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**Report of Visit to the Democratic People's Republic of North Korea (DPRK).
Pyongyang and the Nuclear Center at Yongbyon, Feb. 12 - 16, 2008.
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My visit was sponsored by the John D. and Catherine T. MacArthur Foundation and the Nuclear Threat Initiative. I was accompanied by W. Keith Luse, staff member for Senator Richard Lugar, and Joel S. Wit, former State Department official. This was my fifth visit to the DPRK, and the third to Yongbyon. Discussions in Pyongyang were held with officials from the Ministry of Foreign Affairs. At Yongbyon, we were hosted by officials from the Yongbyon Nuclear Research Center and officials from the General Department of Atomic Energy. This report is confined to the nuclear issues. I also met with officials from the Ministry of Public Health and the Ministry of Education to explore cooperation in those areas.

Executive Summary:

- Our visit leads me to conclude that the DPRK leadership has made the decision to permanently shut down plutonium production if the United States and the other four parties live up to their Oct. 3, 2007 commitments. However, they have retained a hedge to be able to restart the facilities if the agreement falls through. We verified that the disablement actions taken to date will effectively delay a potential restart of plutonium production. Cooperation between the U.S. and DPRK technical teams has been excellent, and until the recent slow-down, the two sides struck the proper balance between doing the job expeditiously and doing it safely. By their definition, the DPRK has completed 10 of 12 disablement actions. They have slowed down the last two to actions to allow the other parties to catch up.
- The current six-party process has put within reach a permanent shut-down of the Yongbyon plutonium production complex. To do so, highest priority must be placed on completing the disablement (discharging the reactor fuel and disabling or selling the existing fresh fuel rods) and proceeding to the dismantlement stage. If this is accomplished, then the DPRK will not be able to make more bombs and, without additional nuclear tests, it will not be able to make better bombs.
- It is important to understand and to be prepared for the fact that the DPRK will have to restart the Reprocessing Facility some time in the next year or so to allow for the safe disposal of its high-level radioactive waste and the remaining low-level uranium waste. I also strongly urge reconsideration of the decision to ship the current load of spent fuel out of the DPRK. Technically, it is much more advisable to allow one more reprocessing campaign under IAEA supervision and ship out 12 kg of plutonium rather than 50,000 kg of highly radioactive spent fuel that will have to be processed somewhere.
- If the DPRK decides to break out of the six-party agreement and restart operations, it will have only limited capacity for plutonium production. After a delay of six to 18 months, depending on how far disablement proceeds, they would be able to regain their prior production rate of six kilograms (or roughly one bomb's worth) of plutonium per

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year. The 50 and 200 MW(electric) reactors do not appear salvageable and, hence, the DPRK will not be able to ramp up plutonium production over the next five to 10 years. If the process proceeds to dismantlement, then no plutonium production is likely for the same time frame.

- Ministry of Foreign Affairs officials stated that they will not proceed with a more complete declaration list until the other parties meet their Oct. 3 commitments. They told us that they reported a total separated plutonium inventory of 30 kilograms (sufficient for four to five bombs) to the United States in November 2007. In response to my comment that this is less than my estimate of 40 to 50 kg based on previous visits and, hence, this would require substantial cooperation on their part to verify the smaller number, MFA officials stated that they are prepared to do so. In response to my question about declaration of their weaponization facilities, they said they are also not prepared to do so until the other parties meet their commitments.

- MFA officials also stated that they view the uranium enrichment issue settled. They explained that the extraordinary access U.S. specialists were given to the aluminum tubes in question at a missile factory demonstrates that the DPRK has no such program. They dismissed allegations that they received centrifuges from Pakistan. They also denied nuclear cooperation with Syria and other countries. When pressed on this issue, they reiterated that they stand by their Oct. 3 commitment not to transfer nuclear materials, technology or know-how to other countries.

