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Verifying Libya's nuclear disarmament

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On 19 December 2003 Libya made the surprise declaration that it would abandon its weapons of mass destruction (WMD) programmes. The breakthrough apparently came in early October 2003 when, under the auspices of the US-led Proliferation Security Initiative (PSI), American, British, German and Italian forces collaborated to intercept the German-flagged *BBC China,* which was carrying five containers filled with over 1,000 assembled gas centrifuges and components. The vessel had picked up its cargo in Dubai and was bound for Libya, before being diverted to the Italian port of Taranto for inspection. The incident may have been the straw that broke the camel's back, finally convincing Libya's leaders that it was time to put an end to the country's WMD programmes.

Prior to the December announcement, the Libyan government had secretly approached the United Kingdom and the United States on a number of occasions. The most recent move was in March 2003, at the start of the war in Iraq—perhaps at a time when it thought it could obtain the maximum benefits in terms of international recognition and financial assistance. Following negotiations with, and visits by, UK and US experts in 2003, Libya agreed to 'disclose and dismantle' all of its WMD programmes and 'immediately and unconditionally' to allow international inspectors to visit the country. On 29 December 2003, while International Atomic Energy Agency (IAEA) Director General Mohamed ElBaradei was in Libya, national authorities confirmed that, pending entry into force, Libya would act as if its Additional Protocol had already come into effect.

Subsequently, over 4,000 centrifuges and some 50,000 tons of other material, including several canisters of uranium hexafluoride (UF_6) gas, were removed and shipped to the Oak Ridge National Laboratory (ORNL) in the US.[1] The IAEA has

access to all of this material for testing and analysis, and is in the process of consulting with Libyan technicians to understand fully the extent of Libya's past nuclear activities. This chapter examines the present status of Libya's nuclear facilities and the true intent of its past nuclear-related actions in light of recent inspections by the IAEA and the UK–US team, as well as Libya's own declarations.

Past ambitions and known or suspected activities

Western intelligence analysts long believed that, despite its expressed commitment to nuclear nonproliferation—ratifying the Nuclear Non-Proliferation Treaty (NPT) in 1975, concluding a safeguards agreement (INFCIRC/282) with the IAEA in July 1980 and signing various regional nonproliferation treaties—Libya was continuing to pursue a nuclear weapons option. They suspected that Libya was carrying out its programme with assistance from a number of countries, including Argentina, Belgium, Brazil, Egypt, France, Germany, India, Pakistan, the former Soviet Union and Sweden. Of particular concern was co-operation between Libya and Pakistan. Libya is known to have provided large sums of money to Pakistan for its nuclear weapons programme; in return, Pakistan may have promised to supply the technology needed to develop nuclear weapons, or to transfer an assembled nuclear weapon to Libya. Until recently, however, no evidence of such a transfer has ever surfaced. Before December 2003, it was thought that the major limitations on Libya's aspirations to develop nuclear weapons were its lack of indigenous natural resources, the rudimentary state of its nuclear infrastructure and a shortage of trained personnel.

The dearth of qualified technicians in Libya appeared to be a major impediment to the development of its nuclear programme. During the 1976 International Conference on World Nuclear Energy in Washington, DC, Libyan officials spoke of the need to amass the required number of qualified technicians and researchers, and mentioned that Libya had implemented a programme to send a 'large number of pre and post graduate students to training centers abroad for education and training associated with nuclear power'.[2] Reports on Libya issued by the IAEA in 2004 confirmed this when they referred to training provided by 'foreign experts at locations in Africa, Asia, Europe, the Middle East, and Southeast Asia'.[3] In

fact, on a number of occasions, the IAEA itself provided training to Libyan scientists as part of specific projects, including a small one on fluoride chemistry in 1985.[4]

Libya's known facilities before the December 2003 announcement included the Tajura Nuclear Research Center (TNRC), which was constructed with the assistance of the former Soviet Union, beginning in the late 1970s. The TNRC is thought to be at the heart of Libya's nuclear activities and has been the focus of foreign technical assistance in the past. In 1984, international journalists were allowed to visit the TNRC and reported having seen various types of 'state-of-the-art' nuclear-related equipment and instrumentation from Hungary, Poland, the former Soviet Union, Switzerland and the US.[5]

The TNRC consists of numerous laboratories and facilities. One such facility is the 10-megawatt (MW), pool-type Tajura Research Reactor (IRT-1),[6] which was constructed in 1980 and went critical in 1981, but probably did not become operational until 1983. The reactor's core is filled with high enriched uranium (HEU) that was originally transferred from the Soviet Union. The TNRC also houses a critical facility that operates a 100-watt critical assembly and a TM4-A Tokamak fusion reactor. In addition the TNRC houses a nuclear metallurgy laboratory and a radiochemical laboratory with a number of hot cells that have been used to produce various isotopes, such as I-131 for medical and agricultural purposes.

