizes and possible loading rates. Weather variations affected arrival times as well as loading capabilities on arrival. Because of these factors, the Sea Island terminal could use only about one-third of its mechanical capacity and the T-jetty could achieve only about 16 percent of its potential. Even so, the capacity of these facilities is well above the maximum amount of crude that can be delivered to Khark through pipelines from the mainland, which restrict Khark's flow rate to about 6.3 million b/d for periods exceeding 30 days.

By introducing a tanker shuttle operation using its own ships to pick up crude from Khark, Iran managed to increase the efficiency of loading operations there. Most important, the shuttle permits higher utilization of fewer berths, partially offsetting the impact of the loss of berths as a result of Iraqi airstrikes. For example, by controlling the number of tankers in the fleet and their schedule, Iran minimizes downtime because of tanker availability and weather problems. Tanker sizes are also controlled, allowing loading and receiving rates to be maximized and the number of partial cargoes reduced. We estimate that use of a shuttle system would have enabled Iran to sustain loadings of about 11.4 million b/d from Khark before the war if sufficient mainland pipeline capacity had been available.

Our analysis shows that, before the introduction of the shuttle operation, the capacity of the seven berths currently in operation—Berths 2, 5, 6, 9, 10, 12, and 15—would be limited to about 4 million b/d, assuming no damage to these berths. The capability to reduce downtime provided by the shuttle boosts the potential capacity of the same set of berths to more than 6.5 million b/d. This rate, however, requires that all equipment be in top condition. Current damage and such stopgap measures as the floating hose operation have reduced the loading rate, resulting in a lower capacity. We estimate that the current capacity of Khark is about 4.5 million b/d–3.2 million b/d at the T-jetty and 1.3 million b/d at the Sea Island.

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Khark's Sea Island loading terminal is more vulnerable than the T-jetty because repairs there probably would take longer. If either of the two platforms were destroyed, we believe NIOC could replace it with an SBM connected to the existing underwater pipelines. Spare SBMs may already have been purchased for the new Ganaveh export terminal and could be used at the Sea Island. If available, SBMs with a capacity of 1 million b/d could be installed in less than four months.

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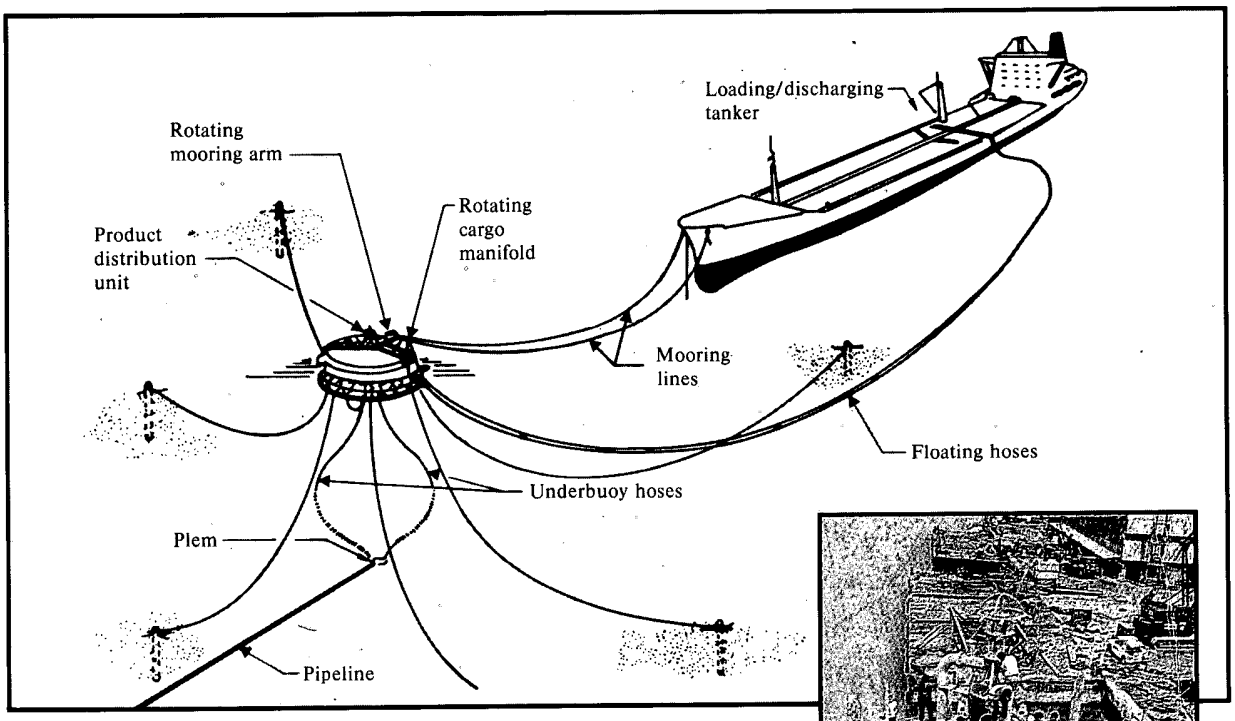
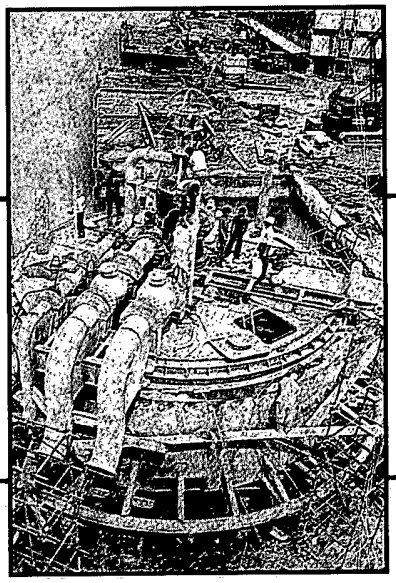
The New SBM Option