- In my view, the most important risk-reduction actions now are to stop the production of more plutonium and to stop export of existing plutonium and nuclear technologies. The current situation puts us within reach of stopping plutonium production for the foreseeable future. The five parties should do everything in their power to get the DPRK to finish the disablement expeditiously and to move on to dismantlement. Whereas the United States should continue to press for a "complete and correct" declaration, it is more important to stop additional production than it is to substantiate whether the current inventory is 30 kg or 50 kg and to find out to exactly what level they developed uranium enrichment. However, it is imperative that the DPRK leadership understands that any previous or future export of fissile materials (or of nuclear weapons) represents a red line and cannot be tolerated by the United States and the other parties.

- Although the DPRK has put nuclear worker reorientation on the back burner waiting for the next stage, we had substantial discussions about potential prospects. We learned much about the current status of the IRT-2000 research reactor, which could be reconfigured for research and medical applications.

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Yongbyon Nuclear Complex: Shut-down and disablement.

On July 15, 2007, the DPRK shut down and sealed the key nuclear facilities at Yongbyon and allowed IAEA inspectors back to monitor the shut-down. DPRK workers began to disable these facilities under U.S. technical supervision a few months later. The shut-down halts the production of additional bomb fuel (plutonium) and the disablement makes it more difficult to restart plutonium production should the DPRK decide to do so.

On Feb. 14, 2008, our delegation was given access to the Yongbyon nuclear facilities to independently verify the disablement actions. We found the level of cooperation between the DPRK nuclear specialists and the U.S. team that is supervising the disablement to be excellent. The U.S. has supplied a large amount of equipment, including protective clothing and radiation monitors, to allow the DPRK to disable the facilities expeditiously and safely. Until the recent slow-down, the two sides struck the proper balance between doing the job expeditiously and doing it safely. The discharge of the spent fuel was initially delayed because the cooling pool water level was low and the chemistry was not acceptable to allow safe storage of the magnesium alloy-clad spent fuel rods. Moreover, the water treatment facility was not operational. The initial speed of discharge also was a good compromise between political expediency and safety.

The American presence and equipment supplied has also significantly changed the health and safety practices at the Yongbyon facilities. Unlike during prior visits to Yongbyon, we were required to wear protective clothing in all buildings. Improved health and safety practices were evident in all of them.

Yongbyon officials defined 12 disablement actions. These actions were taken at the three key nuclear facilities – the fuel fabrication facility, the 5 MWe reactor, and the reprocessing facility (Radiochemical Laboratory). DPRK officials took the unusual step of allowing us to take photographs of the disabled equipment. Photos of the disabled equipment can be found at: <http://cisac.stanford.edu/news/hecker>

The following constitute the 12 disablement actions as defined by Yongbyon officials¹:

Fuel Fabrication Facility:

- 1) Removal and storage of all three uranium ore concentrate dissolver tanks.
- 2) Removal and storage of all seven uranium conversion furnaces, including storage of refractory bricks and mortar sand.
- 3) Removal and storage of both metal casting furnaces and vacuum system, and removal and storage of eight machining lathes.
- 4) Storage of the remaining UO₃ powder in bags with monitoring by IAEA (this constitutes nearly five tons of powder).

5 MWe reactor:

¹ The United States has apparently defined 11 disablement actions that are somewhat different from the DPRK list. The U.S. list does not include #4 and combines #5 and #6. It also includes one additional action – the disablement of fresh, unclad fuel rods fabricated prior to 1994 and stored at the fuel fabrication facility. By U.S. count, eight out of 11 actions have been completed as of Feb. 14, 2008.

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- 5) Cut and removal of portions of steel piping of the secondary cooling loop outside the reactor building.
- 6) Removal of the wood interior structure of the cooling tower.
- 7) Discharge of 8000 spent fuel rods.
- 8) Removal and storage of the control rod drive mechanisms.

Reprocessing Facility

- 9) Cut cable and removal of drive mechanism for trolley that moves spent fuel caskets from the fuel receiving building into the reprocessing facility.
- 10) Cut two of the four steam lines into the reprocessing facility.
- 11) Removal of the crane and door actuators that permit spent fuel rods to enter the reprocessing facility (at Level -1).
- 12) Removal of the drive mechanisms for the fuel cladding shearing and slitting machines (at Level -1).