One can assume that Libya's reactor is of an analogous size and capacity to that of North Korea, since it too came from the Soviet Union and was used for similar purposes. North Korea's IRT reactor and isotope production laboratory, which operated seven hot cells, allowed the country to experiment with spent fuel reprocessing and eventually to separate approximately two to four kilograms of plutonium from the spent fuel.

The TNRC also houses a physics research centre with various facilities for conducting research on nuclear physics, solid-state physics, neutron physics, material science and engineering, radiation biophysics and mass spectrometry. Some of these facilities contain hot cells and glove boxes that, theoretically, could be used to carry out spent fuel analysis, isotope production and other isotope-related research activities.

As a party to the NPT, Libya had pledged not to manufacture or acquire nuclear weapons, nor to receive assistance in this respect from elsewhere. Under the framework of the safeguards agreement that it concluded with the IAEA in July

1980, Libya declared its nuclear facilities, materials and related activities to the agency. The IAEA verified Libya's declaration to ensure that no nuclear material had been diverted for weapons purposes. The IAEA periodically conducted comprehensive inspections of Libya's facilities and gave Libya a 'clean bill of health' on numerous occasions. Intelligence community suspicions aside, it was not until Libyan President Moammar Gaddafi's announcement of December 2003 that the international community learned of the illicit nature of Libya's nuclear-related activities.

Libya comes forward

On 20 December 2003, at a meeting with IAEA representatives, the Libyan government pledged to eliminate 'materials, equipment and programmes' that can be used in nuclear weapons development.[7] Libya's declaration was reportedly the outcome of nine months of secret diplomacy with the UK and the US.[8] Prior to December 2003, American and British specialists travelled to Libya to visit projects and installations at more than 10 sites, including a uranium enrichment facility.[9] It appears that the IAEA had no knowledge of negotiations between Libya and the UK–US team before US President George W. Bush and UK Prime Minister Tony Blair issued a statement on 19 December 2003. According to a diplomat based in Vienna, Austria, the IAEA suffered 'hurt feelings' as a result of the surprise announcement.[10] The media later reported that 'turf battles' had erupted between the IAEA and the UK–US team over who would take the lead in disarming Libya, and there was uncertainty regarding to what extent the agency would be involved in the verification process.

Initially, the UK and the US planned to remove sensitive nuclear material and equipment, including weapons designs, from Libya, and to transfer them to the United States for in-depth inspection, verification and storage.[11] The details of who would be responsible for overseeing the dismantlement of Libya's WMD programmes were discussed at the meetings between Libya, the UK and the US. According to senior Western diplomats, during those meetings Libya pressed for an international organization, namely the IAEA, to take the lead, contrary to the wishes of London and Washington.[12] At subsequent meetings with IAEA officials, in January 2004,

Libya notified them of the discussions. The IAEA, not unexpectedly, protested, arguing that 'these items constituted a part of the Agency's evidence and were to remain under Agency seal and legal custody until the Agency has been able to verify the correctness and completeness of Libya's declarations'.[13] On 19 January 2004, American and British officials met with ElBaradei to establish a bilateral arrangement that would serve as the basis for verification and disarmament activities in Libya. The parties agreed to the following division of labour: the IAEA would 'verify that Libya's programme is properly dismantled, while the Americans and Britons would physically destroy the capabilities'.[14]

Nine days after the renouncement of its WMD programmes, Libya agreed to sign an Additional Protocol to its existing safeguards agreement with the IAEA, allowing for more thorough inspections of its nuclear facilities.[15] By the end of December 2003, ElBaradei had travelled to Libya to begin the process of verification of its nuclear capabilities and their dismantlement and destruction. According to its declarations to the IAEA and the UK–US team, from 1978 until 2003 Libya pursued uranium conversion, enrichment and reprocessing programmes, and had obtained nuclear weapons designs.

Verification of Libya's programme[16]

The IAEA relied on interviews with government officials and scientists, visual inspections of facilities and equipment, analyses of technical documents and shipment records, environmental samples and discussions with nations that were involved in assisting Libya's programme, to verify its declarations of past activities. When Libya admitted that it was receiving nuclear technology from foreign sources, it also revealed the existence of a vast procurement network that spans a number of countries, including China, France, Germany, Japan, Malaysia, South Africa, Switzerland and the United Arab Emirates. Established by Dr A.Q. Khan, the 'father' of Pakistan's nuclear bomb, the network has helped various nations, specifically Iran, Libya and North Korea, and possibly Iraq, to develop nuclear weapons programmes.