The addition of a new export location off the coast of Ganaveh could boost Tehran's total export capacity to about 6.5 million b/d, further increasing its flexibility and reducing its vulnerability to Iraqi attacks. The new Ganaveh facility will include four floating buoys for offshore tanker loading (figure 8), onshore storage tanks, a metering station, and control facilities. These





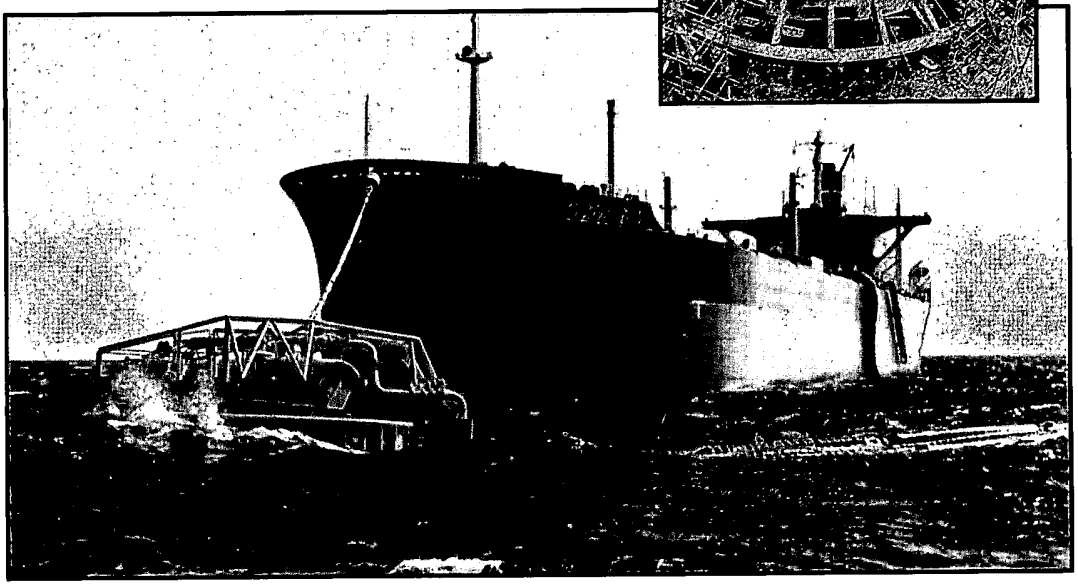


Figure 8. Typical Offshore Oil Loading System. *(Right) Single buoy mooring under construction (11 meters in diameter, 3 meters high); (below) single buoy mooring oil transfer system.*

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new loading facilities will have a capacity of about 2 million b/d and could be operating by late 1987. The SBMs have been in place 16 kilometers (km) offshore since last year. pipelines and valves onshore are being buried and may be dispersed to reduce the risk of air damage as much as possible. Controls to operate loading valves may even be underground. The original manifold area that controls flow to Khark Island has been buried and, as a result, disruption of flow to Khark by air attack against Ganaveh would now be limited. In addition, the offshore buoys are only 11 meters in diameter—a difficult target for an air attack. The exposed metering station, control house, and crude oil storage tanks permit a smoother operation but are not critical to export at Ganaveh.