The operational definition of “disablement” is to make it more difficult, but not impossible, to restart the nuclear facilities. As of Feb. 14, 10 of the 12 disablement actions identified by the DPRK had been completed. The discharge of the reactor fuel rods from the 5 MWe reactor (#7) was intentionally slowed down by the DPRK. The removal of the control rod drive mechanisms (#8) will be completed once all fuel rods are discharged.

5 MWe reactor. Several sections of pipe in the secondary cooling loop had been cut and were lying on the ground. The internal wooden structure of the cooling tower had been taken down and disposed of (some 240 cubic meters of wood). The Chief Engineer told us that it would take one year to rebuild this structure, although it most likely could be done much more rapidly if necessary. The initial discharge of fuel began in mid-December 2007 at a rate of 80 fuel rods per day. At this rate it would have taken 100 days to finish the job. However, the DPRK has since slowed the rate to 30 per day to allow the other five parties to catch up with their commitments per the Oct. 3, 2007 second-phase actions agreement. On Feb. 14, 2008, we were told that 1440 of the 8000 fuel rods had been discharged. Hence, the reactor fuel discharge may not be complete until late September 2008.

Should the DPRK choose to restart the reactor, they would have to rebuild the interior of the cooling tower or find alternative paths to release steam from the reactor. In addition, the more of the current fuel in the reactor is discharged, the longer it will take them to reload the reactor with new fuel. They have in storage less than a quarter of a reactor load of clad fuel rods. They also have in storage a full load of bare uranium fuel rods (our best estimate is 12,000) for the 50 MWe reactor. It appears that these can be used for the 5 MWe reactor, but may require some machining, and would have to be clad with magnesium alloy cladding. These operations would require the reconstitution of parts of the fuel fabrication facility, including the machine shop. Such actions would most likely take close to one year.

One of the most notable actions at the reactor is the installation of radiation monitors in the reactor building that remotely monitor the removal of the fuel rods. This instrument

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package contains gamma-ray detectors and a neutron detector built at Los Alamos National Laboratory and installed by its technical specialists.

Fuel Fabrication Facility. The front end of fuel fabrication (Bldg. 1) had been operating making uranium dioxide (UO_2) from uranium ore concentrate right up to the time the facility was shut down on July 15, 2007. The back end was operational with seven conversion furnaces, two casting furnaces, and eight machining lathes. However, the middle part, the fluorination facility, had deteriorated so badly during the freeze (1994 to 2003) that the building has been abandoned (as we were shown in August 2007). However, the DPRK had recently completed alternate fluorination equipment (using dry rather than wet techniques) in one of the ancillary buildings. However, this was a make-shift operation that has limited through-put potential. It was not put into full operation by the time of the shut-down on July 15.

The disablement steps taken at the fuel fabrication facility focused on those buildings and equipment that were in reasonable working order. The removal of the three uranium dissolver tanks and the disassembly of the seven conversion furnaces (with thousands of refractory bricks) are serious disablement steps. The removal of the casting furnaces and the machining lathes also constitute significant steps. The DPRK has not been willing to take steps to render the fresh fuel in storage not usable for a reactor restart. These fuel rods could be bent, making it necessary to recast and remanufacture the rods to precise tolerances. Or, since the uranium metal content is substantial (close to 100 metric tons of natural uranium metal), the fresh fuel rods could be sold to one of the five parties, which could use the uranium as feed material for light-water reactor fuel. DPRK officials say that they await additional corresponding measures by the United States before they are willing to take actions on the fresh fuel rods. If the fresh fuel rods are bent, the DPRK would have to recast and remachine, which would add several months to a restart time. If the fresh fuel were sold, then the DPRK would have to restart the entire fuel fabrication facility and produce new uranium metal, which would add approximately a year to a restart time.