The IAEA's verification work revolved around five issues: Libya's imports of yellowcake and other uranium compounds; uranium conversion experiments and

procurement plans for a uranium conversion facility (UCF); a gas centrifuge enrichment programme; uranium target irradiation and reprocessing; and weapons designs. An essential part of its verification work involved investigating and understanding the exact role played by the Khan nuclear network in Libya's weaponization activities.

Nuclear material imports

In its deliberations with the IAEA, Libya declared that, between 1978 and 1981, it imported 2,263 tons of uranium ore concentrate (UOC)—yellowcake—from two producers in an unnamed country, presumed to be Niger.[17] A total of 587 tons was imported before Libya's safeguards agreement entered into force in July 1980, and thus was not previously reported to the IAEA.

During its January 2004 inspection, the IAEA verified Libya's declared total of imported UOC by inspecting the documents provided by the supplier country. On 25 January 2004 IAEA inspectors travelled to the UOC storage facility at Sabha, where they carried out an inspection and took samples of UOC for analysis. They found the facility disorganized and lacking documentation on stored material; some UOC drums were inaccessible. The IAEA planned to return to Sabha to verify the condition of this material after Libyan technicians have had a chance to put the plant in order.[18]

In January 1985, in return for the possible procurement of a uranium conversion facility from a nuclear weapon state (widely presumed to be China), Libya exported approximately 100 kilograms of UOC to that country.[19] One month later, the nuclear weapon state shipped back some 39 kilograms of natural UF_6, six kilograms of uranyl uranate (U_3O_8), six kilograms of uranium dioxide (UO_2) and five kilograms of uranium tetrafluoride (UF_4). Before December 2003, Libya had reported neither this export of yellowcake nor successive receipts of converted nuclear material.[20] On learning of these transactions, the IAEA reviewed shipping documents, provided by Libya, and analyzed the imported nuclear material. It confirmed Libya's declaration, and placed the material under IAEA seal before it was transferred to the US. The IAEA has also verified the declared containers of U_3O_8, UO_2 and UF_4, which remain in Libya.

In its new declarations to the agency, Libya stated that in September 2000 it imported two small 5A-type cylinders, each containing approximately 25 kilograms of UF_6, and that in February 2001 it imported a large 30B-type cylinder, containing

approximately 1,600 kilograms of UF_6. These imports were previously undeclared to the IAEA. Libya reported that it received the cylinders from an unnamed country through a foreign clandestine network.[21] IAEA inspectors used the non-destructive assay measurement process to establish the content of the cylinders. The 30B-type cylinder contained low enriched uranium (LEU) (approximately one per cent uranium-235 (^{235}U)), while the 5A-type cylinders contained natural and depleted uranium (0.3 per cent ^{235}U). The content of the three cylinders was placed under IAEA seal and shipped out of Libya. Other states have since provided information on these activities, and the IAEA is continuing to investigate the matter, particularly with regard to the procurement network utilized by Libya.

According to Libya's statements, the same network sold it another 16 kilograms of uranium compounds for use as 'laboratory standards' in chemical laboratories in 2002. The compounds, mostly uranium acetate and uranium nitrate, were reportedly never used. Visual inspections and statements by Libyan officials have allowed the IAEA to learn that the compounds were acquired through foreign intermediaries. However no billing or shipping documents were available to identify the source. The IAEA took samples of compounds for laboratory analysis, the results of which were not available as of September 2004.

Lastly, Libya requested that Russia take back 16 kilograms of HEU originally supplied for the operation of the IRT-1.[22] In March 2004, the fuel, consisting of 13 kilograms of uranium-235 isotopes and three kilograms of natural uranium, was sealed by IAEA inspectors and moved to the Dimitrovgrad Nuclear Reactor Scientific Research Institute in Russia.[23]

Uranium conversion

Conversion experiments

Libya stated that it used about 35–38 kilograms of yellowcake from drums stored at Sabha for laboratory-scale and bench-scale uranium conversion experiments at the TNRC in the mid-to-late 1980s and on a limited scale after 1994. IAEA inspectors verified present holdings of feedstock and product resulting from these experiments and found them to be consistent with Libya's statements. Although only limited data were available on the extent of uranium conversion experiments at the TNRC, the IAEA appears to be satisfied with the information received.

Uranium conversion facility

In 1981, Libya negotiated with a West European company for the construction of a 100 ton per year yellowcake conversion plant at Sabha and a related set of laboratories at the TNRC.[24] Although these plans were cancelled, as part of its proposal the firm provided Libya with a number of detailed diagrams of buildings and illustrations of chemical processes. The company has subsequently made information available to the IAEA regarding these negotiations. Libya did not volunteer this information to IAEA inspectors during their initial visits in December 2003 and January 2004, but it has since confirmed that negotiations took place as described by the company, and provided related documents during IAEA visits in April and May 2004.