The Export Pipeline Option

For several years Tehran had plans to build a 900-km crude oil export pipeline bypassing the Strait of Hormuz to a terminal outside the range of Iraqi air attacks. Recent press reports claim that Tehran has been secretly building a pipeline to a point outside the Strait near Jask that may be completed this year.

The Tanker Shuttle System

Tehran set up a simple tanker shuttle system in 1985 to reduce the war risks to its crude oil customers and to control escalating insurance rates. The system essentially moves the customers' lifting operation from Khark Island to the eastern edge of the Gulf, which is much less accessible to Iraqi aircraft (figure 9). Crude is shuttled from Khark in Iranian-leased or -owned tankers to a point in the southeastern Gulf, where it is offloaded onto permanently anchored storage vessels. Customers' tankers then lift their cargoes from the storage vessel, avoiding the risky trip up the Gulf (figure 10). Iraq, however, extended the tanker war in August 1986 by attacking several tankers anchored at the initial shuttle transshipment location at Sirri Island. Tehran responded by moving the transshipment location to a point even farther east near Larak Island, which was subsequently attacked in November 1986.

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The shuttle system could become a critical bottleneck for Iranian exports if enough tankers were not available and most customers refused to lift directly from Khark. Iraqi shipping attacks have thus far done little to disrupt Iranian oil exports. To date, Tehran has had no problem arranging for additional tankers to replace those damaged, and we believe that the shuttle system should be able to sustain current exports as long as loading capacity is intact at Khark itself. In fact, we estimate that Tehran could continue to export at current levels with only about 10 tankers instead of the 15 or so now in use. The extra capacity in its shuttle system gives Iran more flexibility to deal with the short interruptions caused by Iraqi attacks and tanker replacements and the relocation of storage vessels if the transshipment location is moved.

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Oil Products: A Critical Vulnerability

The biggest challenge for Iran's oil system is maintaining domestic oil product supplies. Iran's refined product consumption normally averages about 800,000 b/d, of which about 700,000 b/d is processed by domestic refineries. The remaining product needs are met by imports delivered primarily by means of a tanker shuttle system for oil products—independent of the crude oil shuttle—and are then distributed inland by pipelines and trucks (figure 11). Besides the critical nature of Iran's refineries, they are difficult targets to protect from air attacks. Since March 1986 Iraq has launched more than a dozen attacks against Iran's operating refineries, damaging all six critical components—such as crude distillation units, steam plants, and power facilities—were damaged in key refineries, probably by precision-guided munitions in at least one instance. Refinery capacity fell to a low of about 130,000 b/d