Reprocessing Facility (Radiochemical Laboratory). The disablement actions at the Reprocessing Facility were restricted to the front end – the fuel transfer building and fuel transfer areas in the main building. The hot cells and the plutonium laboratories have not been affected. At this time, no new spent fuel can be transferred and processed at the plant. The four disablement actions at the facility are substantial, but could most likely be reversed in a matter of months.

The principal reason for leaving the hot cells in tact for now is that they still contain all high-level radioactive waste (a volume of ~80 cubic meters) from their reprocessing campaigns. In addition, the facility also contains low-level uranium waste from previous campaigns. The high-level waste represents the most hazardous product of the reprocessing operations. It is important that it be treated, stored and disposed of properly. The DPRK has very little experience with such waste. When questioned about their disposition plans, they told us that they have only done a few experiments on waste disposal. They have explored vitrification of the waste and separation of cesium and

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strontium with subsequent disposal of what remains as mid-level waste. They have done some small-scale vitrification experiments. When questioned about their plans to disable the hot cells or the plutonium laboratories, they said they had no such plans because they considered the entire Reprocessing Facility disabled if the front end is disabled.

In response to my question, Yongbyon officials stated that they are not able to do any equipment maintenance. They said all of the facilities in question are under IAEA seal and monitoring. When asked how long they can do without maintenance and still be able to salvage the facilities, they said that the ability to restart the facility vanishes if maintenance restrictions last for a long time (they did not define what they mean by long). In any case, they have a limited time to treat the high-level waste or wind up with a significant safety problem. They estimated that it would take them one year to finish the waste treatment job.

It is important to understand and to be prepared for the fact that the DPRK will have to restart the Reprocessing Facility some time in the next year or so to allow for the safe disposal of its high-level radioactive waste and the remaining low-level uranium waste. I also strongly urge reconsideration of the decision to ship the current load of spent fuel out of the DPRK. The spent fuel rods are now being discharged into the cooling pool where they would have to be recanned for safe transportation outside the DPRK. It is still possible to re-install the disabled equipment on the front end of the Reprocessing Facility and to conduct one more reprocessing campaign with IAEA monitoring. Although diplomatically this may be considered a step backward, technically it would be a giant step forward. Technical considerations strongly favor reprocessing the spent fuel under IAEA monitoring and dealing with the disposition of 10 to 12 kilograms of plutonium. The current plan of recanning 50,000 kg of highly radioactive spent fuel for interim storage and eventual shipment is a monumental job. Moreover, eventually this spent fuel will have to be reprocessed somewhere due to its unstable nature. DPRK officials stated that the final disposition of the fuel rods has not yet been decided in the six-party process. They are taking the disablement, dismantlement, and final abandonment one step at a time.

My overall assessment is that the disablement actions are significant. I believe that the DPRK leadership has made the decision to permanently shut down plutonium production if the other parties do their part. However, they have retained a hedge to be able to restart the facilities if the agreement falls through. All of the equipment removed as part of disablement is being stored. A key question is how much of a time delay to restart the Yongbyon Nuclear Complex is incurred by the disablement actions and to what level could the DPRK reconstitute or enhance plutonium production.

At this point, all actions could be reversed and the facilities restarted. With only approximately one quarter of the reactor fuel having been discharged to date (end of February 2008), it may take six to 12 months to restart all facilities. If the reactor fuel discharge is completed and the fresh fuel in storage is disabled or sold, the time for restart would most likely increase to 12 to 18 months. In any case, none of these actions can be taken without the knowledge of the U.S disablement team and IAEA technical

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monitoring team. Also, since no maintenance is allowed, the longer the facilities remain disabled, the more difficult it will be for the DPRK to restart them.

However, even if the DPRK decides to break out of the six-party agreement and restart operations, it will have only limited capacity for plutonium production. In the scenario described above, it may be possible to replace the discharged fuel and reload one more reactor core with fresh fuel. Consequently, the DPRK could continue to produce approximately six kilogram of plutonium (or roughly one bomb's worth) per year for the next four to six years. If they reconstitute all fuel fabrication facilities, then they could produce additional fuel for future reloading and continue to produce that much plutonium into the foreseeable future. Although the 5 MWe reactor had some operational difficulties before the shut-down, it can most likely be kept operational for quite a few years.