In 1983 Libya negotiated with a 'nuclear weapon state' for the construction of a conversion plant with the capacity to produce 120 tons of natural UF_6 per year, but the negotiations ended without agreement.[25] Libya has provided the IAEA with limited documentation on these negotiations, including a copy of a preliminary contract. However, no technical plans or information from the nuclear weapon state were available. The agency will continue to pursue other means of verifying Libya's declaration on this matter.

In 1984 Libya ordered and received a pilot scale, portable, modular, 'uranium conversion facility', from a 'Far Eastern Country'.[26] The plant has an estimated feed capacity of 30 tons of uranium and is capable of producing UF_4, UO_2 and uranium metal, but not UF_6—although the Libyans had requested this capability from the supplier. The plant modules began to arrive in Libya in 1986 and were stored at various locations until 1998, when most of them were taken to, and assembled at, Al Khalla. The facility was subsequently moved to Salah Eddin, which was first inspected by the IAEA in December 2003.

In its reports to the agency, Libya stated that, while some cold tests were conducted in early 2002, no uranium was actually processed at the UCF. The IAEA took environmental samples from the surfaces of the UCF equipment, and was able to confirm Libya's statements. In January 2004, as part of the agreement between Libya, the UK and the US, all of the facility modules were shipped to the US. The IAEA is continuing to investigate Libya's plans for UF_6 production, particularly with respect to academic research into uranium conversion conducted by Libya's scientists.

Gas centrifuge enrichment

Libyan officials told the IAEA that they began developing the country's uranium enrichment programme in the 1980s. At least two facilities were built to conduct centrifuge research and development: the original testing facility at Al Hashan; and the newer research facility at Al Khalla. Later the machine shop 'Project 1001' was constructed to assemble centrifuges.[27] During the 1980s, Libya's scientists worked with a 'European expert with relevant experience' to design a gas centrifuge.[28] The expert brought a centrifuge design with him to Libya, and worked with the Libyans to develop two types of centrifuges. Although they were not successful in building a working centrifuge system, Libya did gain experience in designing and operating centrifuge equipment and related technologies. According to IAEA reports, Libya was interested in both what the agency has termed 'L-1 and L-2 type' centrifuges (presumably the same as Pakistani P-1 and P-2 centrifuges).[29] The IAEA inspected centrifuge components remaining from that period. Subsequently it took environmental samples of those components and found the analysis results to be consistent with Libya's declarations that no UF_6 was used. It also discovered on inspection several unfinished, maraging steel cylinders in Libya's inventory of centrifuge components from the early 1980s. The cylinders have the same parameters as the advanced L-2 centrifuges of Pakistani design obtained by Libya in September 2000. The IAEA will continue to investigate the origin of these cylinders.

According to a Malaysian police report of 20 February 2004,[30] in the late 1990s, Libyan officials contacted Khan for assistance in procuring uranium enrichment technologies. In 1997, Khan and his deputy, Buhary Sayed Abu Tahir, met with Libyan representatives Mohamed Matuq and an individual known as Karim on several occasions.[31] According to a senior European diplomat with access to intelligence information, the Libyan programme had 'certain common elements' with Iran's enrichment programme, which are suspected to have come from Pakistan. Iran's centrifuges use an aluminium rotor with a diameter of around 100 millimetres. This is similar to centrifuges that Pakistan acquired clandestinely in the mid-1970s. According to Western officials, Iranian centrifuges have a production capacity of approximately two separative work units (SWUs) per year.

In 1997 Libya began importing L-1 centrifuges through 'foreign intermediaries'. The first delivery included 20 pre-assembled centrifuges and components for an

additional 200 centrifuges. In 2000 Libya began 'progressively' installing 9-machine, 19-machine and 64-machine L-1 centrifuge cascades. By 2002 the cascades were at different stages of completion, with the 9-machine cascade closest to being operational. According to the Libyans, no nuclear material was used during any of the tests conducted on these centrifuges. The IAEA confirmed Libya's declaration through information received from other sources, possibly from the governments of countries where foreign intermediaries operated. Libya has stated that no nuclear material was used in two successful high-speed tests conducted at the Al Hashan testing area between May and December 2002. However, analyses of environmental samples taken from the L-1 centrifuge test area at Al Hashan indicated the presence of LEU and HEU on the floor of the site, as well as on centrifuge and related equipment. The contamination might have occurred prior to the equipment being imported into Libya.[32] The IAEA will continue to investigate the source of the contamination. It will have to rely on analyses of environmental samples taken from the supplier state to match the contamination found at Al Hashan and on additional information received from countries where the components may have been manufactured.