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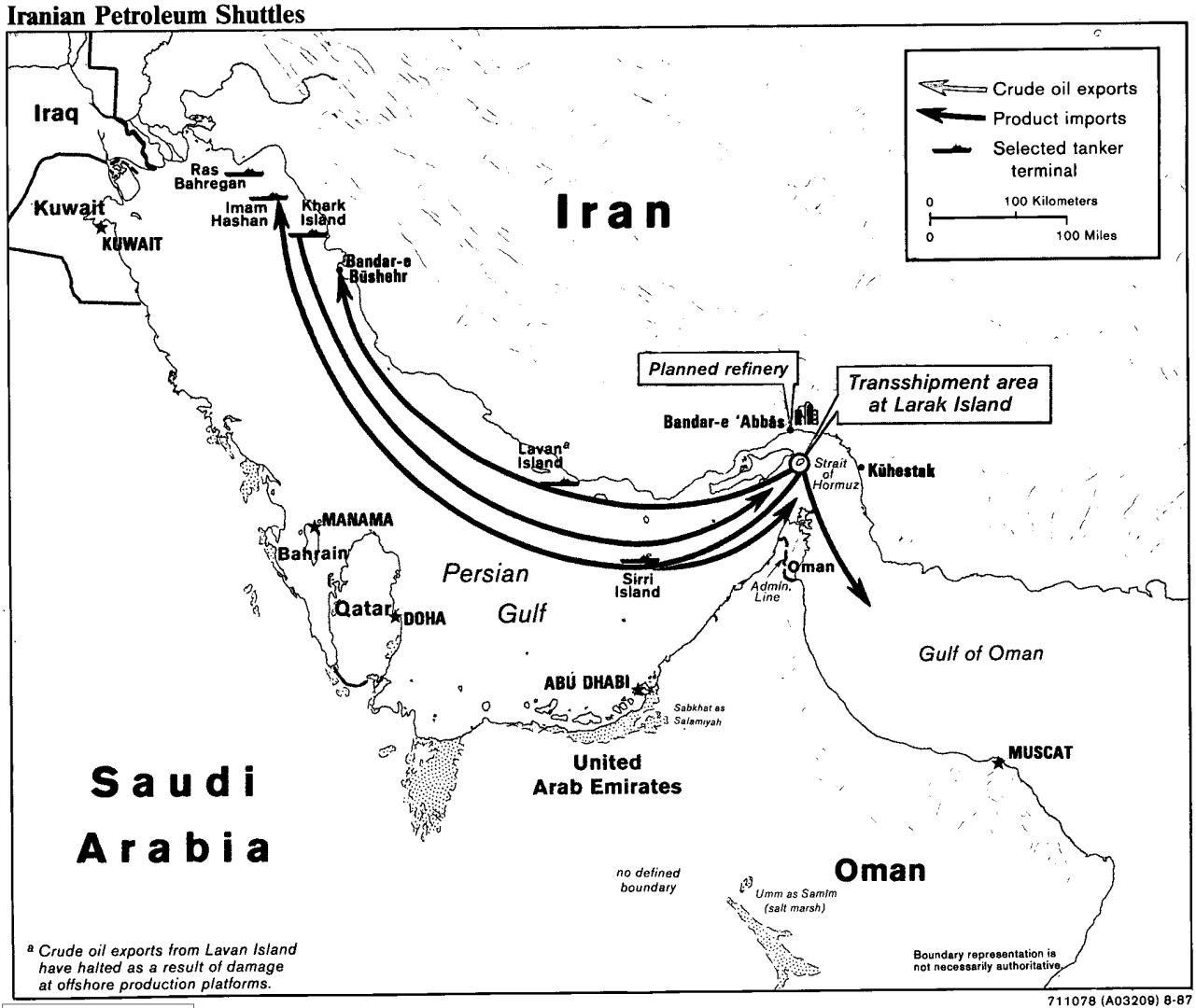
Figure 9
Iranian Petroleum Shuttles



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in September 1986. To help offset its refining capacity losses, Tehran imposed rationing to reduce consumption and increased its imports of petroleum products to nearly 300,000 b/d in late 1986.

Status of the Refineries

Repairs have been effective in restoring refinery operations to more than 90 percent of normal levels before an August 1987 attack on the Tabriz refinery.

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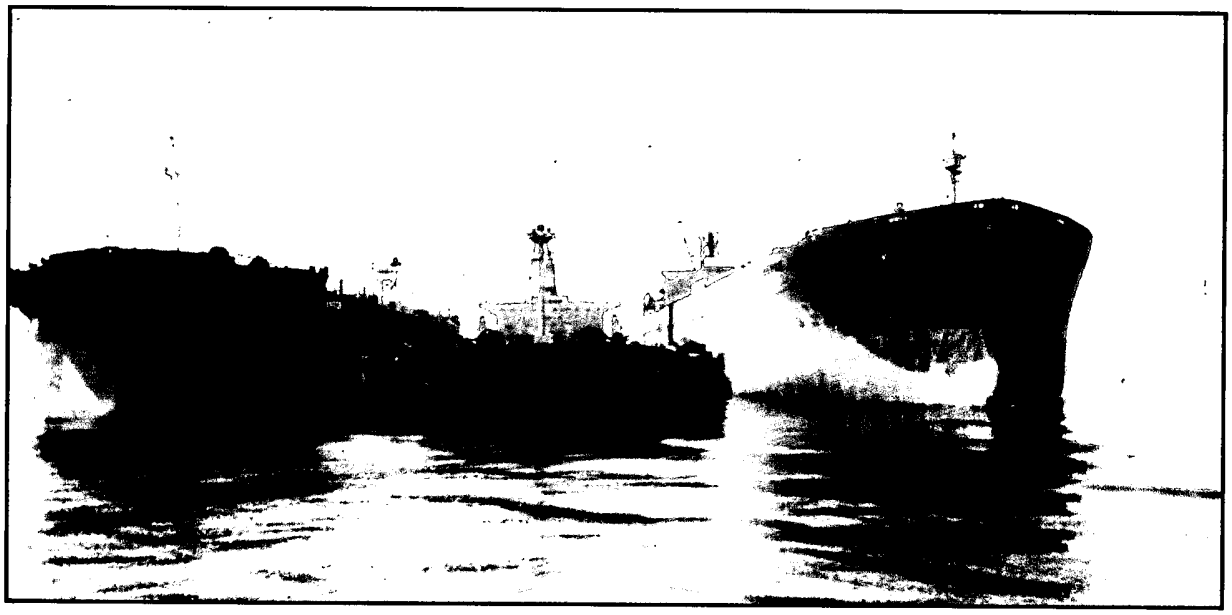