The DPRK would not be able to scale up its plutonium production any time soon. Based on discussions and observations from my previous visits, I believe that the 50 MWe and 200 MWe reactors are not salvageable. The DPRK would have to start over. It has limited industrial capacity to build these reactors in the near future. Therefore, the most that a restarted Yongbyon plutonium production complex could produce over the next five to 10 years is one bomb's worth of plutonium per year.

The current six-party process has put within reach permanently shutting down the Yongbyon plutonium production complex. To do so, highest priority must be placed on completing the disablement (discharging the reactor fuel and disabling or selling the existing fresh fuel rods) and proceeding to the dismantlement stage. If this is accomplished, then the DPRK will not be able to make more bombs and, without additional nuclear tests, it will not be able to make better bombs.

Discussions with Ministry of Foreign Affairs on declaration of nuclear programs.

Although Ministry of Foreign Affairs officials initially claimed that they met their declaration responsibilities in November, when pressed about a "complete and correct" declaration, they stated that they are not prepared to provide such a list until the five parties complete their corresponding obligations according to the Oct. 3 agreement. We discussed what I consider to be the three principal components of a complete and correct declaration: 1) Plutonium and weaponization, 2) Uranium enrichment, and 3) Nuclear cooperation and export.

MFA officials claimed that they told the U.S. government that they have 30 kilograms of reprocessed plutonium. I told them that this amount is lower than my estimate of 40 to 50 kg based on findings from four previous visits to the DPRK. It will require substantial cooperation and transparency on their part to verify the lower number. Such actions will require access to reactor production records, reactor components and products, reprocessing plant records and facilities, and waste products and sites. MFA officials said they are prepared to provide such access once we move to the next stage. I asked about declaration of the weaponization facilities, such as those in which the plutonium pits are cast and machined, the explosives are produced and assembled, and

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the weapons themselves (all of which I believe are outside the Yongbyon nuclear complex). MFA officials said they are not prepared to declare these facilities until the five parties meet their Oct. 3 obligations.

With regard to uranium enrichment, MFA officials told us that they have resolved this issue with the Americans. They gave U.S. experts access to the aluminum tubes in question at a missile factory and demonstrated that these were not used for enrichment purposes. In response to my question about reports of A.Q. Kahn having sold them centrifuges, they said "that's your story." I told them that, in fact, it was Pakistani President Musharraf's story since he stated this in his recent book. They responded that they have no uranium enrichment connections to Pakistan. We were told that DPRK military and industrial officials were extremely unhappy with the access the Americans were granted and with the fact that they were given samples of the aluminum tubes in question. When I asked to visit this factory, I was told that neither I, nor anyone else, will get access again. Clearly, they were unhappy with the consequences of having giving the U.S. access and samples.

We discussed the issue of nuclear cooperation and possible export of nuclear materials and technology. Specifically, we stated that it is well known that the DPRK has dealt with countries such as Pakistan, Iran and Syria in the area of missile technologies. I said that I cannot rule out that similar cooperation has occurred in the nuclear field. I specifically mentioned the concerns reported in the press that the Syrian site bombed by Israel on Sept. 6, 2007 may have been a nuclear facility and that the DPRK may have had a connection to such a facility. I stated that it is quite likely that the Syrian site was a nuclear site based on these reports and the fact that Syria cleaned up the bombed site so rapidly and completely. I also said that I find it conceivable that the DPRK may have assisted Syria in such a venture. MFA officials denied having any nuclear connections to Syria. When we reiterated the importance of preventing nuclear exports, we were told that the DPRK will abide by the Oct. 3, 2007 agreement not to transfer nuclear materials, technology, or know-how. We stressed our concern that should past transfers come to light in the future, they may derail the diplomatic process.