In September 2000, according to its declaration, Libya imported two L-2-type test centrifuges and some small UF_6 cylinders from an unnamed supplier state through a network of foreign intermediaries.[33] This led to an initial order of 5,000 L-2 centrifuges, which was later expanded to 10,000. The IAEA's discussions with the supplier state have confirmed the details of this transfer. The 10,000 L-2 centrifuges began to arrive in December 2002, again through a foreign procurement network. By the time Libya decided to dismantle its WMD programmes in December 2003, a large quantity of L-2 centrifuge components and supporting equipment was already in its possession.[34] Similarly Libya imported equipment for a large precision machine shop that it planned to use for domestic centrifuge production. During its inspections in January 2004, the IAEA examined centrifuge components and supporting equipment, as well as the machine shop that was to be used for assembling centrifuges. It found all components boxed and unopened, confirming Libya's statements that no assembly or testing had taken place.

As with the L-1 centrifuges, the agency discovered HEU contamination on the first two complete L-2 centrifuges and on some of the L-2 components.[35] All

centrifuges and related components and equipment were removed from Libya and shipped to the US between January and March 2004. The IAEA is continuing to analyze centrifuge design drawings and documents, as well as centrifuge-related computer data, such as assembly and test instruction manuals that Libya reportedly received from the A.Q. Khan network. The IAEA is also investigating Libya's participation in various centrifuge-related training programmes provided by experts at locations in Africa, Asia, Europe, the Middle East and Southeast Asia.

Uranium irradiation and reprocessing

According to Libya's declarations, between 1984 and 1990, it manufactured several dozen small UO_2 and uranium metal targets, each containing one gram of uranium, and irradiated them in the IRT-1 reactor. Staff at the radiochemistry laboratory, located at the TNRC, then used both the ion exchange and solvent extraction methods to dissolve the targets and to extract radioisotopes, including 'small quantities' of plutonium, in several of the laboratory's hot cells.

The agency has taken environmental samples of the hot cells—the analysis results were not available as of September 2004. It should also investigate any possible foreign assistance in the irradiation and reprocessing training provided to Libya's scientists. Libya has agreed to include the radiochemical laboratory in the revised design of the IRT facility, which will ensure future monitoring of the plant.

Weaponization

The National Board for Scientific Research (NBSR) was the entity in charge of Libya's nuclear weapons programme. Libya declared that, in late 2001 or early 2002, it had obtained two copies of documents related to nuclear weapons design and fabrication, including a series of engineering drawings related to nuclear weapon components, and handwritten notes related to the fabrication of nuclear weapon components.[36] The latter suggest the involvement of other parties outside of Libya. The Libyans stated that they had not taken steps to assess the credibility of the documents because their personnel were not competent in this area. They said that they had planned to ask the supplier for assistance once they were at the stage of developing, designing and constructing their own nuclear weapon.

Before the IAEA's arrival in December 2003, the UK–US inspection team had access to copies of the documents. In January 2004, IAEA officials—nationals of nuclear weapon states—were present when American and British weapons experts examined the designs. Although few details of the IAEA's meeting of 19 January 2004 with the UK and the US are known, a decision may have been made to restrict access to nuclear weapons-related information to those IAEA inspectors who are nationals of nuclear weapon states, so as to avoid any 'proliferation' or allegation of 'proliferation' of weapons information to non-nuclear weapon countries. The IAEA then placed the documents under seal, at which point they were transferred to the US. Pursuant to the 19 January agreement between the IAEA and the UK and the US, agency representatives were also present when the seals were broken in Washington.

Dismantling Libya's nuclear infrastructure: a chronology

March 2003	Libya approaches UK and US, seeking to dismantle its WMD programmes in exchange for normalizing relations with the West
4 October 2003	*BBC China* is seized on its way to Tripoli. Five containers packed with centrifuges and related components are found on-board
19 December 2003	Libya announces elimination of its WMD programmes
27–29 December 2003	ElBaradei visits Libya
29 December 2003	Libyan authorities confirm they will sign Additional Protocol
27 January 2003	US airlifts shipment of components seized from Libyan facilities
20–29 January 2004	IAEA inspectors, including centrifuge specialists, visit Libya
16–19 February 2004	IAEA inspectors continue verification process in Libya
23–24 February 2004	ElBaradei and senior agency officials visit Libya to discuss safeguards implementation and nuclear proliferation matters
25 February 2004	Libya, Russia and IAEA sign tripartite contract to ship fresh HEU from Libya to Russia
8 March 2004	Russia airlifts from Libya 13 kilograms of research reactor fuel assemblies containing 80 per cent HEU, and sends three kilograms of uranium back to Russia for down blending
10 March 2004	Libya signs Additional Protocol
25 May 2004	Libya submits its initial declarations required under Additional Protocol, as well as nuclear accountancy reports for TNRC.