Figure 10. Floating storage tanker moored between offloading Iranian shuttle tanker and customer tanker. 25X1

Further repairs required to return refinery output to levels near 700,000 b/d—typically reached in early 1986—may not be completed until late 1987, in our judgment, assuming no additional damage (table 2). Maintaining production over the long term, however, will be complicated by the generally poor condition of most refineries, caused by Tehran's policy of "pushing" production well above design capacity for extended periods without proper maintenance.

Unlike the production and export systems, Iran's refining system has no cushion of surplus capacity to offset the impact of damage. Moreover, Tehran's policy of operating above design capacity accelerates maintenance needs and deterioration of equipment, further reducing flexibility. Key components remain highly vulnerable, and even periodic attacks could severely restrict refinery production for as long as a year, forcing Tehran to import more products for domestic consumption. Tehran has done about all it can to protect its refineries and workers, but refinery equipment is very large and difficult to protect. The

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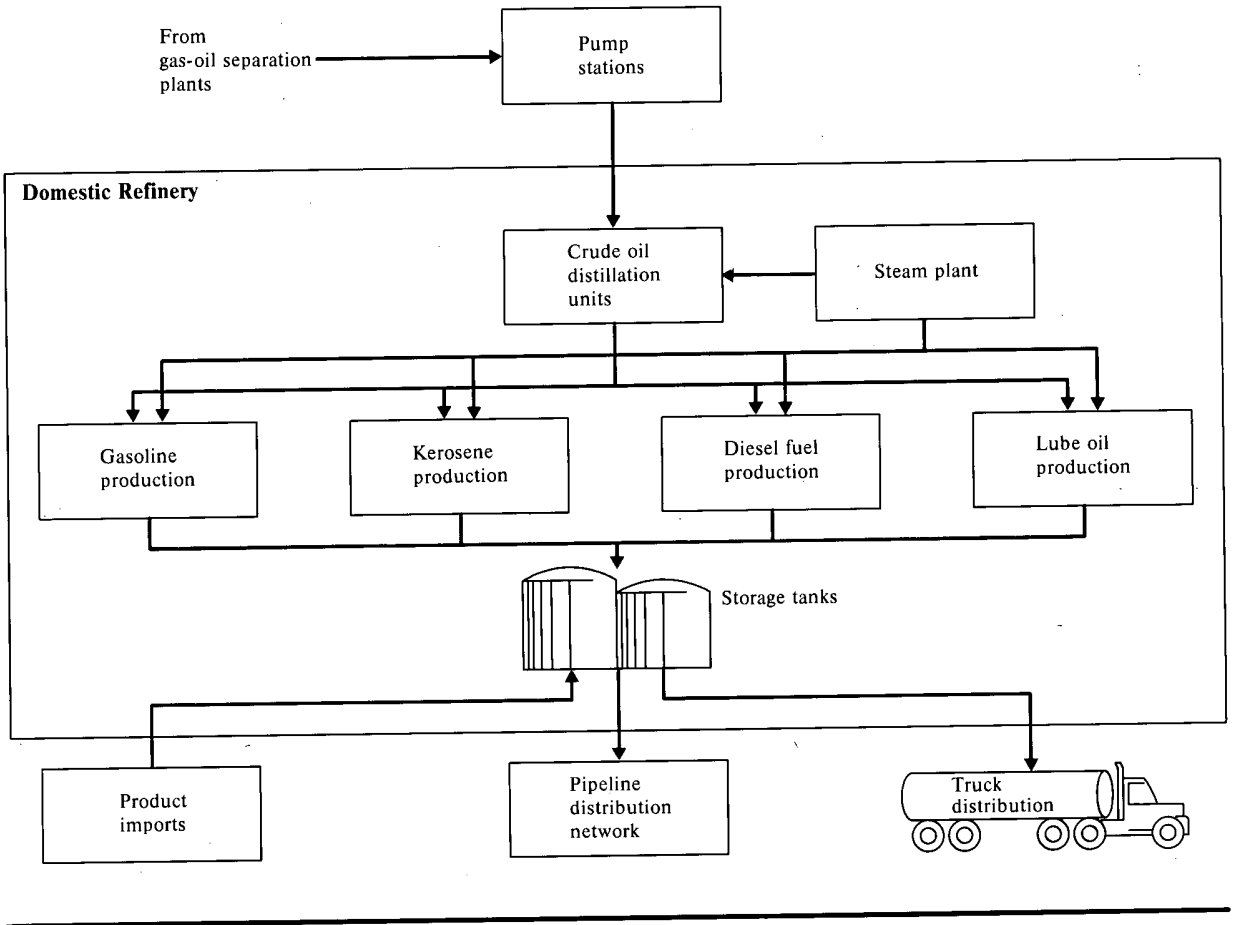
drop Iranian refinery capacity by more than 500,000 b/d (to about three-fourths of current capacity) for more than a year. 25X1