What we found in our discussion with MFA officials is that at this point they justify not providing a complete and correct declaration on the lack of progress by the other five parties of living up to their Oct. 3 commitments. Specifically, we were told that instead of one million tons of heavy fuel oil that was promised (500,000 tons in HFO and 500,000 tons in HFO equivalent) only 200,000 tons have been delivered and South Korea and China have provided very little of the HFO equivalent. In addition, they expected the United States to remove them from the states sponsoring terrorism list and drop the application of the Trading with the Enemy Act. They complained that neither of these has been done. Consequently, they have slowed down their disablement actions and they are not prepared to present a complete declaration.

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Dealing with the current negotiations impasse.

In my view, the greatest threats posed by the DPRK nuclear program are 1) The potential export of nuclear weapons, fissile materials, or nuclear technology and know-how and 2) The possession of a limited nuclear arsenal and inventory of fissile materials (specifically, plutonium). We had previously estimated the DPRK inventory of plutonium to be quite small – 40 to 50 kg. The DPRK's declaration of 30 kg is plausible, but must be verified. The Oct. 9, 2006 nuclear test was at best only partially successful. Hence, their small nuclear arsenal is most likely of primitive design. It is highly unlikely that the DPRK has the confidence to mount a nuclear device on a missile. Moreover, it is unlikely that they can develop a more sophisticated weapon without additional nuclear tests.

The most important risk-reduction actions are to stop the production of more plutonium and to stop export of existing plutonium and nuclear technologies. The current situation puts us within reach of stopping plutonium production for the foreseeable future. *The five parties should do everything in their power to get the DPRK to finish the disablement expeditiously and to move on to dismantlement.* It is more important to stop additional production than it is to substantiate whether the current inventory is 30 kg or 50 kg. Not permitting the plutonium inventory to grow reduces the likelihood of export or of additional nuclear tests. In other words, no more bombs, no better bombs, and less likelihood of export.

It will, of course, be important to verify the exact quantities of plutonium produced and expended. DPRK officials indicated they are prepared to do what is required for adequate verification once the five parties meet their commitments. Likewise, it will be important to determine the exact nature of the uranium enrichment effort. MFA officials believed that the extraordinary access allowed U.S. specialists to the aluminum tubes at the missile factory was adequate to prove they do not have a uranium enrichment program. However, this exercise resulted in new questions since traces of enriched uranium were reported to have been detected on the aluminum tubes. In addition, the DPRK has not adequately addressed the Pakistani connection. It is very likely that the DPRK had a uranium enrichment research effort, but unlikely that it came close to commercial scale. *Therefore, the United States should continue to press for a "complete and correct" declaration, but not allow this to impede completing the disablement and moving on to dismantlement of the Yongbyon nuclear complex.*

The potential of nuclear exports from the DPRK represents a serious risk. It is imperative that the DPRK leadership understands that any previous or future export of fissile materials (or of nuclear weapons) represents a red line and cannot be tolerated by the United States and the other parties. The export of nuclear technologies or know-how must be acknowledged and assessed, and most importantly must be terminated. Such exports are especially worrisome to states such as Iran that are developing a robust nuclear infrastructure under a civilian umbrella. DPRK officials focused their discussion of exports on the future, stating that they will abide by the Oct. 3 agreement not to transfer nuclear materials, technologies or know-how. However, a reconciliation of past activities must be included.

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The final elimination of all nuclear weapons and weapons-usable materials have been agreed to in principle in the Sept. 19, 2005 Joint Statement. However, the details have not been worked out. I believe that denuclearization of the Korean Peninsula will require a transformation in relationships between the DPRK and the United States. It appears possible, but may be a long way off. The United States should not only press China and South Korea to get the DPRK to comply, but it should meet its own obligations and put the burden squarely on the DPRK to proceed with denuclearization.

Nuclear worker redirection.