According to the IAEA, 18 locations were of potential utility for a nuclear weapons programme, specializing in the handling of high explosives, ammunition production, missile propellant fabrication and testing, missile warhead design and manufacturing, metal casting, welding and machining, and research and production of materials. Between 1994 and 1998, several institutes of concern were constructed, including the Advanced Center of Technology, and the Higher Technical Center for Training and Production. According to the Libyans these were not associated with the nuclear programme. However, one of them housed a large precision machine shop that could be used for domestic centrifuge production. The IAEA plans to conduct further analyses, perhaps involving forensic tests, to verify Libya's declaration and to investigate the possible involvement of other parties in its weaponization programmes. Although no specific facility was determined to be involved in the design, manufacture or testing of nuclear weapons, IAEA inspectors requested and were granted access to sites that they deemed capable of providing support for nuclear weapons research. The lack of information available for verification of this matter presents perhaps the biggest challenge to the agency in building a complete and accurate picture of Libya's nuclear weapon-related activities.

Next steps

Following Libya's December 2003 decision to abandon and dismantle its WMD-related programmes, the IAEA, in co-operation with the UK, the US and other countries, such as Russia, has conducted a tremendous amount of work to verify the completeness and correctness of its declarations and to ensure that nuclear-related programmes and equipment will not be used for illicit purposes in future. Much more work remains to be done, however. In its March and May reports to the IAEA Board of Governors, the agency outlined specific issues that require further investigation. For instance, there are plans to visit Libya's facilities again, including the one at Sabha, to verify its holdings of UOC.

Meanwhile, the IAEA will continue with its efforts to confirm the origin of the UF_6 received in 2000 and 2001, and will consider Libya's overall intentions to produce and acquire nuclear material. It also plans to continue to investigate the source of the LEU and HEU contamination of gas centrifuge parts found in Libya,

as well as to assess the country's gas centrifuge enrichment activities. Finally, the IAEA plans to discuss Libyan interactions with third parties and to conduct forensic analyses of nuclear weapon-related documents to understand fully the history of Libyan nuclear weapon-related activities.

Several other issues related to verification and the dismantlement of Libya's nuclear programme, while not on the list of specific tasks set out by the IAEA, are nonetheless important. The first involves ensuring that all orders previously placed by Libya for material and equipment for its nuclear programme have either been received or cancelled, and are not on their way to the country from foreign locations. A case in point is the container on the *BBC China* that arrived in the Libyan capital of Tripoli in January 2004, carrying components for L-2 centrifuges. The *BBC China* arrived three months after the American-led teams intercepted and seized five containers full of centrifuge parts at Taranto in October 2003.[37] The arrival of the container raises questions regarding the effectiveness of US counter-proliferation initiatives, and suggests that the PSI cannot be counted on as the sole tool for tracking down illicit shipments of WMD-related materials.

Second, the IAEA will need to continue to investigate past training programmes for Libya's scientists and monitor future research activities, particularly in the area of uranium enrichment, conversion and reprocessing. Libya's new agreements with the international community will facilitate admissions to Western universities to study disciplines previously restricted to them. Also promised to Libya in return for dismantling its WMD programmes is greater economic aid. With the lifting of decade-long sanctions on nuclear exports in September 2003, and with Libya opening up to the international community, foreign technical assistance, including IAEA technical co-operation, will be much more readily available to the country in future than it has been at any point in its post-monarchical history. Although sanctioned by the NPT to aid countries in the employment of nuclear technologies for civilian purposes, some of these activities may also be used to further nuclear weapons programmes. The IAEA and the international community must continue to be diligent in their investigation and monitoring of past and future developments in Libya, and proceed with cautious optimism.

In its May 2004 report, the IAEA asserted that, 'the existence of [a] procurement "network" was of decisive importance in Libya's clandestine nuclear weapon

programme'. Libya's indigenous scientific and technical capability is arguably the least developed in the Middle East. Libya was able to take advantage of the 'indifference displayed by a lot of Western suppliers',[38] as well as the willingness of a few, motivated and well connected individuals to circumvent weak export regulations, to make significant progress towards developing a nuclear capability. Understanding the full extent of the foreign network will not only help the IAEA complete its inquiry into Libya's past nuclear activities, but it will also help to ensure that nuclear equipment and technology will not flow from supplier states to would-be proliferators in future.