To reduce the vulnerability of its refining sector and to prevent an overdependence on costly imports resulting from a long-term refinery shutdown, Tehran, 25X1 is seeking to purchase a secondhand 125,000 b/d refinery for relocation in Iran and will probably go ahead with the construction of a new $2 billion, 200,000 b/d refinery in Bandar Abbas. Each project will take at least two years to complete, however, and until then even occasional Iraqi attacks resulting in only minor refinery damage could cause problems for Tehran in meeting domestic oil product needs. 25X1

Pump stations along pipelines that supply crude oil to refineries from the oilfields have also been damaged and remain highly exposed and vulnerable. 25X1 25X1

Figure 11
Oil Products Subsystem



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Iraqi attacks in late 1986 destroyed pump houses along pipelines serving refineries at Esfahan, Tehran, and Tabriz, causing a temporary loss of flow to all three. Quick short-term repairs, pipeline bypasses, and a redundancy in pumping capacity permitted the refineries to return to service after only a two-week shutdown. Our analysis indicates that destruction of the pump station at Lah Bid along the Marun-Esfahan pipeline—or two or three other stations along this line, together with the loss of two or three stations on the Ahvaz–Shahr-e Rey pipeline—would completely stop flow to the three largest refineries—Shahr-e Rey, Esfahan, and Tabriz. 25X1

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flow reductions could extend beyond six months if damage is extensive. 25X1
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The Product Import Option

Tehran has increased its capability to import refined products to nearly 300,000 b/d. Products are imported via a separate shuttle system from Larak to ports

Table 2
Iranian Refinery Capacity

Thousand b/d

Refinery [a]	Original Capacity		Postattack Capacity	
	Design Capacity (*thousands*)	Maximum Operating Capacity [b]	September 1986 Maximum Operating Capacity [c]	Expected Yearend Maximum Operating Capacity [d]
Total	**568**	**795**	**130**	**710**
Tehran (Shahr-e Rey)	200	275	50	250
Esfahan	200	320		300
Shiraz	40	50	40	40
Tabriz	80	100	20	85 [e]
Lavan	20	20	20	20
Bakhtaran	28	30		15

[a] Abadan, formally Iran's largest refinery with a capacity of more than 600,000 b/d, was damaged early in the war and has remained shut down. The Masjed E. Soleyman refinery that fed Abadan has also been shut down since early in the war.
[b] Maximum operating capacity represents the volume of product that can be obtained by operating each refining process at its peak rate within allowable engineering specifications. Operating at maximum operating capacity increases maintenance requirements and the risk of equipment failure without proper servicing.
[c] Represents month of lowest capacity.
[d] Assumes no additional damage. Total maximum operating capacity is about 640,000 b/d.
[e] Restricted by amount of oil that can be delivered by pipeline. Could be artificially increased to about 100,000 b/d by use of drag reducing agents injected into oil at pump stations.