We told our MFA hosts that we were interested in exploring the future redirection of the Yongbyon nuclear workers. Since the Soviet-built IRT-2000 reactor could potentially be used for medical isotope production, I asked to visit the reactor and determine key operational characteristics. We were told that although the future of the nuclear workers is important, the DPRK was not prepared to discuss this subject at this time. They indicated that such discussions would be initiated once dismantlement of the Yongbyon facilities had been achieved. We were denied access to the IRT-2000 reactor.

At Yongbyon, we met with former Yongbyon Director, Dr. Ri Hong Sop, other Yongbyon officials, and officials from the General Department of Atomic Energy (GDAE). They repeated the MFA comment that this is not the proper time to discuss worker reorientation. However, they were willing to get our input and they did respond to our questions. We were able to find out the key operating parameters for the IRT-2000 reactor and its operational status without a visit.

Dr. Ri said that in the future they would like the Yongbyon workforce to be directed to energy; specifically peaceful nuclear energy. They expect that an LWR will be introduced. They could train their technicians and engineers for the LWR. They are also studying how to train their nuclear engineers in other areas. He said he is interested in my ideas. He wanted to know how to keep a scientific base for the future. This could be implemented after the agreement is fulfilled. To date, they are still only thinking about this. They are not ready to do anything.

I presented the following ideas for consideration:

1) In the near future, the focus will be on dismantlement, which will require decontamination and decommissioning of facilities. These activities will engage a significant fraction of the Yongbyon workforce.

2) The Yongbyon nuclear complex has significant needs in radiation health physics and environmental remediation. Their facilities contain a lot of radioactive materials and there is heavy contamination. It will be important for them to do the job safely. We could develop collaborations in radiation monitoring and assessment of health effects. The U.S. has many years of experience in assessing the health effects of radiation. Similarly, it has developed significant expertise in environmental assessment and remediation. Yongbyon

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officials agreed that these are good areas for cooperation once dismantlement is complete. They indicated that they have also been thinking along these lines.

3) I discussed the potential use of the IRT-2000 reactor for research, medical, and industrial applications. I told Yongbyon officials that we have a lot of experience with research reactors. We had one at Los Alamos while I was director. I also have worked closely with colleagues from the former Soviet Union who worked with reactors similar to the IRT-2000 reactor. I presented an extensive list of possible applications for the IRT-2000 reactor and told them that we need to know the specifications of the reactor to judge what applications may be feasible. The list included radioisotope production (primarily for medical applications), neutron activation analysis, neutron diffraction and radiography, neutron transmutation doping, reactor fuel studies, and neutron radiation cancer therapy.

Yongbyon officials responded that they have had experience with some of the applications I had mentioned. They were clearly pleased with my discussion of the possible options. They said the key to the IRT-2000 reactor is the fuel. They have not been able to get delivery of new fuel (Director Ri had previously told me all fuel was supplied by the Soviet Union, and that they had not received any new fuel since the dissolution of the Soviet Union). The most recent fuel used in the reactor was 36 and 80 % enriched in U-235. I told them that it would not be possible to get new HEU fuel because of proliferation concerns. They indicated that it would be possible to convert the core back to low-enriched uranium, which is what the original fuel was when the reactor was delivered by the Soviet Union. They also stated that the reactor could be operated for several more decades with rather minor enhancements.

Yongbyon officials stated that they have experience in the production of medical and industrial isotopes. The Isotope Production Laboratory (IPL) has channels that allows them to extract targets and extract the radioisotopes of interest. They have not done cancer treatments – said they could not get results (it was not clear whether or not they actually tried). He said it would be helpful to have exchanges in this area. They have people who suffer from thyroid cancer, but can't treat them.

Director Ri also indicated that they would like to put their technical people onto projects for light-water reactors (LWR). If Yongbyon is shut down, he and his colleagues will be concerned about their engineers will do. They have no LWR experience now, but they would retrain them. They will need to think about how to best accomplish that. I asked about what Yongbyon workers could do outside the nuclear arena. I told him that this has turned out to be difficult in the U.S. and Russia. It depends on what skills and talents their workers have. Ri said there will be time in the future to share that kind of information about Yongbyon workers. He hopes that time will come.