Conclusion

As attempts are being made to convince Iran and North Korea to curtail their nuclear ambitions, some experts and government officials are pointing to the Libyan case as a workable model to persuade countries to roll back their weapons programmes. However, those in the know are expressing their disdain for this concept. They believe that Libya is not an appropriate paradigm, and that the West should not be fooled into believing that other nations are going to go the way of Libya and give up their WMD assets so easily. Although the dialogue with Libya came directly at the start of the war with Iraq, it would be short-sighted to argue that Libya's disarmament was a consequence of that conflict, and that such results might be emulated elsewhere and should be expected. In the final analysis, the reasons most commonly cited for Libya's actions are the dire state of its economy, caused in part by the economic sanctions imposed after Libya was implicated in the 1998 bombing of a Pan Am airliner over Lockerbie, Scotland, and Gaddafi's desire to bring his country out of international isolation.[39] Libya's admission came voluntarily and with a high degree of co-operation, which is in stark contrast to the current behaviour of Iran and North Korea.

In the aftermath of these events, the IAEA's ability to detect and stop countries that might be developing nuclear weapons has again been called into question. Observers highlight uncomfortable similarities between the agency's failure to detect the nuclear programmes of Iraq and North Korea, and the present case of Libya. As some analysts note, though, with budgets approximately 10 times

larger than the IAEA's, the American and Israeli intelligence agencies also failed to produce credible evidence of Libya's nuclear weapons programme prior to it coming forward.[40] While its detection capabilities have drastically improved since the early 1990s, particularly through the strengthened safeguards system, including the Additional Protocol system, the IAEA remains limited in terms of its finances and legal authority. The way in which Libya was persuaded to disarm may yet prove to be a useful model for further examination. Perhaps individual states, especially nuclear weapon states, should engage in greater co-operation with the IAEA in carrying out more intrusive forms of detection, interdiction and verification. The IAEA could take advantage of individual states' superior detection capabilities and bilateral negotiating strategies, and couple them with its own experience and impartiality to monitor, verify, detect and possibly prevent potential violations of countries' nonproliferation obligations.

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11 Paula A. DeSutter, 'US government's assistance to Libya in the elimination of its weapons of mass destruction (WMD)', testimony before the Senate Foreign Relations Committee, 26 February 2004, US Department of State, www.state.gov.

12 'Qadhafi plans international campaign against nuclear weapons', Global Security Newswire, 8 January 2004, www.nti.org/d_newswire/issues/2004_1_8.html.

13 'Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya', International Atomic Energy Agency Board of Governors, Report by the Director General, GOV/2004/12, 20 February 2004, www.iaea.org/Publications/Documents/Board/2004/gov2004-12.pdf.

14 DeSutter; 'Experts begin disarming Libya', 20 January 2004, http://edition.cnn.com/2004/WORLD/africa/01/20/libya.nuclear.reut.

15 The Additional Protocol is a voluntary arrangement between a state and the IAEA, 'designed to strengthen and expand existing IAEA safeguards for verifying that non-nuclear-weapon states-parties to the nuclear Nonproliferation Treaty only use nuclear materials and facilities for peaceful purposes'. See 'The 1997 IAEA Additional Protocol at a glance', Arms Control Association, January 2004, www.armscontrol.org/factsheets/IAEAProtocol.asp and Kenneth Boutin, '93+10: strengthened nuclear safeguards a decade on', VERTIC Brief, no. 2, April 2004. Libya only signed an Additional Protocol after revealing its nuclear weapons programme.

16 The majority of Libya's declarations about its past nuclear activities has been extensively covered in two IAEA reports outlining agency inspection and verification activities in Libya: 'Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya', GOV/2004/12; and 'Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya', GOV/2004/33. The information in this section is drawn from these two reports, unless otherwise stated.

17 'Libya: the search for nuclear technologies', *Library of Congress Country Studies,* 1987, http://lcweb2.loc.gov/frd/cs/lytoc.html.

18 It is unclear whether the UOC inventory comes under the aegis of Libya's agreement with the UK and the US, and hence will be moved from Libya to the US.

19 The IAEA reports do not identify the nuclear weapon state involved. Given China's past involvement in the possible sale of conversion technology to Iran, though, it is probable that it is the country in question.

20 Since the importing country was a nuclear weapon state, Libya was not required to report the export of UOC to the IAEA under the export-reporting requirement of Article 34(a) of its safeguards agreement.

21 The IAEA believes that the same clandestine network was utilized by Libya to procure centrifuges and related equipment. The centrifuge design and subsequent statements made by Libya have led observers to believe that the supplier country is Pakistan, and that the intermediary is the A.Q. Khan nuclear smuggling network. See DeSutter.

22 The Tajura Research Reactor will soon be modified to operate on LEU.

23 'Removal of high-enriched uranium in Libyan Arab Jamahiriya', International Atomic Energy Agency Staff Report, 8 March 2004, www.iaea.org/NewsCenter/News/2004/libya_uranium0803.html.

24 Although the identity of the company was not disclosed in the IAEA reports, it has been speculated elsewhere that it is the Belgian firm, Belgonucleaire. See 'Libya: nuclear overview', *Nuclear Threat Initiative,* May 2004, www.nti.org/e_research/profiles/Libya/3939_3940.html.