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at Bandar-e Bushehr, Khark, and the largest import location at Iman Hashan. In addition, ports at Bandar-e 'Abbas and Bandar Beheshti (Chah Bahar), which is 180 miles east of Jask, also directly receive imports

Some limited additional products are delivered by truck from Turkey.

Shuttled products at Ras Bahregan are received at offshore SBMs and delivered to the mainland through underwater pipelines. In late 1985 or early 1986, Tehran constructed a 125,000-to-150,000-b/d-product pipeline from Ras Bahregan to the Ahvaz area, where it ties into an existing pipeline to Tehran and surrounding areas. Various press reports indicate that part of the offshore equipment at Ras Bahregan may have been damaged in an Iraqi air attack in late November 1986, which might have restricted imports.

Even with the recent expansion of its product import system, we doubt that Iran could meet all of its domestic needs through imports if its main refineries were out of operation for an extended period.

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Outlook and Implications

Iran's ability to cope with the increase in Iraqi air attacks and its steps to reduce its vulnerability decrease the risks that Iraq will disrupt oil exports for a significant period. If Iraq continues its current air war strategy and launches only sporadic attacks against the Iranian oil system, Tehran should be able to maintain its recent export rates of 1.5-2.0 million b/d. Certain attacks might depress exports below that level for a short time, but Tehran has demonstrated the ability to recover lost capacity and to cushion effectively the impact of damage through a variety of

means. We believe that Tehran's strategy to reduce its system vulnerability will probably prevent actual exports from dropping below 1 million b/d for more than 30 days in response to Iraqi attacks on either export or production facilities.

The market experiences from the Iran-Iraq war have probably served to temper the volatility often caused by speculation associated with risk of supply disruptions. Iran's ability to maintain its exports demonstrates that, while individual petroleum facilities are highly vulnerable, it is difficult to disrupt supplies for an extended period.

Despite the resilience of the Iranian oil system, a sustained Iraqi campaign might have a dramatic impact. An Iraqi air campaign at the level of intensity achieved between August and October 1986 would cause severe economic problems in Iran after about six months, in our view. A combination of lower exports and increased refined product shortages would cause a sharp loss of income and possibly lead to civil unrest.

Iran's refineries remain the most vulnerable areas in the Iranian oil system. Even under the current attack strategy, a series of successful Iraqi attacks could easily reduce Tehran's refining capacity to levels that would force increased rationing, reduce the distribution of durable and consumable goods, and possibly affect the supplies of fuel for the military. We believe that Tehran will try to expedite the purchase and construction of new refineries and locate them out of easy range of Iraqi aircraft, but we expect Iraqi attacks to cause additional hardships until the new refineries are commissioned.

The impact of Iraq's air campaign against the Iranian oil system hinges more on Baghdad's will than its capabilities. Although Iran's new strategy to reduce its vulnerability may raise the cost to Baghdad of cutting the oil lifeline, we believe Iraq retains this capability. Iraq has demonstrated its ability to reach targets deep in Iran and inflict substantial damage to key components. We believe, however, that Baghdad would be reluctant to launch an effective, long-term air campaign on the Iranian oil system—largely because Iraqi leaders are sensitive to even minor aircraft losses. Among the options acceptable to Baghdad, a resumption of attacks against refineries offers the best potential to disrupt Tehran's war effort.

Iraq is likely to continue to use its superiority over Iran in the air war and the threat to Iranian economic facilities as a counterbalance to Iran's advantage in the ground war. Further Iranian success in the war on the ground would raise the likelihood that Iraq would intensify its effort against the Iranian oil system. Iraqi attacks, however, are likely to provoke further Iranian retaliation against Iraqi economic targets and population centers and against the oil export operations of Baghdad's Gulf allies.

Opportunities for Foreign Companies

We believe that the damage to oilfield equipment and refineries, the need for oil well maintenance, and Tehran's desire to expand its gas network both for domestic and export purposes increase the need for foreign equipment and services. The bulk of these projects, however, will probably be won by Korean or Japanese firms because of lower costs and the possibility of barter deals. *The majority of the labor required for most projects will probably be Iranian, with technical assistance from the winning firms.*

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