25 The IAEA report did not disclose the identity of the nuclear weapon state involved, but some analysts have theorized that it could be either China or the former Soviet Union. See Joe Fiorill, 'Nuclear weapon state processed uranium for Libya, IAEA says', Global Security Newswire, 23 February 2004, www.nti.org/d_newswire/issues/2004_2_23.html. At the time the former Soviet Union had been helping Libya to complete the 10 MW Tajura Research Reactor. China, meanwhile, was assisting Iran with similar uranium conversion technology.

26 Coming on the heels of unsuccessful negotiations with a 'nuclear weapon state' for a UF_6 conversion plant, it is possible that the 'nuclear weapon state' and the 'Far Eastern Country' are one and the same, China, and that the 1984 sale was the conclusion of the negotiations that began in 1983.

27 'Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya: Annex 2', International Atomic Energy Agency Board of Governors, Report by the Director General, GOV/2004/33, 28 May 2004, www.fas.org/nuke/guide/libya/iaea0504.pdf.

28 Although unnamed in the IAEA report, open sources reported that the European expert was apparently a former employee of a German company. See Peter Slevin, 'Libya made plutonium, nuclear watchdog says', *Washington Post,* 21 February 2004 (via Lexis-Nexis). The expert could possibly be one of the European experts connected to the A.Q. Khan network, like, for example, the late German engineer Heinz Mebus, who in 1984–85 was allegedly involved in negotiations to supply Iran with centrifuge designs, or Gotthard Lerch, who is suspected of having tried to procure supplies of pipes for Project 1001. See 'Press release by Inspector General of Police in relation to investigation on the alleged production of components for Libya's uranium enrichment programme', *Polis Diraja Malaysia* (Police Report Malaysia), 20 February 2004, www.rmp.gov.my/rmp03/040220scomi_eng.htm.

29 L-1 (or P-1 or G-1) refers to an old design of European origin; L-2 is a more advanced design.

30 'Press release by Inspector General of Police in relation to investigation on the alleged production of components for Libya's uranium enrichment programme'.

31 'Press release by Inspector General of Police in relation to investigation on the alleged production of components for Libya's uranium enrichment programme'.

32 This is similar to contamination found on centrifuge components in Iran in summer 2003. Iran, which imported the parts through foreign intermediaries, stated that the contamination occurred prior to importation. In August 2004 experts involved in the IAEA investigation into the contamination confirmed that the traces of uranium were from centrifuge equipment obtained from middlemen, some of whom had connections with the A.Q. Khan nuclear smuggling network. According to the same experts, inspectors discovered two levels of contamination on Iran's equipment: particles with 54

per cent enrichment, which they believe came from Pakistan's nuclear weapons programme; and particles with 36 per cent enrichment, which most likely came from Russian equipment imported by Pakistan. Investigations into the origin of Libya's contamination will probably confirm that Pakistan was also the source of its centrifuge equipment. Dafna Linzer, 'Findings could hurt US effort on Iran', *Washington Post,* 11 August 2004 (via Lexis-Nexis).

33 Given Libya's other statements, the supplier country is thought to be Pakistan, while the foreign intermediary is believed to be the A.Q. Khan nuclear smuggling network. See DeSutter.

34 One container of P-2 centrifuge components reportedly arrived in Libya in January 2004. Libya informed the IAEA of its arrival, and it was subsequently removed from the country. See William J. Broad and David E. Sanger, 'After ending arms program, Libya receives a surprise', *New York Times,* 29 May 2004 (via Lexis-Nexis). This raises serious questions about the ability of the PSI to halt the proliferation of nuclear material.

35 It is unclear whether this contamination has been explained by the supplier state or if the matter remains unresolved and thus is an issue for further investigation by the IAEA.

36 Some notes were reportedly in English and Chinese. Analysts believe that the documents are Chinese nuclear weapons designs, which China later shared with Pakistan. Joby Warrick and Peter Slevin, 'Libyan arms designs traced back to China', *Washington Post,* 15 February 2004 (via Lexis-Nexis).

37 Broad and Sanger.

38 Dany Shoham, 'Libya: the first real case of deproliferation in the Middle East?' *Disarmament Diplomacy,* no. 77, May/June 2004, www.acronym.org.uk/dd/dd77/77libya2.htm.

39 Ronald Bruce St. John, '"Libya is not Iraq": preemptive strikes, WMD and diplomacy', *Middle East Journal,* vol. 58, no. 3, pp. 386–402.

40 'Coming clean', interview by Gwen Ifill with Joseph Cirincione and Paul Leventhal, Online News-Hour, 30 December 2003, www.pbs.org/newshour/bb/africa/july-dec03/libya_12-30.html.